# Project Portfolio - Ioan Assenov

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My name is Ioan Assenov. I am a mechanical engineering student at the University of Michigan in my fourth year of undergraduate studies. I am passionate about dynamics, controls, robotics, and intelligent systems and their application to improve our societies. My other interests include project management, team-wide coordination, and system integration. In this document I outline a selection of my notable engineering projects.

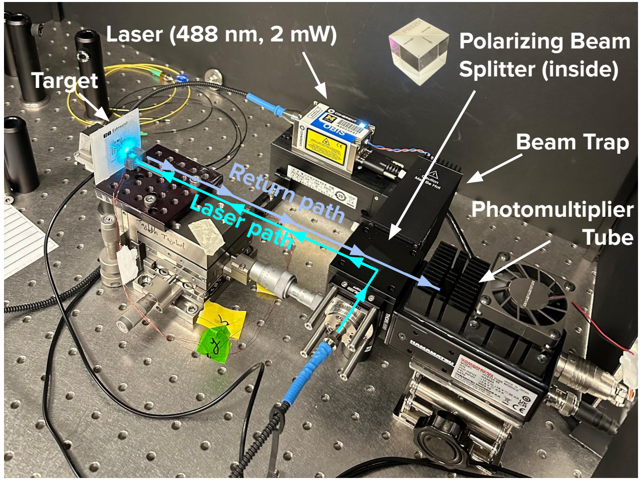

*Inert propellant flow test of MASA's ME-5 Engine – May 2024*

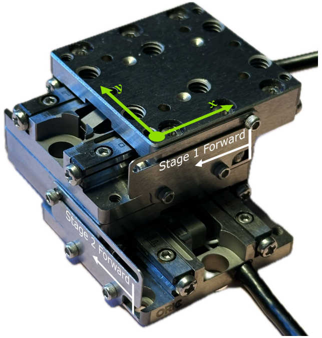
# Piezoelectric Linear Translation Stage Test Platform

I developed software to drive a set of linear actuators in two directions to scan an optical target with a stationary laser. I then developed a script to process the reflection data into an image using several algorithms for data cleanup and reconstruction. This project taught me advanced data processing and real time data acquisition in MATLAB.

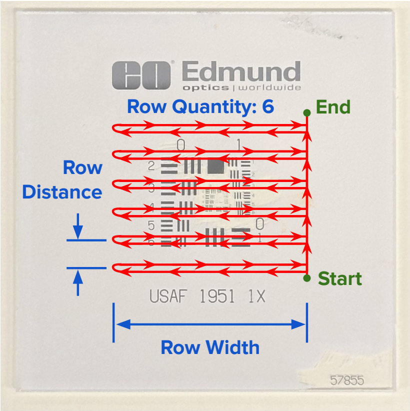
Right: Two linear stages fixed together for two axis planar motion. A similar configuration is used in the actual experimental setup.

Below: Experimental setup with stationary laser and target mounted on test platform.

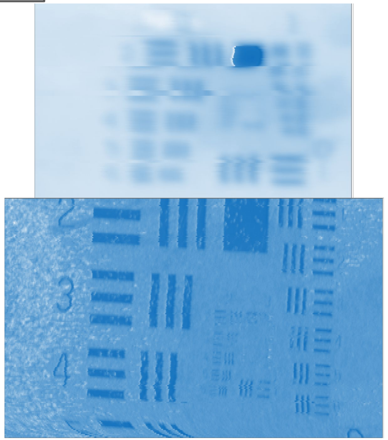



Scan pattern parametrization overlaid on the USAF 1951 1X optical target. The pattern is parametrized by row width, quantity, and distance.




Scan progress over several iterations.



Process flow that was used to collect data for a given scan pattern and image reconstruction

**Begin Data Acquisition** → Move across row → Save row data & stop → Return to row start → Data integrity healthy?

Data integrity healthy? — N → Begin Data Acquisition; Y → Was this the last row?

