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INTRODUCTION

I am a senior studying Aerospace Engineering at the University of Michigan with a minor in Computer Science. Next year, I hope to complete my masters in Space Engineering. During my time here, I have designed, built, and tested record breaking rockets with MASA, as well as innovating new aircraft mechanisms with MACH. I have significant experience in team leadership, project management, and the design of deployment systems and structural components for flight vehicles.

Please see my attached resume for more details!

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The launch of Clementine, the largest liquid rocket ever launched by students, in May 2023.

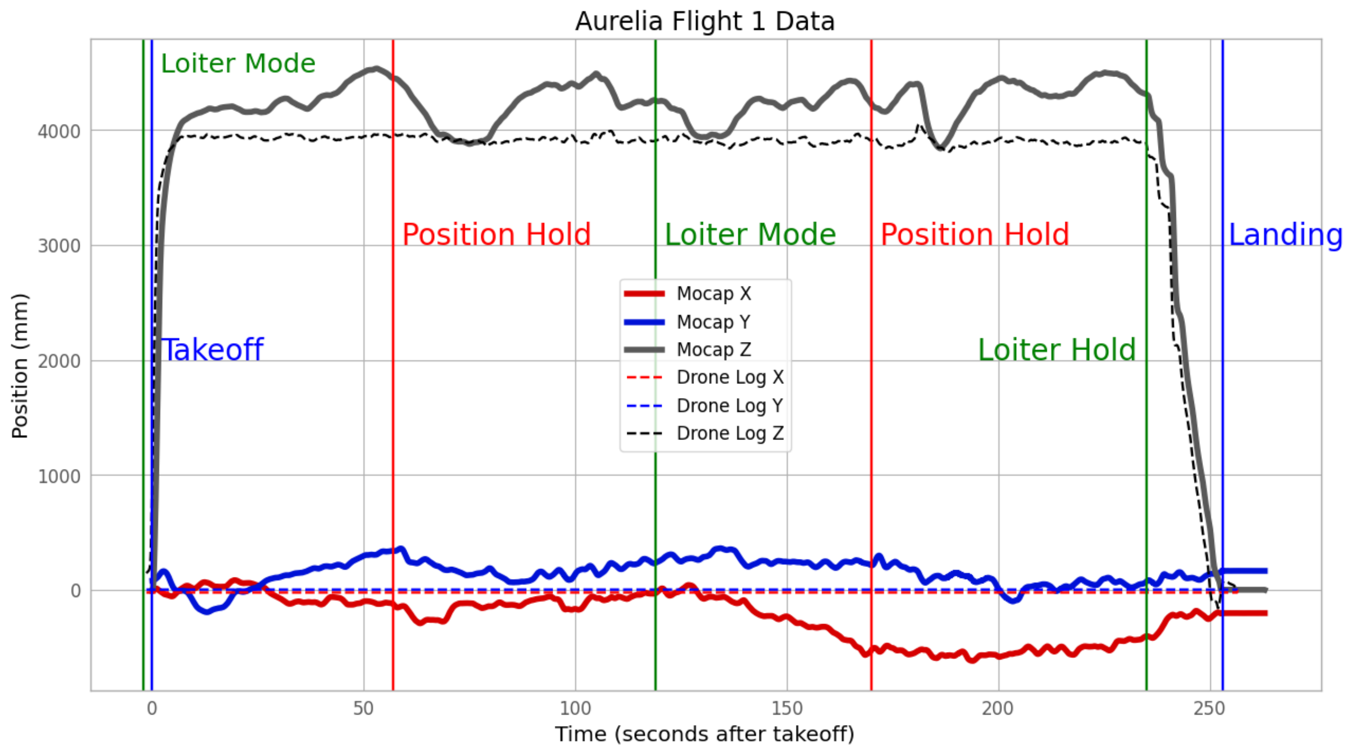
Formation Flying Space Interferometer

Flight Stability Characterization (2022-2023)

During the fall of 2022, I enrolled in the model-based systems engineering course sequence. As a member of the FFSI team, we designed a drone system to showcase technology for a future space telescope. This system was intended to redirect light from a laser or star between drones, paving the way for a low-cost, high-resolution telescope dedicated to searching for exoplanets. That fall, we developed a concept of operations, established a set of requirements, and conducted trade studies.

As we moved into the spring, we underwent a reorganization, and my focus shifted to improving the flight stability of the drones. In a prior flight test, one of the drones had crashed into the ground, prompting me to initially address issues with the control system and firmware. Subsequently, we conducted flight tests with each drone, experimenting with various flight modes and collecting accurate position data through a motion capture system. This allowed us to compare internal position estimates to the actual position and identify the most stable mode.

