Soil Properties Assessment Ressistance and Thermal Analysis Probe
(SPARTA)

Jet Propulsion Laboratory
California Institute of Technology

Intern Project: Summer 2025

OVERVIEW

- SPARTA (Soil Properties Assessment, Resistance, and Thermal Analysis) is a multi-instrument regolith characterization system developed at NASA Jet Propulsion Laboratory (JPL).
- The system integrates a cone penetrometer (CPT), vane shear tool (VST), dielectric sensor (DSP), and thermal control probe (TCP) to measure mechanical, thermal, and electrical properties of planetary soils.
- SPARTA is designed for deployment across diverse planetary environments, including the Moon, Mars, Venus, asteroids, and comets.
- The platform supports in situ subsurface investigations critical to landing safety, mobility analysis, excavation, and future in-situ resource utilization (ISRU) missions.

PURPOSE

- Reliable planetary surface operations require accurate, in-situ knowledge of regolith mechanical and thermal properties, which are currently limited and uncertain.
- SPARTA was developed to address this gap by providing a robust, multi-instrument system capable of characterizing planetary soils across diverse environments.
- The system supports mission-critical decisions related to landing safety, mobility, excavation, and ISRU, reducing risk for future robotic and crewed exploration.

CONTRIBUTION

- Designed stabilizing rails for the SPARTA testbench to guide the drill assembly and reduce lateral drift during penetration and shear tests.
- Modeled custom hardware in SolidWorks, produced 3D-printed prototypes, and prepared designs for future machining and integration.
- Improved sensor data accuracy and repeatability through software refinements, including automated zero/tare routines, noise filtering, and improved numerical processing.
- Developed Python-based data analysis tools to parse and overlay large sets of CSV files for efficient comparison of multiple test runs.
- Contributed to vibration-enabled regolith container designs, including motor mounts, O-ring sealing features, and clearance geometry to support automated soil reconditioning.

CREDIT

Robert C. Anderson (Mentor)

SPARTA PROBE AND TEST BENCH

Figure 1. SPARTA Testbench on field

- Figure 1 shows the SPARTA testbench, a vertically integrated actuation and sensing assembly designed to apply controlled axial and torsional loads to the probe during subsurface interaction tests. A linear actuator provides precise axial motion and is coupled to a load cell for direct measurement of penetration force, followed by a planetary gear reduction stage to increase available torque while maintaining compactness and alignment. The gearbox output is instrumented with a torque sensor, and the SPARTA probe is mounted at the tip, enabling simultaneous force and torque measurements during penetration, shear, and soil–tool interaction experiments.
- Figure 2 shows the SPARTA multi-instrument probe, which integrates a Cone Penetrometer (CPT), Vane Shear Tool (VST), Dielectric Sensor Probe (DSP), and Thermal Control Probe (TCP) within a compact assembly. This configuration enables simultaneous mechanical, electrical, and thermal characterization of planetary regolith during a single deployment.