Was this the last row? — N → Move to next row → Begin Data Acquisition; Y → Output raw data matrix

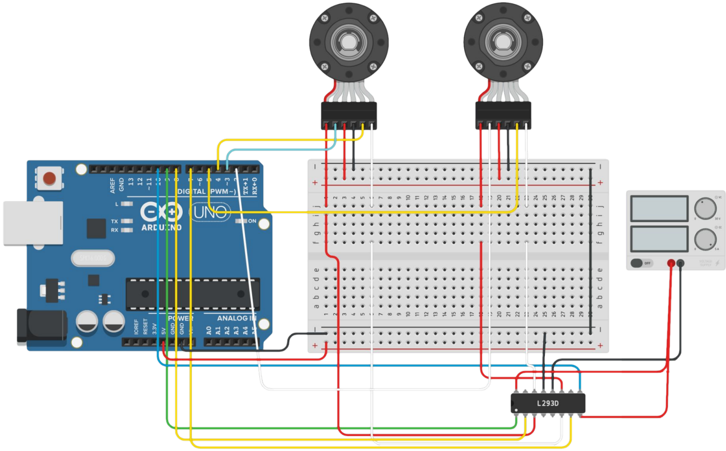
Output raw data matrix → Cleanup raw row data → Downsample data → **Construct image**

https://github.com/ioanassenov/Piezo-Motor-Stage-Scanning

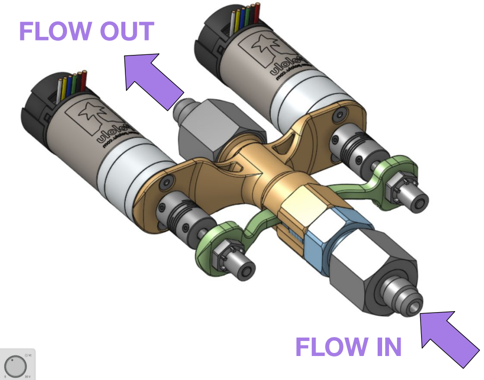
# Throttleable Liquid Oxygen Valve Control

I designed an embedded system to control the throttle setting of a liquid oxygen valve for a rocket motor in real time as my capstone design project.

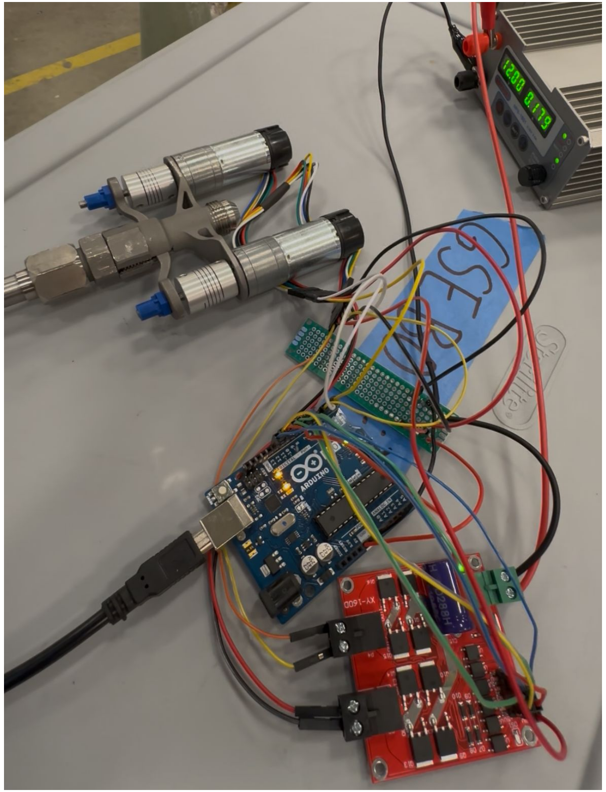
The throttle valve utilized a linear sleeve design actuated by lead screws driven by two motors. The motors were driven in tandem using a tuned PID controller to a desired position which would result in a corresponding flow rate.




Right: image of functional prototype of the throttle valve. The valve is connected to a 100 psi air supply and throttled to measure flow restriction and test motor response.



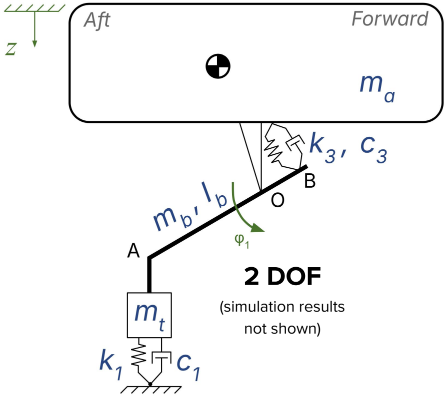

This project taught me how to implement a custom PID control loop based on encoder feedback and tuning it to avoid jitters and overheating the motors during operation.