Regrettably, none of these modes met our stability requirements. Consequently, I also worked on implementing a LIDAR ground sensor and RTK GPS to enhance the drones' position estimates and, in turn, their stability.



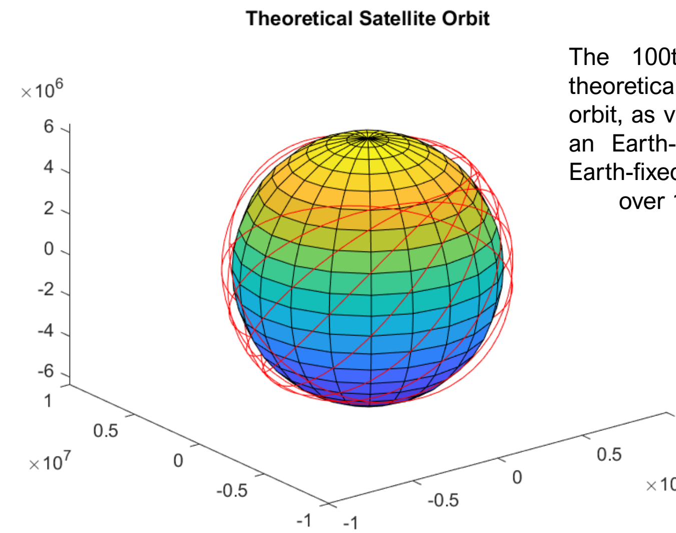
Orbital Slot Dynamics for LEO Constellations

Reduced Order Gravity Modeling (2023)

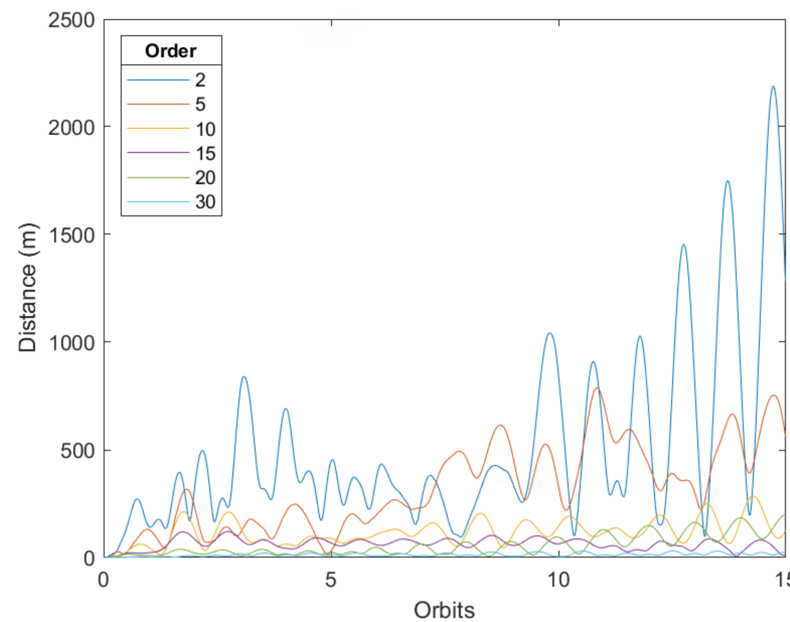
As someone interested in the future of space infrastructure, I've always wondered how to manage the thousands of satellites in each LEO megaconstellation. To address this challenge, I collaborated with Prof. Max Li, an expert in air traffic management, and Prof. Jia-Richards, who specializes in astrodynamics. Our approach involved modeling an orbital slot system where each satellite would have a designated orbital altitude and position. Given the high cost of modeling these slots far into the future, our research focused on exploring the relationship between model fidelity and slot size.

One significant factor affecting satellite trajectories is the irregularities in Earth's gravitational field. To account for these variations, we employed a 100th order version of the NGA's 2008 Earth Gravitational Model to create a high-fidelity satellite model. We then compared this model to various slots, which we positioned in the same location and propagated using lower orders of the same model. Over time, the satellite deviated from the slots, with the deviation decreasing as model fidelity increased. This highlights the engineering tradeoff in the slot model—higher-order slots can accommodate denser packing but at the cost of increased computational complexity.