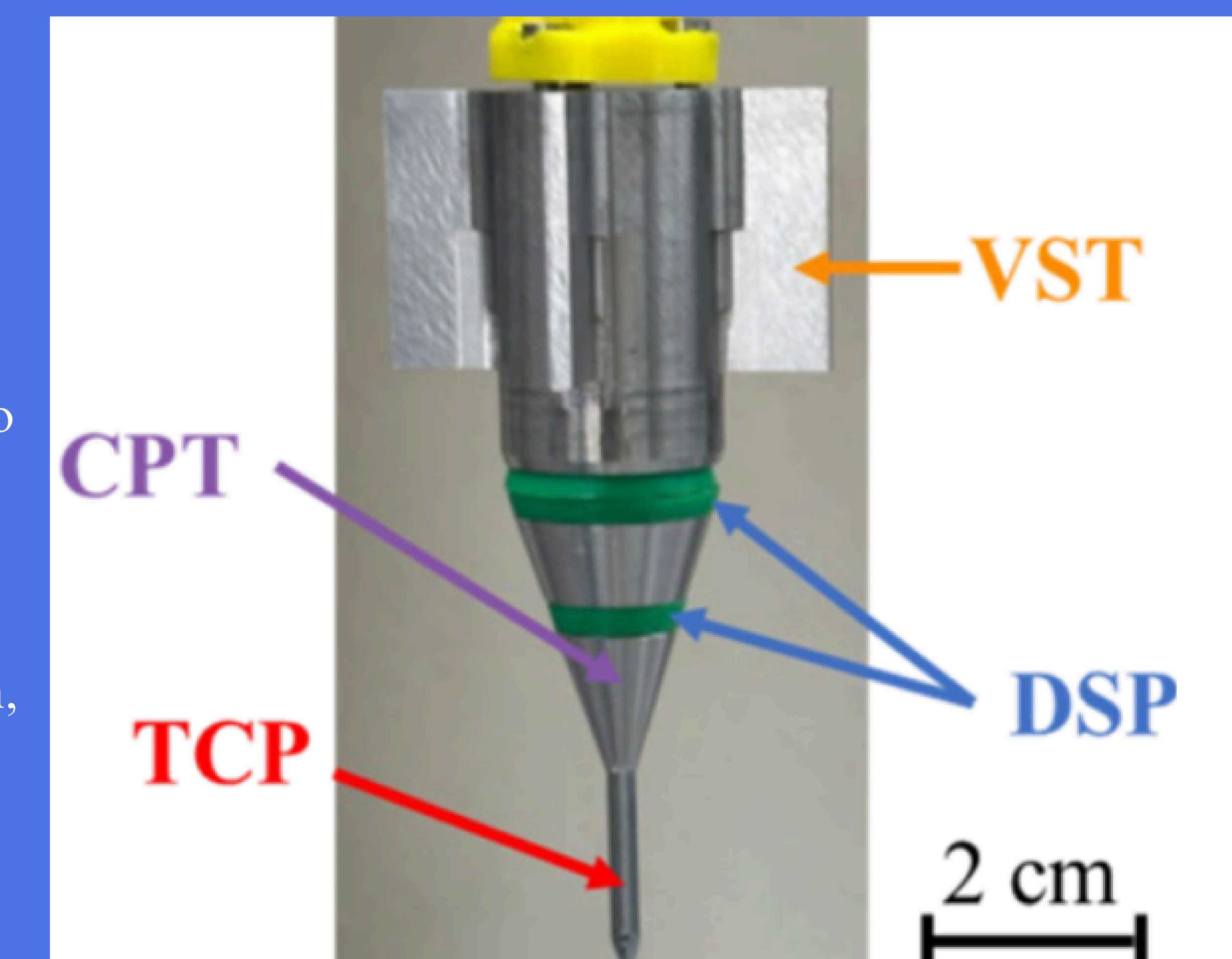


Figure 2. SPARTA Probe

IMPROVEMENTS MADE TO THE SYSTEM

MECHANICAL CONTRIBUTION

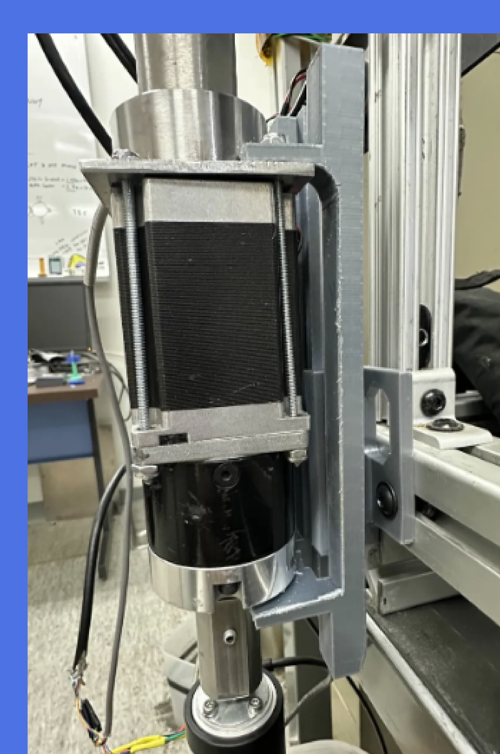


Figure 3. Stabilizing Rail

- Developed stabilizing rails for the test bench to guide the drill and limit any drift. Custom Parts are modeled in Solidworks and 3D printed to test and will be machined later. This component was created to fix the testbench issue with swaying when the drill is in the air and causing data inaccuracies. As shown in figure 3.
- This was done in conjunction to the software improvement made in figure 4 to further improve visibility and readability of the graphs given by the testbench

