Athip Thirupathi Raj

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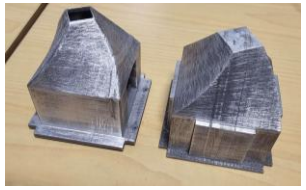
Research and Professional Overview

- **Core Specialization: In-Space Assembly & Manufacturing (ISAM)**
  - Designing autonomous docking mechanisms and modular structural frameworks for next-generation orbital infrastructure.
  - Advancing Hardware-in-the-Loop testing protocols to validate robotic interactions in microgravity.
- **Space Systems Engineering & Leadership**
  - **Agnikul Cosmos (Key Employee):** Contributed to the development of semi-cryogenic rocket engines and launch vehicle architecture.
  - **SpaceTREx Laboratory (Research Assistant):** Leading multidisciplinary teams in the design, fabrication, and testing of flight-ready small satellite components.
  - **NASA MIRO Scholar:** Selected for elite workforce development and mentorship within the NASA Space Technology mission directorate
- **Technical Competencies**
  - **Design & Prototyping:** High-fidelity CAD, DMLS/FFF metal 3D printing, and rapid hardware iteration.
  - **From-Scratch Simulation:** Custom Python physics environments for GNC, pose estimation, and orbital mechanics, removing reliance on black-box tools.
  - **Awards & Recognition:** Winner of the NASA Space Tech Catalyst Award; asteroid (333632) Athipathi named by the IAU in recognition of contributions to space science.

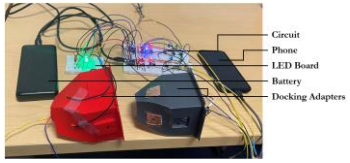
Small Satellite Docking without Robotic Manipulators

Problem: Traditional robotic berthing is too heavy/power-intensive for small sats.
Solution: Eliminate active manipulators via passive geometry.

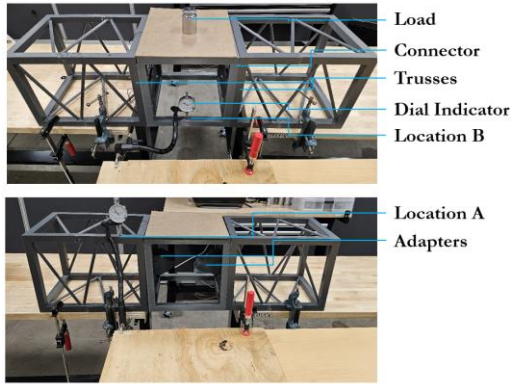
- **First-Principles Approach:** Replaced active sensors with Modified Cone/Probe geometry as Contact Alignment Guides. This forces rotational and parallel alignment upon contact, removing the need for power-intensive Guidance, Navigation, and Control (GNC) corrections.
- **Technical Trade-offs:** Iterated through CAD designs to maximize internal payload volume while maintaining structural rigidization for docking loads.
- **The Hardware MVP:** Validated designs through DMLS (Aluminum) and FFF (Stainless Steel) metal 3D printing to achieve flight-equivalent performance with rapid, low-cost fabrication.
- **Demonstrated Results:** Successfully integrated pogo-pin interfaces to achieve reliable power and data transfer immediately upon hard capture.



DMLS metal adapters (70% scale)



Power and Data Transfer Demo

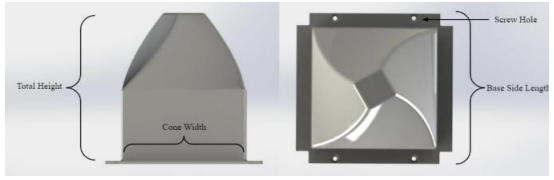


Comparison Experiments: Bolted unit truss (Top); Docked unit truss (Bottom)