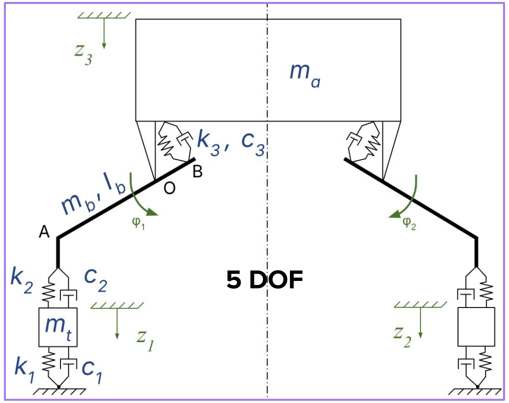


# Landing Gear Dynamic Simulation

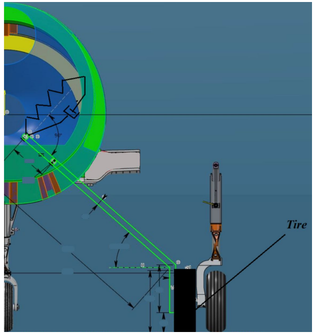
As a structural engineering intern at DRONAMICS, I had the opportunity to model the landing dynamics of a new proposed landing gear design for the Black Swan aircraft. This project involved a significant amount of modeling nonlinear ODEs in MATLAB and Simulink and tested my understanding of engineering fundamentals.

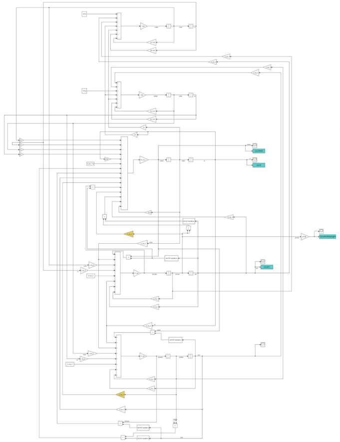

I developed and simulated several dynamics models of the main landing gear.

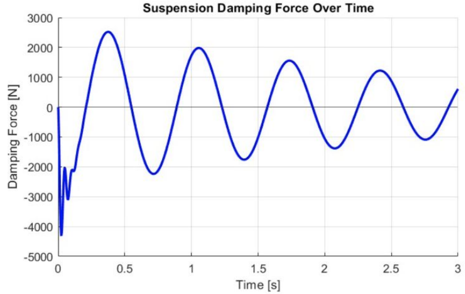


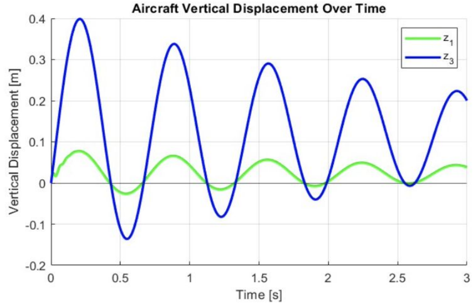




The Simulink block diagram and graphs below are simulation results of the 5 DOF system which provided the most conservative results and included elastic properties of the proposed landing gear beam.



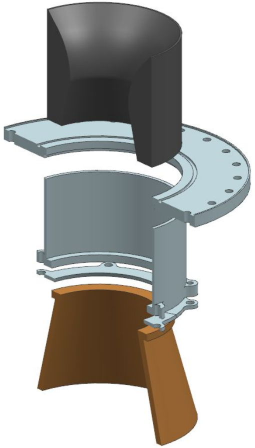


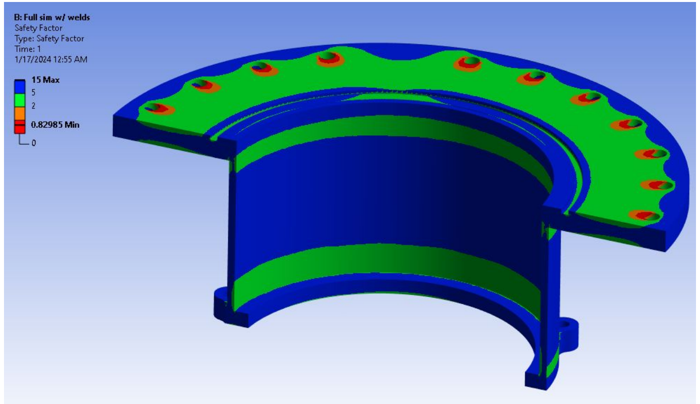
# ME-5 Nozzle Project Lead (1/2)

I was the project lead for the nozzle of MASA's 12.5kN RP-1/LOx engine, ME-5. I owned the project over its entire course from initial ideation to its ultimate integration with the engine. This project helped me build fundamental intuition for structural engineering and material behavior and helped me develop my skills with industry standard software.