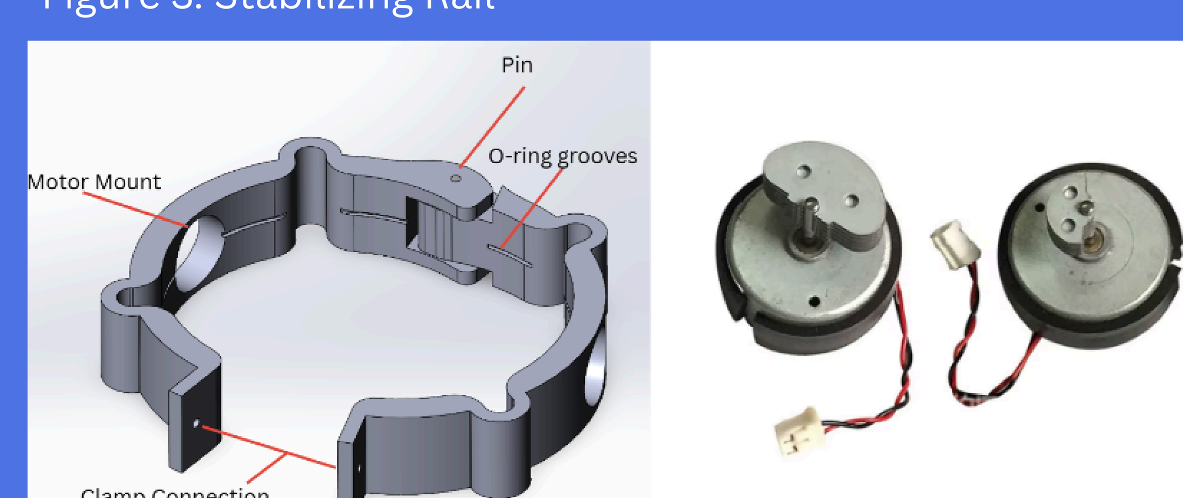


Figure 4. Custom tailored components for Blue Origin SPARTA Payload

- Custom clamps made to hold small rumble motors rated for consistent vibration. O-ring grooves are to provide a tight seal connection to the container so it doesn't move when vibrated. Open the motor mount to give a good contact between the motor and container. Clearance grooves are made to avoid interference with a metal rod pillar inside the system.