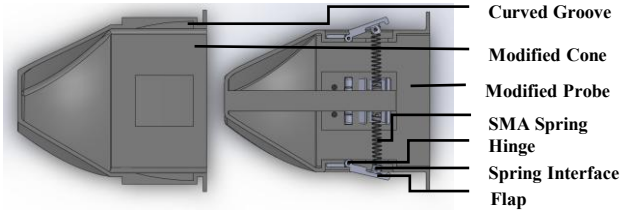
More details including videos, presentations and publications are present in my portfolio website: https://athipa95.github.io/

Invention disclosure: [Link]; Movie: [Link]

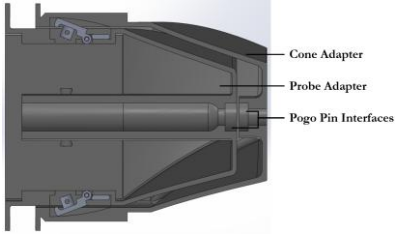
Contact Alignment Guides (IAC 2021)



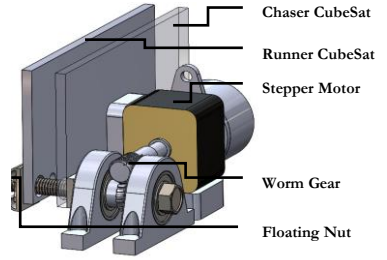
Maximize Internal Volume (AASGNC 2022)



Second Stage for Hard Capture (AIAA ASCEND 2023)



Power and Data Transfer (AIAA ASCEND 2024)



Structural Rigidization (2025 – 2026)

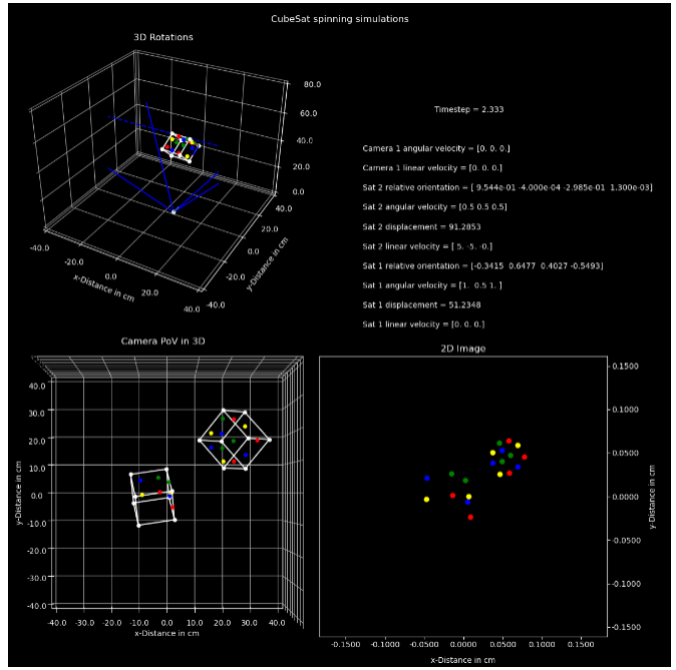
Monocular Pose Estimation using LED Lighting Cues

Problem: Traditional methods for active ranging and pose estimation are often too computationally expensive or power-intensive for small sats.
Solution: A high-accuracy, low-power alternative using simple LED key points.