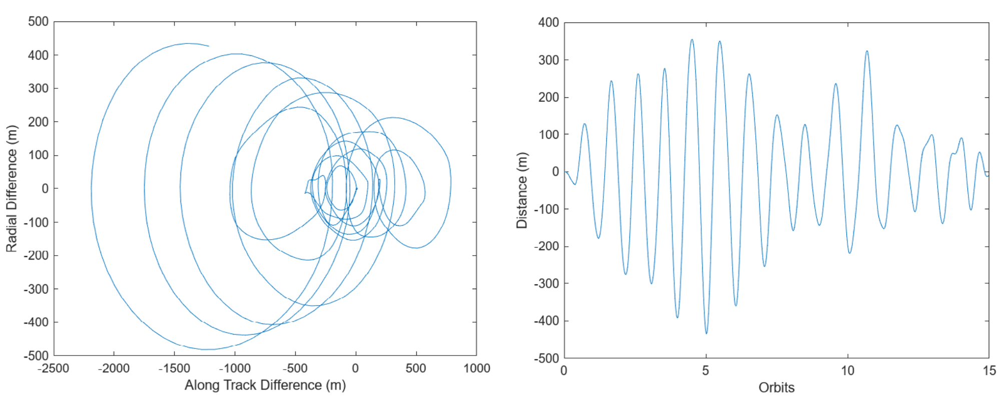
Our models were created using MATLAB, utilizing 'ode45' for position propagation in the Earth-centered Earth-fixed frame and 'gravitysphericalharmonic' to incorporate the EGM2008 model.



The 100th order theoretical sattelite orbit, as viewied in an Earth-centered Earth-fixed frame over 15 orbits.



Low order slots deviate by kilometers in ~1 day, but even the 10th order has a major improvememnt, staying under 300 m away from the slot center.

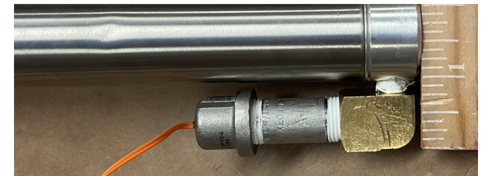


Top down and side views of the theoretical satellite within a 2nd order slot.

Clementine

Nosecone-Airframe Coupler (2021-2022)

Between 2021 and 2023, MASA built Clementine with the goal of bringing us back to the launchpad while innovating on the best of previous designs. Clementine was one of the most advanced rockets ever built at the collegiate level when it launched in May 2023.



Until August 20222, I led the design, testing, and construction of the nosecone-airframe coupler, ensuring the nosecone stays attached up until parachute deployment. During the design phase, I acted as a liaison between the nosecone, recovery, and airframe teams, coordinating timelines, writing grants, and ensuring interoperability and ease of assembly.

During the summer of 2022, we took the coupler into the prototyping and testing phases. I led multiple layups, of both the coupler and the airframe. These prototypes were tested exhaustively, ensuring the shear pins would break on deployment, and that the nosecone would clear the airframe in flight. When our testing showed that the pyrotechnic bolt design was unreliable, I designed and sourced a new system, improving reliability and ease of assembly.

Following my exit of MASA at the end of summer, the team integrated the deployment system and conducted full system testing. While the rocket launched sucessfully in May 2023, an anomoly during flight led to a hard landing.

Tangerine Space Machine

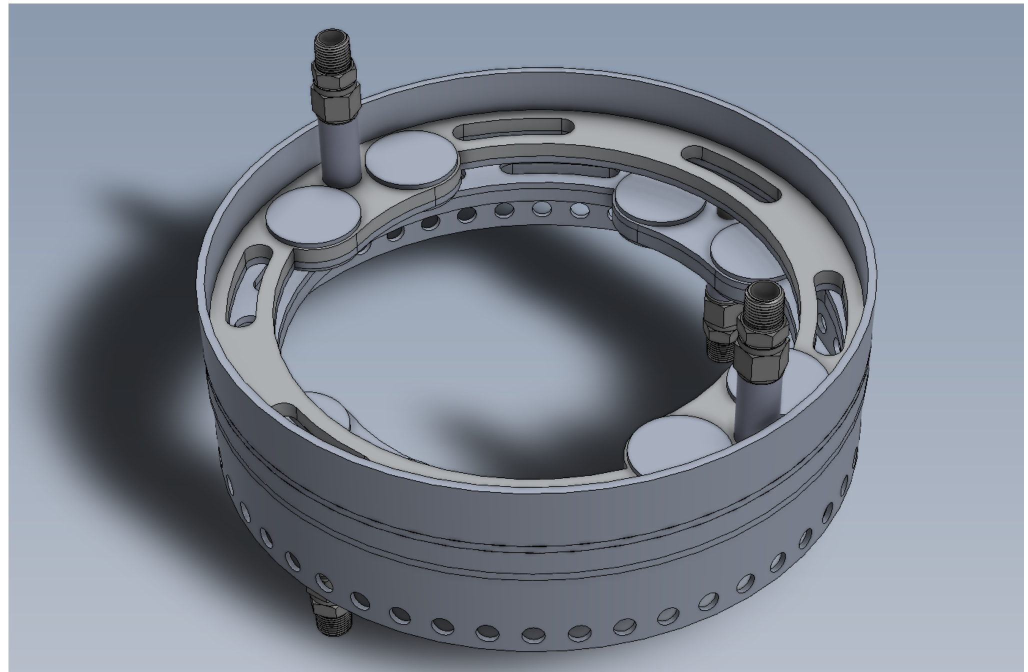
Separation Mechanism (2020-2021)