SOFTWARE IMPROVEMENTS

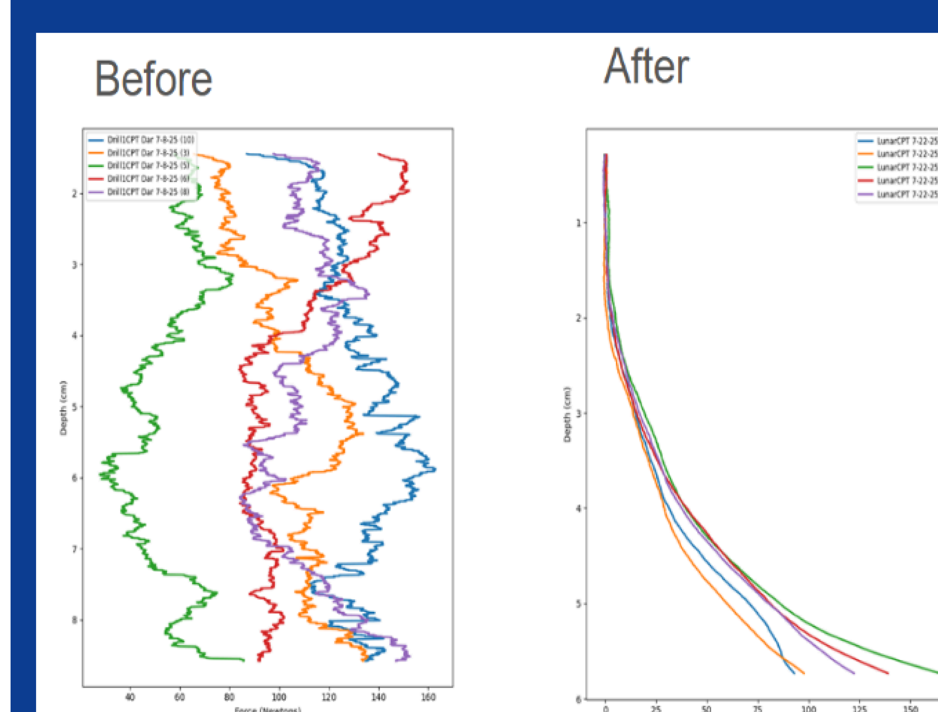


Figure 5. Software Improvements

In addition to hardware improvements, several software updates were implemented to improve the accuracy and reliability of sensor data, including load, torque, and thermal measurements. The data acquisition and processing pipeline was refined using NI cDAQ and Python visualization tools to improve consistency and reduce measurement noise. The following software features were added:

- Implemented an automatic zero and tare routine before each test run to ensure accurate force measurements
- Improved consistency and repeatability across consecutive test runs
- Enhanced signal filtering to reduce noise in load, torque, and thermal sensor data
- Refined numerical calculations to improve overall data accuracy and reliability

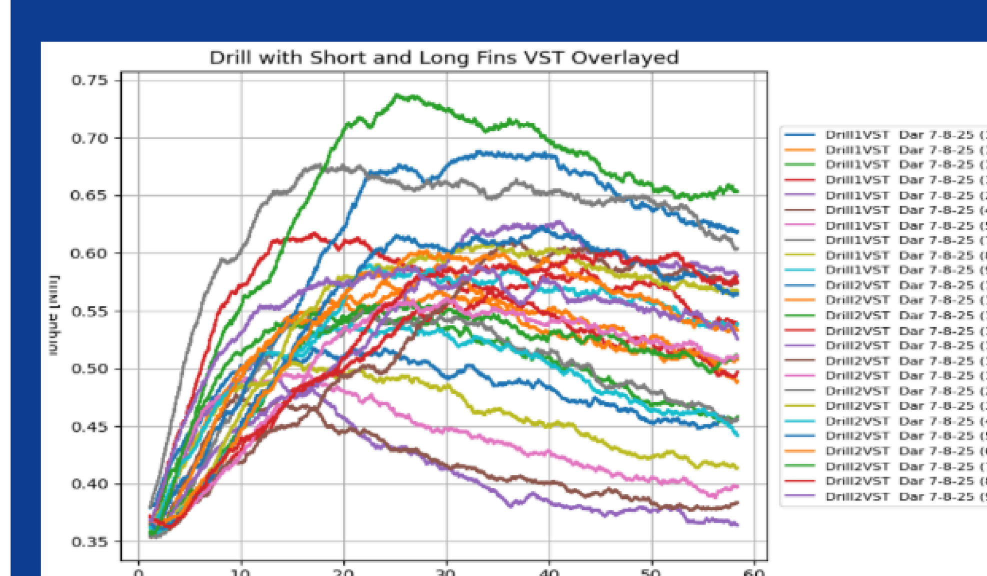


Figure 6. File Parser

Created a script to parse several csv files from test run to overlay them on top of each other. Two CSV File Parser that can parse and overlay 100 files every 30 min. This file parser helps see the difference between each test run a lot easier and will be integrated with the software to make it Autonomous.