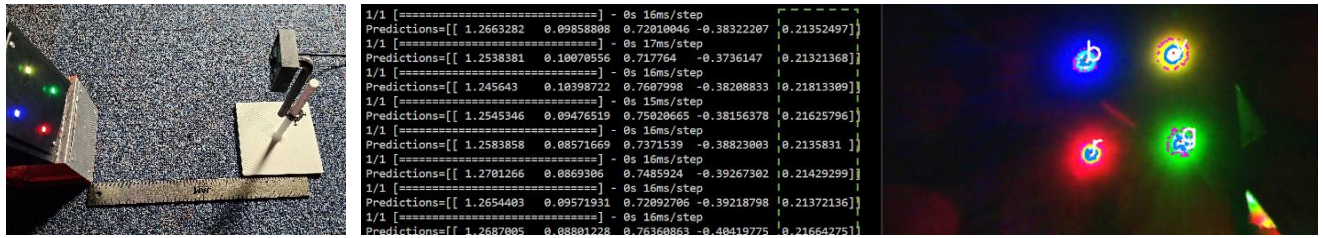
- **Physics Simulation**: Coded spinning CubeSat dynamics and pinhole camera projection from scratch in Python. This enabled the generation of high-fidelity synthetic datasets tailored to specific mission geometries (Code available in my GitHub)
- **Neural Network Architecture**: Developed and trained a pose estimation model to extract ranging and quaternion data from 2D lighting cues
- **Optimization**: Utilized Grid Search and K-fold Cross-Validation to tune hyperparameters, ensuring the model's robustness against variable noise and lighting conditions.
- **Hardware-in-the-Loop Validation**: Transitioned from simulation to physical reality by testing with LED-equipped CubeSats.
- **Demonstrated Results**: Achieved ~90% accuracy in real-world ranging trials, aiming to prove that simple lighting key points can replace complex sensor suites.

More details including videos, presentations and publications are present in my portfolio website [Link]

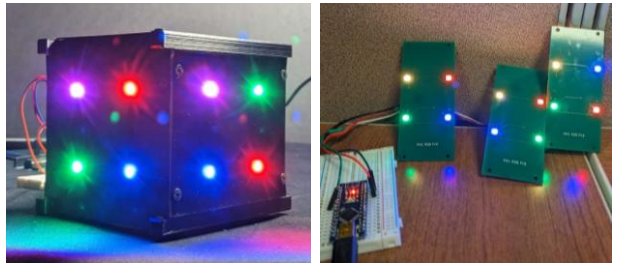
Invention disclosure: [Link]



Synthetic Data Generation using Python



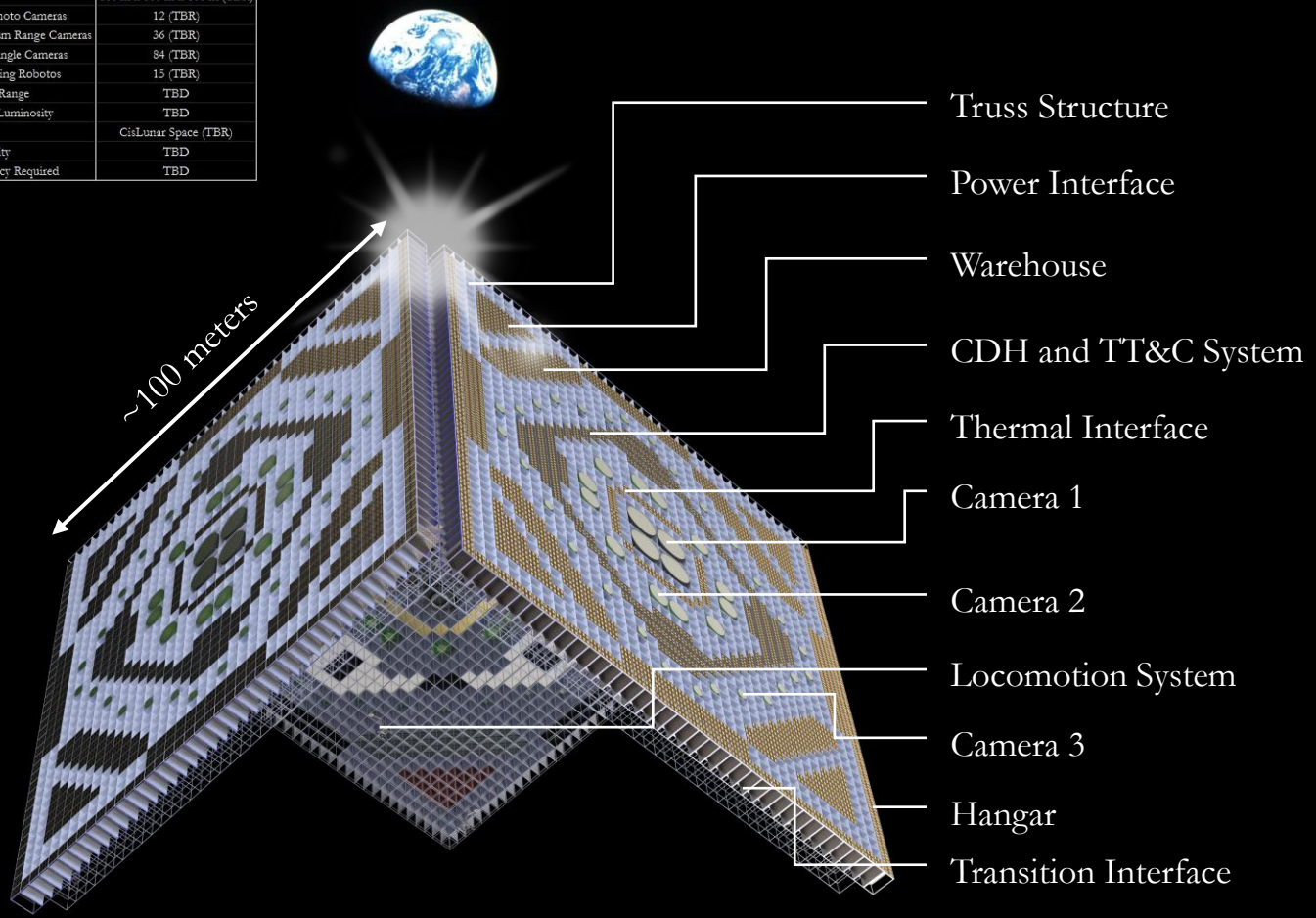
Preliminary Trial Result: Ranging at ~90% Accuracy (AASGNC 2024)