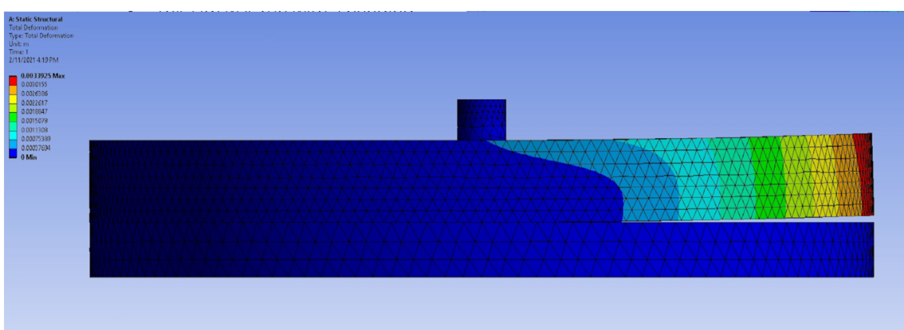
As part of the Base 11 Space Challenge, Tangerine Space Machine was set to be the first student built liquid rocket to cross the Kármán line and enter space. As such, the separation mechanism faced a completely different set of design requirements.

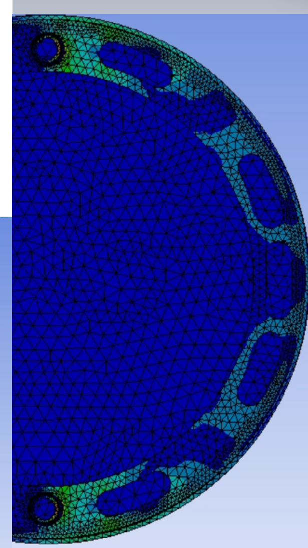
Our two largest considerations were the oxygen-free environment and the bending moment induced by aerodynamic loads.

In regards to the environment, we had a redundant system of two pins, with two rings pushed apart by a set of 8 springs. It was important that we maximized spring energy to ensure recovery and range safety in an abort case, and as such, I conducted a trade study out of 543 springs to find which held the most energy within our size and clamp force.

However, our greatest challenge was the bending moment induced by the nosecone. I proposed and simulated multiple designs in ANSYS Mechanical, resolving issues with yielding and failed simulations. Eventually, we settled on a thicker base and walls, with holes to save mass.







Tangerine Space Machine

Fin Can Test Stand (Summer 2021)

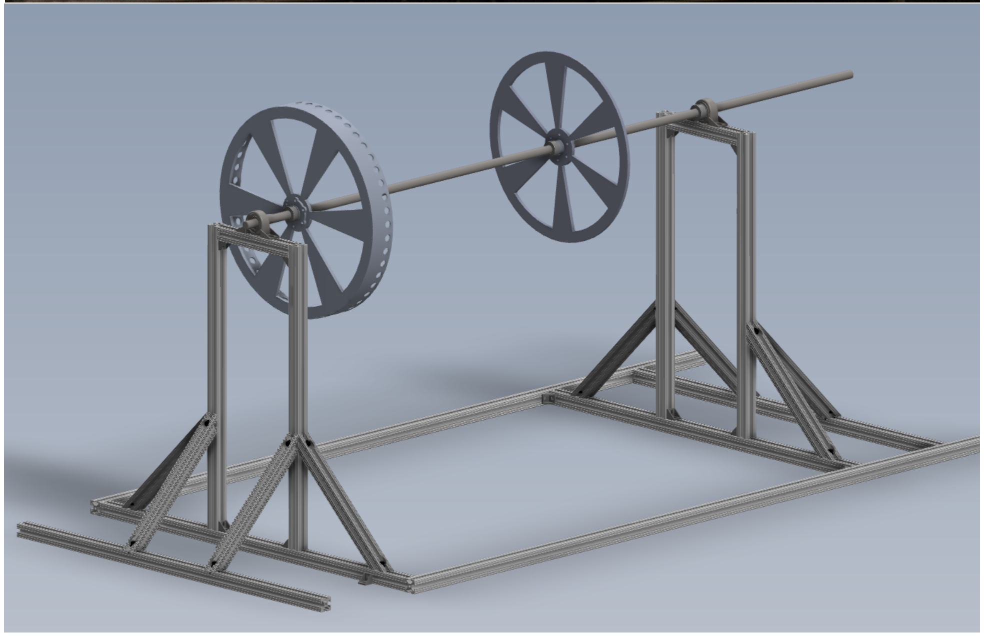
A common issue with fins in rocketry is that any inaccuracies in construction might cause them to induce significant roll. Given that partner teams have lost rockets due to inertial roll coupling, this was of great concern to the team.