CALIFORNIA STATE UNIVERSITY
LONG BEACH

Design of a Quasi-Steady Powder-Burner Test Bench

Dararath Run

Research Project: Fall 2025 VIEW RESEARCH DOCUMENT

ABSTRACT

- Hybrid gas-particle combustion is important for metallized propulsion and dust-explosion safety, but there are few small-scale burners that can produce well-characterized, quasi-steady dust clouds for detailed study.
- This work presents a quasi-steady powder-burner test bench that injects controlled solid particles into a premixed methane-air stream while maintaining optical access at the nozzle for flame imaging/diagnostics.
- The design matured through four iterations emphasizing leakage control, manufacturability, sample-loading clearance, and reliable actuation, culminating in a buildable lower-section architecture with defined interfaces for future modules.

MOTIVATION

- Hybrid gas-particle combustion is important for metallized propulsion and dust-explosion safety, but small-scale burners that generate well-characterized, quasi-steady dust clouds are limited.
- This thesis designs a quasi-steady powder-burner test bench that meters particles into a premixed methane-air stream while preserving optical access at the nozzle.
- The design advanced through four iterations focused on sealing, manufacturability, loading clearance, and actuation, producing a complete lower-section layout with defined interfaces for future modules.

DESIGN OBJECTIVES

- Create a quasi-steady powder burner that injects particles into premixed methane–air while maintaining nozzle optical access.
- Achieve precise, repeatable powder feed control with leak-tight sealing and manufacturable/serviceable interfaces.
- Improve safe sample loading and reliable actuation (torque-sized using O-ring contact/friction estimates) and define interfaces for future upper-section development.