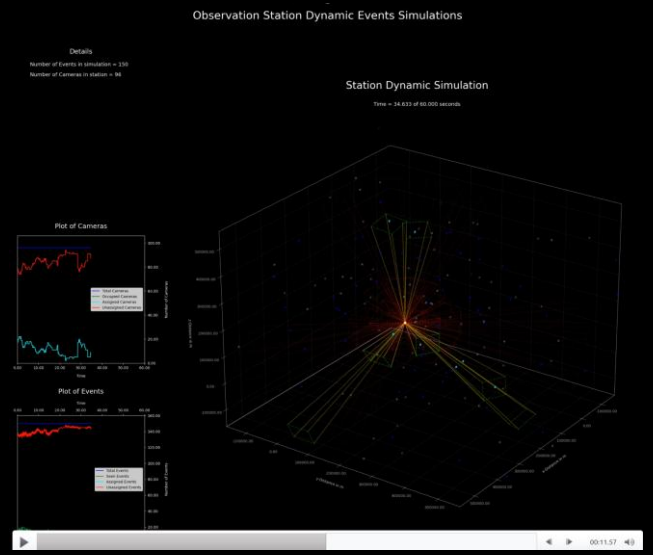
Prototype CubeSat Hardware with LED keypoints (AIAA ASCEND 2024)

Mission Concept RAVEN: Robotic Autonomous Vision and Exploration Node

Dimensions	100 m x 100 m x 100 m (TBR)
Number of Telephoto Cameras	12 (TBR)
Number of Medium Range Cameras	36 (TBR)
Number of Wideangle Cameras	84 (TBR)
Number of Servicing Robotos	15 (TBR)
Max. Observable Range	TBD
Min. Observable Luminosity	TBD
Location	CisLunar Space (TBR)
Warehouse Capacity	TBD
Resupply Frequency Required	TBD



- **System of Systems Architecture**: Performed high-level Systems Engineering for a modular, expandable, autonomous robotic system to host a wide range of payloads.
- **Operations Simulation**: Coded a dynamic station functioning and payload observation simulator from scratch in Python. This removed reliance on black-box mission tools to ensure full control over orbital mechanics and scheduling logic.
- **Autonomous Resource Management**: Designed a high-level Operations Scheduler and performed inventory management analysis. This ensures the system can autonomously prioritize observation tasks and resource allocation without constant ground-station intervention.