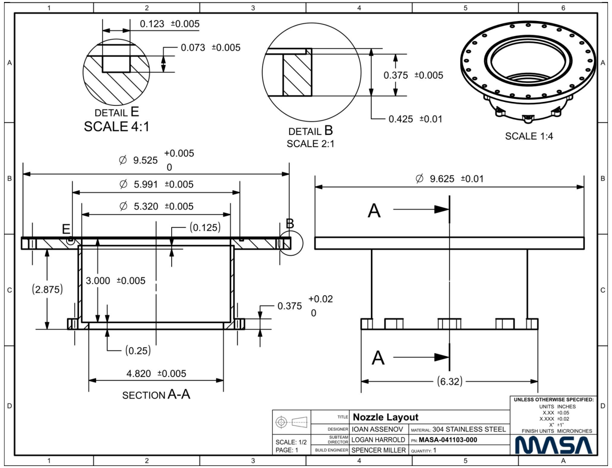
Right: exploded section view of all 5 nozzle components. The dark gray graphite insert defines the throat of the nozzle and experiences the most thermal loads out of all parts. The ablative extension below (in orange) is a brand new concept we attempted to implement in order to increase the engine's expansion ratio and thus efficiency. Creating this part taught me about composite materials and their properties.



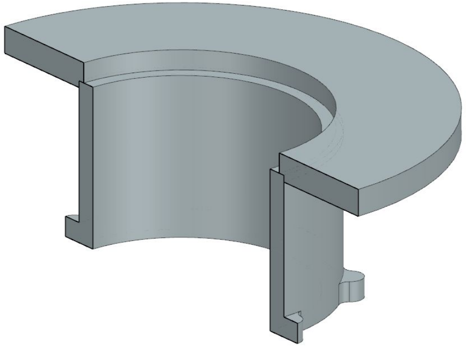
Below: FEA results of preliminary nozzle design. Over 20 FEA were conducted and verified using hand calculations to understand the nozzle structural performance and to determine areas for optimization and mass savings.




Below: drawings of the nozzle flange plate and barrel for in-house manufacturing purposes. The two parts were welded and then post-machined to final dimensions to account for warping.




Below: pre-weld CAD for the nozzle flange plate & barrel. The dimensions of the design were based on tolerance stack analyses and estimations for post-weld warping.

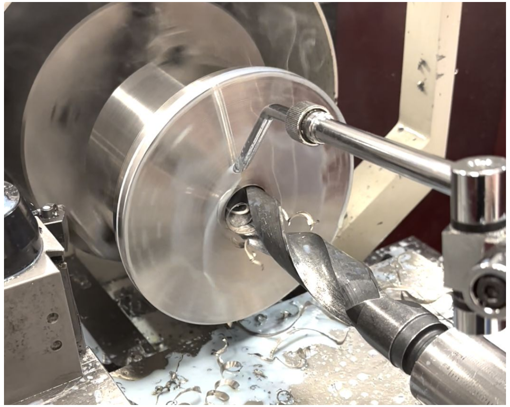


# ME-5 Nozzle Project Lead (2/2)

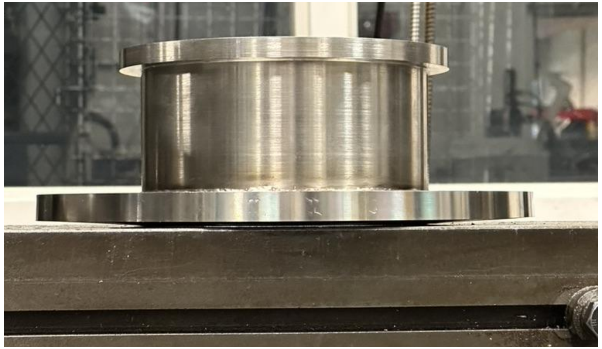
The in-house manufacturing of the nozzle flange plate & barrel took approximately 6 weeks. The graphite nozzle insert and ablative extension were made out of house and ultimately the nozzle was completed fully within tolerance for the May 2024 hotfire attempt. Designing for manufacturability is an important lesson I learned during this process.

Right: fully assembled nozzle prior to installation onto engine assembly. The graphite insert was installed using room temperature vulcanizer which also acts as a sealant preventing combustion gasses from escaping.