ACKNOLEDGEMENTS

- Advisor: Professor Joseph Kalman
- MAE Department, CSULB

TESTBENCH OVERVIEW

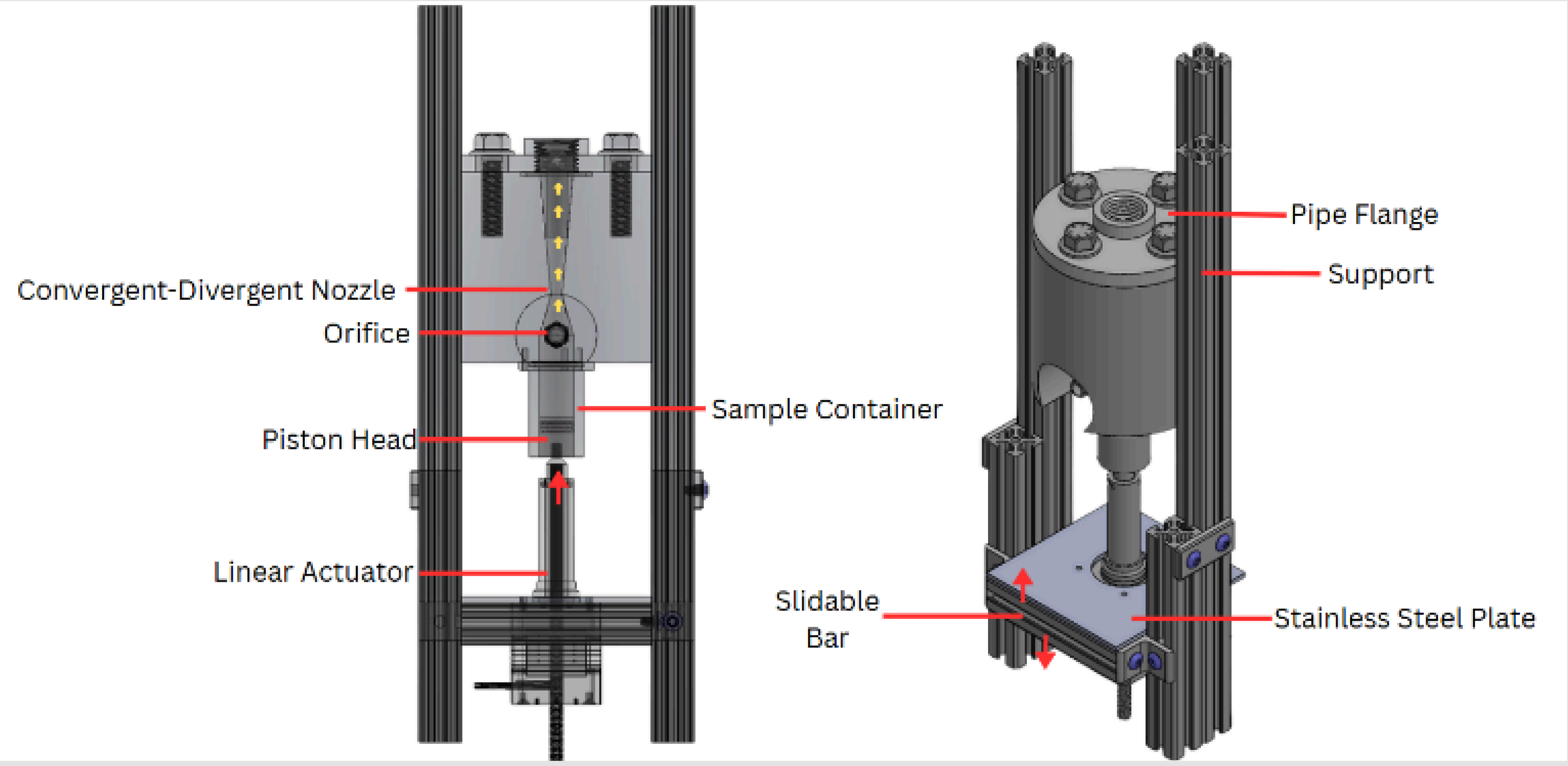


Figure 1. Particle Disperser Testbench

- The testbench is a quasi steady powder burner system built around a rigid vertical frame that supports the flow hardware and the sample feed mechanism.
- Methane enters through a flanged inlet and is metered through a small orifice into a converging diverging Venturi section, which acts as an ejector mixer to create a low pressure region and promote particle entrainment and mixing.
- A sealed sample container below is driven upward by a variable speed linear actuator and piston to introduce controlled amounts of powder into the throat region. The lower assembly is mounted on a sliding platform so the actuator and sample section can be repositioned to provide clearance for loading and maintenance.