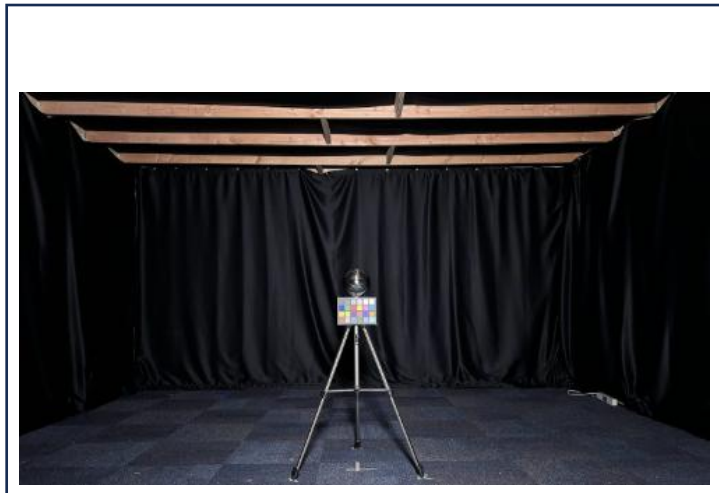
Operations Scheduler Simulations (AIAA SciTech 2025)

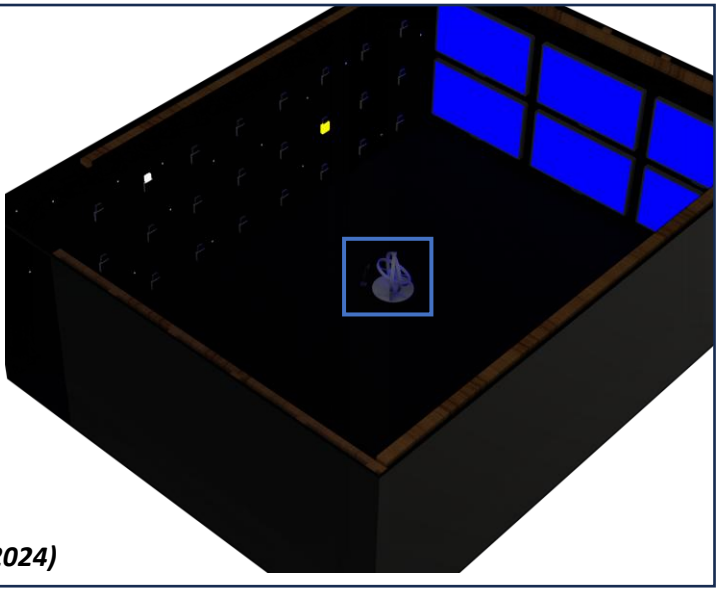
- **Movie:** https://youtu.be/Z4FPFL-YI6c

Test Facilities Constructed

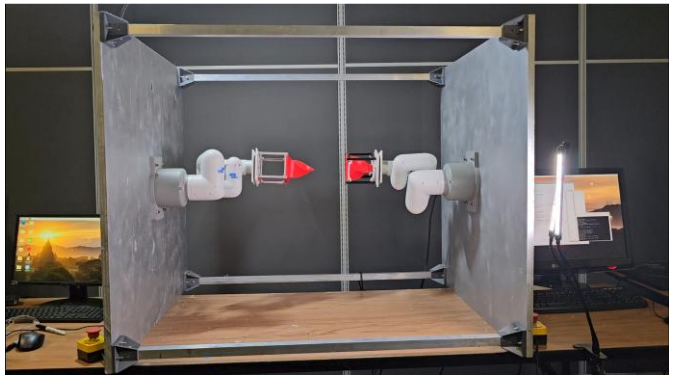
- Constructed SWORD (Spacecraft Workings and On-orbit Robotics using Drones), a 20 ft x 15 ft x 8 ft zero-lux facility a bridge to validate my research in a physical environment.
- Fabricated a motorized gyro for a 1U CubeSat payload calibrated with onboard IMU to stress test pose estimation algorithms.
- Fabricated a remote-controlled Stewart Platform for Manual Docking experiments, establishing performance benchmarks for my autonomous systems.
- Developed an Autonomous Docking Test Platform featuring dual-arm robotics to validate dynamic capture protocols in real-time.