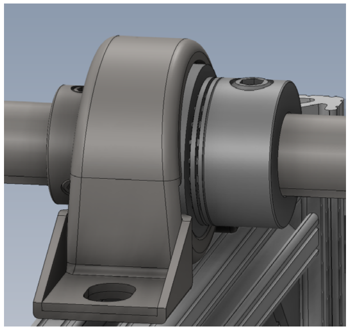
Over the summer of 2021, I designed a rotating stand that allowed us to quantify this effect, in the university's 5'x7' wind tunnel. It had to:

- Be adaptable to the pre-existing floor hole layout
- Adjust to up to 2° AOA
- Survive 400 lbs of downforce and ~100 lbs of thrust
- Not significantly disrupt the airflow around the fins

As such, I chose 80/20 extrusion due to its adaptability. I then drafted designs in SolidWorks and performed an internal design review before moving into discussions with the wind tunnel manager. From there, I significantly reinforced the design and moved into the production phase.

I also wrote the grant that funded the project and sourced the materials from metal suppliers and McMaster-Carr. As the summer ended, the project was handed off to a capstone project team.





I used a needle-roller thrust bearing to ensure drag forces were transferred around the bearing.

MACH 6

FEA and Rear Faring Hatch

I discovered MACH in the December 2021, and joined soon after, wanting to explore my interest in aircraft. At the time, MACH did not have anyone with FEA experience, and as such, my role was to simulate loads on the wing spar attachment and motor mount.

The wing spar attachment was a custom 3-D printed geometry, and the simulations found that it had a sufficient safety factor, backed up by physical testing. For the motor mount, the preliminary design called for a wooden plate. However, the simulation showed that it would fail. We instead switched over to two plates, one plastic and one metal, bolted together.

The challenge called for us to insert two packages into the plane as quickly as possible. I led the development of a single pin design for our detachable rear fairing, decreasing complexity, while still constraining all six degrees of freedom. This allowed us to retain the aerodynamics of a smooth rear fairing, while maintaining easy access for the ground crew.

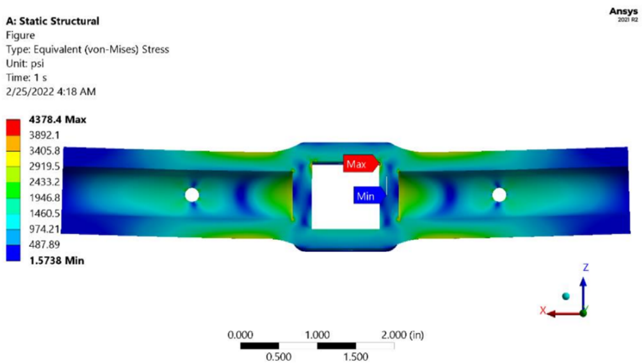


Figure 31: Stress in Wing Mount for 3-G Upward Load Case

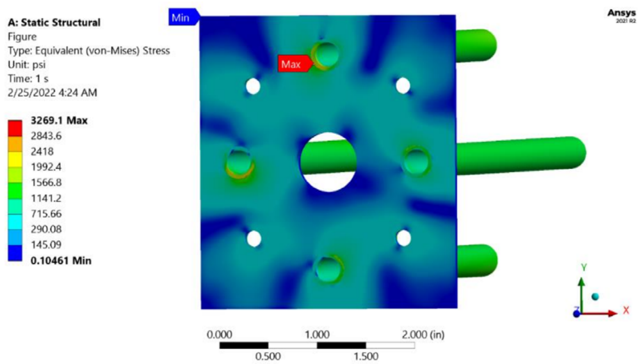


Figure 32: Stress Results from FEA Analysis of Motor Mount