FEATURES

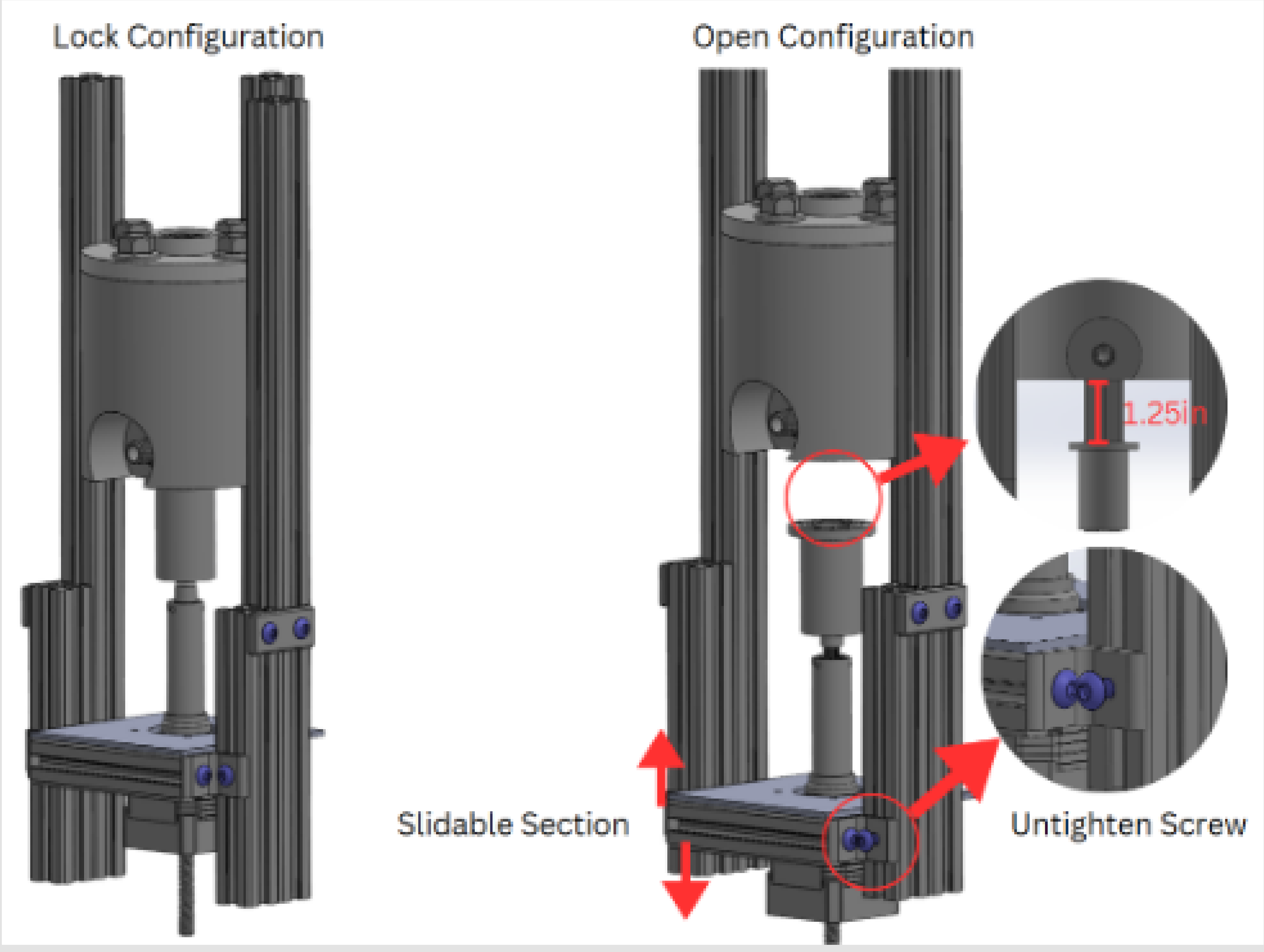


Figure 2. Slidable Platform

The testbench uses a slidable lower platform to make loading and maintenance faster and safer. By loosening the fastening screws, the bottom section can be shifted downward to create a larger access gap for inserting the sample container and handling powdered mixtures. Once the sample is loaded, the platform is raised back into position and locked to restore a rigid, well aligned structure for repeatable operation.