More details including videos, presentations and publications are present in my portfolio website [Link]

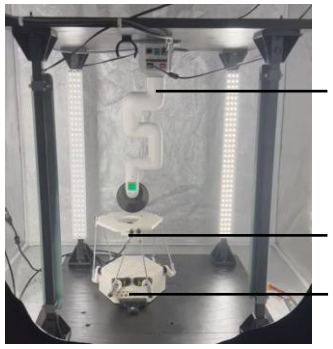




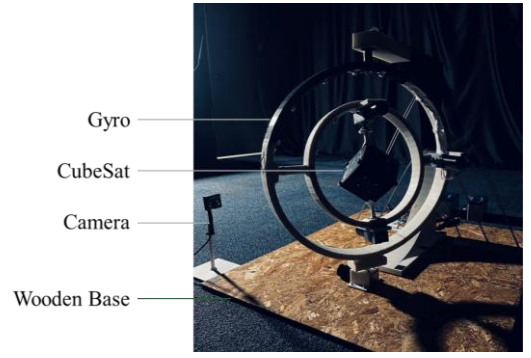
SWORD Facility (AASGNC 2024)



Autonomous Docking Test Platform (AASGNC 2022)



Manual Docking Test Platform (AASGNC 2022)

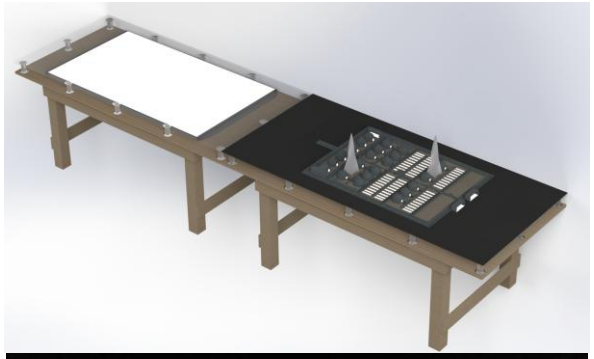


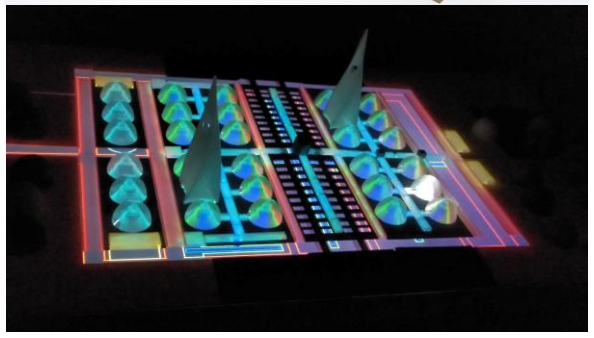
Motorized Gyro for CubeSats (AASGNC 2024)

Other Activities at the U of A

3D Printing

- Fabricated a 500-part miniature model of an autonomous lunar base as part of an exhibit for a conference.
- Utilized transparent 3D prints and integrated displays to create a functional, educational exhibit





Deployable CubeSat SCT Telescope using Tensegrity Structures

- Engineered a Schmidt Cassegrain Telescope that goes from 20 cm x 20 cm x 10 cm in the stowed configuration to up to 20x20x50 in the deployed configuration.
- A system of 4 stepper motors spool in strings to hold the telescope in the deployed configuration via tensegrity.