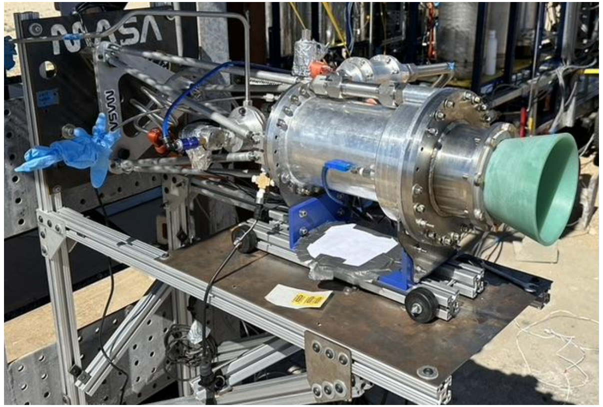
Below: manufacturing of nozzle barrel section. All load-bearing components were manufactured in-house out of 304 steel. Parts were made using a manual mill and lathe as well as a CNC waterjet and CNC lathe.



Below: nozzle flange plate and barrel post-weld warping. Thanks to the large material tolerances implemented following tolerance analyses, we were able to machine the nozzle to the correct final size during post-weld ops.

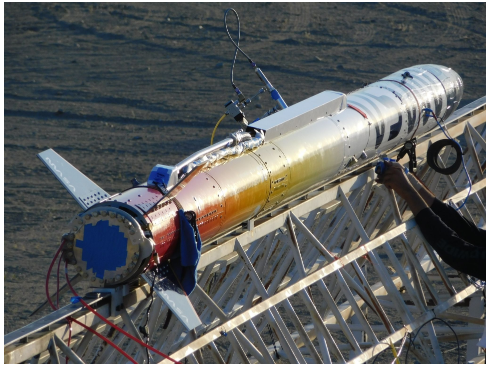


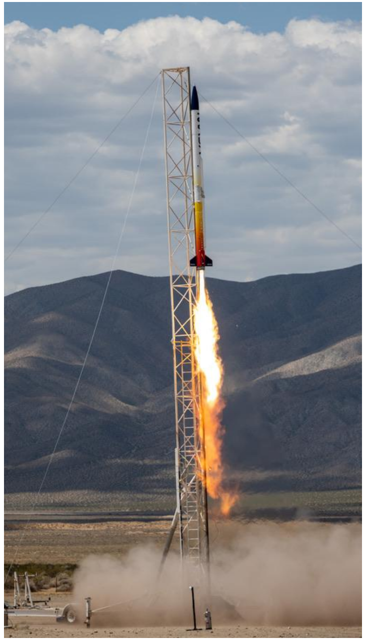
Below: ME-5 prepared for hotfire on test stand. The nozzle is visible on the very right of the engine with its green glass phenolic extension

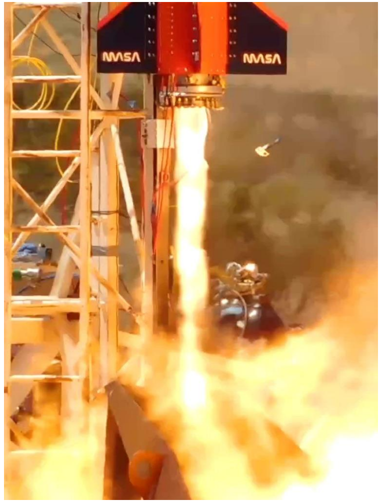


# Propulsion Engineer - Clementine Launch Crew

I was part of the 23 person launch crew of MASA's Clementine rocket as a propulsion engineer in May 2023. The launch trip occurred after the conclusion of the 12 week coldflow campaign which verified the entire vehicle using inert fluids. My responsibilities included understanding engine architecture and ensuring proper construction of the thrust chamber assembly in the field. The images to the right show the fully integrated rocket on the launch rail.






Above: mach diamonds visible in the plume due to slight overexpansion.

Left: liftoff of the Clementine rocket. The rocket's thrust was estimated to be about 5kN, making it one of the most powerful student built liquid rockets ever flown. The maximum altitude achieved was ~2.3km however the purpose of Clementine was to serve as a technological demonstrator for our fuel-side regeneratively cooled engine design.

Below: engine mounted to rocket with thrust transfer structure (in bubble wrap). This was a complex assembly process as the rods must be under equal stress throughout to avoid damage before flight.