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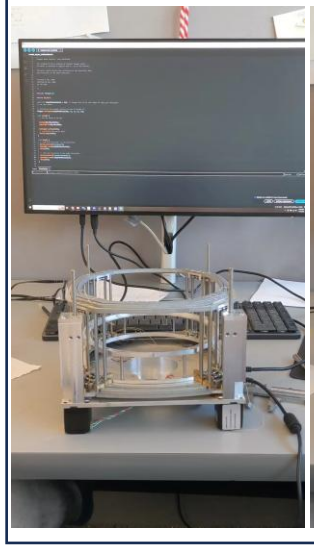
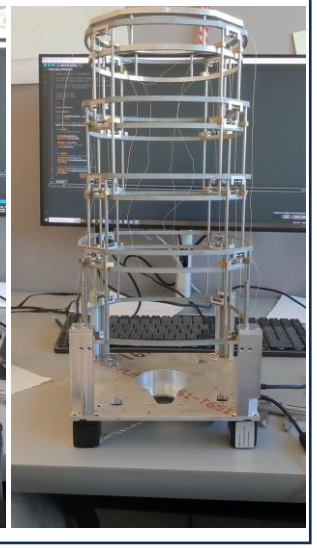
Invention disclosure: [Link]





3D Modelling, Animation and Video Editing

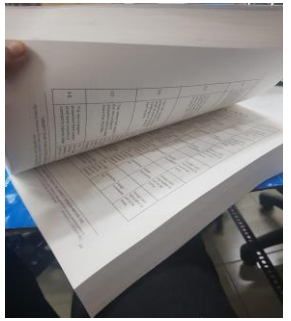
- Created Sci-Fi themed promotional videos of SpaceTREx lab projects using Blender, Adobe Premier Pro and Adobe After Effects.
- YouTube: [Link]

Award Winning NASA MIRO Student Mentorship

- Mentored more than 35 underrepresented students as part of workforce development in the NASA MIRO program.
- Three-time recipient of the NASA MIRO scholarship.
- Winner of the first NASA Space Tech Catalyst award recognizing my mentorship activities.

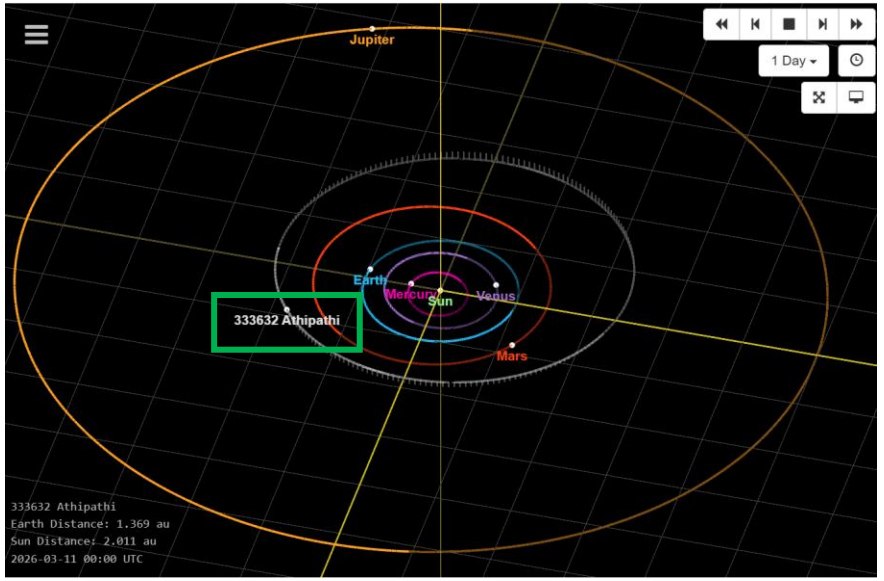
Agnikul Cosmos – Space Systems Engineer

- Worked a the Lead Systems Engineer of the Semi Cryogenic Thrust Stand “SeCrTS”, thrust stand test facility for Agnilet, India’s first 3D Printed Rocket Engine.
- Co-Authored and Edited the Small AgniBaan Rocket “SAR” Design Document and AgniBaan v 1.0 Configuration Document.
- Worked as the Systems Engineer for v1 of Agnilet, a 3D Printed 3kN semi cryogenic rocket engine.
- **Systems Engineering Architect**: Developed systems engineering protocols for effective communication between different subsystem teams as the company scaled up from 10 to 80 employees in one year.
- Identified as “Key Employee” by Agnikul.



Awards and Honors

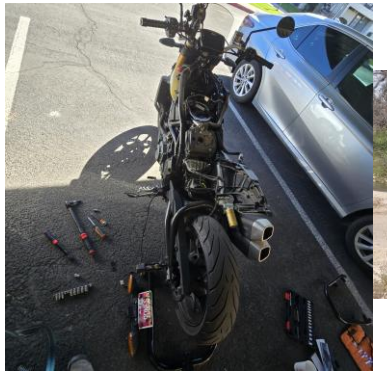
- **NASA Leadership and Mentorship:** Winner of the first NASA Space Tech Catalyst award recognizing my mentorship activities at the U of A ($25,000).
- **Asteroid "Athipathi" 2008 GH_{52} named** by the IAU (International Astronomical Union) under recommendation of Dr. Mike Nolan, Science Team Chief of OSIRIS-REx [Link]
- **Featured in PBS** "New Frontiers" debut episode [Link]. More media mentions and honors present in my portfolio website
- Three-time recipient of the **NASA MIRO scholarship**.
- Graduate and Professional Student Council (GPSC) **Research Grant** ($1500)
- **Honorable mention (Winner)** in Tech Briefs Create the Future Contest (2023)
- **Top 100 entry** in Tech Briefs Create the Future Contest (2022, 2023, 2024)
- **NASA-XHAB** 2017 winner ($15,000)
- **Outstanding student award and best sportsman award** 2016 at NIT Trichy, India (Bachelor's degree)



Other Activities and Hobbies

- Motorcycling (On and Off Road) and maintenance/servicing (2019 Indian FTR 1200S and 2012 Honda NC 700X)
- Astrophotography and Telescope Mount Design and Fabrication
- Aquatics (Swimming) and Track and Field sports
- Home Automation (Raspberry Pi home assistant, NAS)
- Android App Development
- Building Architecture and Structural Design







Thank you!

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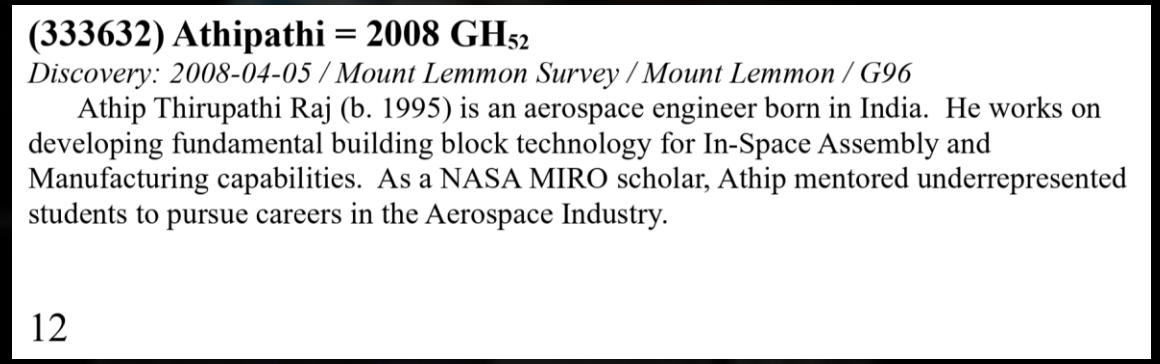

(333632) Athipathi = 2008 GH_{52}

Discovery: 2008-04-05 / Mount Lemmon Survey / Mount Lemmon / G96

Athip Thirupathi Raj (b. 1995) is an aerospace engineer born in India. He works on developing fundamental building block technology for In-Space Assembly and Manufacturing capabilities. As a NASA MIRO scholar, Athip mentored underrepresented students to pursue careers in the Aerospace Industry.

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