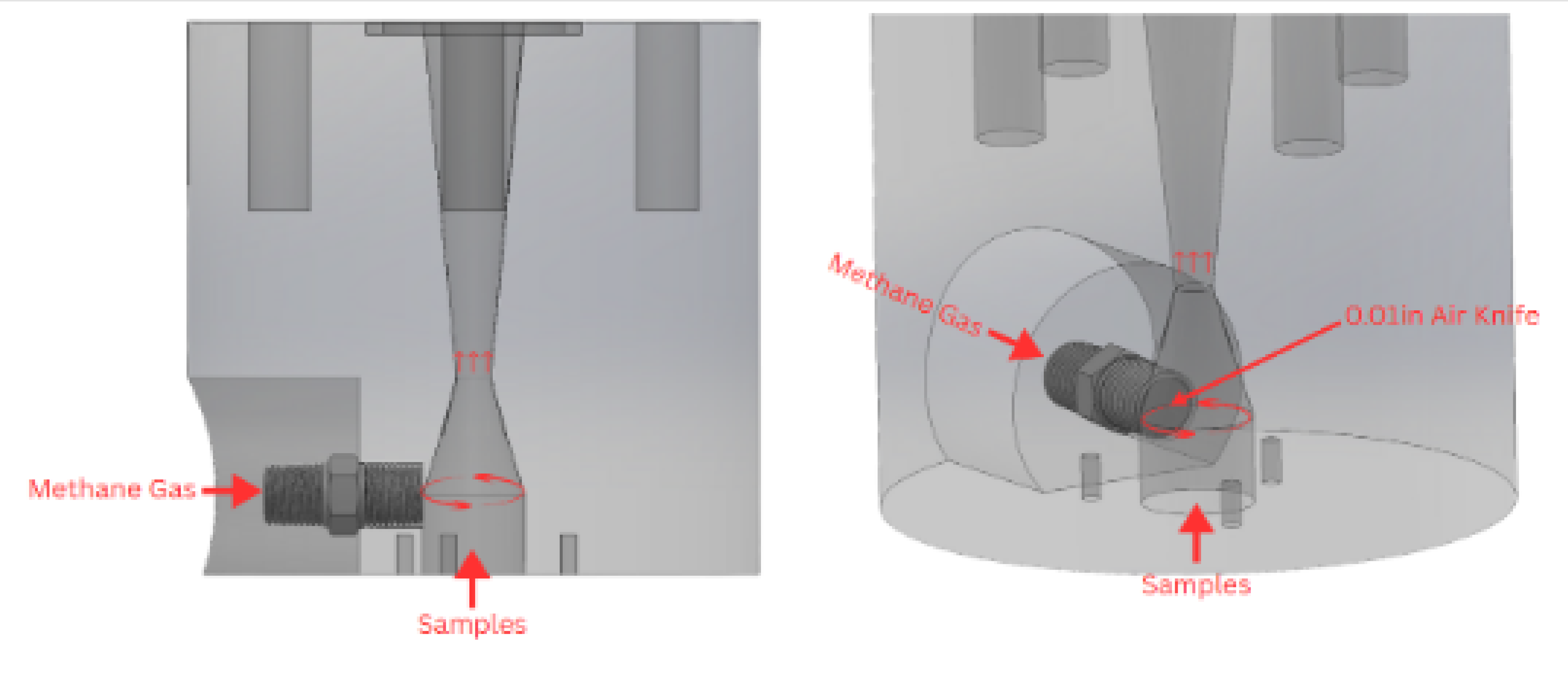


Figure 3. Airknife

Methane is introduced through a small orifice to form a thin, high velocity airknife that sweeps across the Venturi throat. This jet helps create a strong local shear layer that pulls particles into the low pressure region, breaks up clumps, and promotes consistent entrainment of the powder into the main flow. The result is more uniform mixing of the powdered sample with the methane air stream before the mixture expands through the diverging section.

CALIFORNIA STATE UNIVERSITY LONG BEACH

Senior Design Expo Presentation: Fall 2025

FireEye UAV: Fire Response & Surveillance

George Galeas, Pavly Abdelsayed, Ricardo Martinez, Dararath Run , Cedric Samkian

CALIFORNIA STATE UNIVERSITY LONG BEACH

ABSTRACT

- The FireEye UAV is a hybrid VTOL (Vertical Takeoff and Landing) fixed-wing aircraft designed to support wildfire detection, monitoring, and reconnaissance. The system combines quad electric VTOL propulsion for takeoff, landing, and hovering with a gasoline-powered pusher engine for long-endurance cruising.
- Using MATLAB-based propulsion analysis tools and CAD-derived mass properties, the team developed an aircraft capable of sustaining 4+ hours of flight, carrying a 10-kg payload, all while meeting the 100-kg MTOW requirement.
- This hybrid architecture enables precise operations around active wildfire regions, rapid deployment, and reliable loiter capability for continuous surveillance awareness.

MOTIVATION

- More frequent, intense wildfires demand rapid detection and continuous monitoring that current manned aircraft and UAVs cannot reliably provide, motivating the FireEye UAV, which combines VTOL flexibility with fixed-wing efficiency to reach remote fire zones without runways and sustain long-endurance environmental monitoring.

DESIGN OBJECTIVES

- Develop a hybrid UAV capable of vertical takeoff/landing, efficient cruise, and robust endurance.
- Achieve ≥4 hours of cruise time with 15% fuel reserve.
- Support 100 kg MTOW including airframe, battery, fuel, avionics, and payload.
- Maintain cruise speed of 25 m/s for optimal coverage.
- Integrate a 10 kg payload bay suitable for a fire suppressant payload.
- Optimize propulsion for minimum subsystem mass while satisfying thrust, climb, and reserve requirements.

ACKNOWLEDGEMENTS

Our Team Phoenix 1 thanks:

- Advisor: Professor Praveen Shankar
- MAE Department, CSULB
- Our instructors and peers for continuous feedback throughout MAE 478 & 479

DESIGN METODOLOGY AND COMPONENTS DESIGN

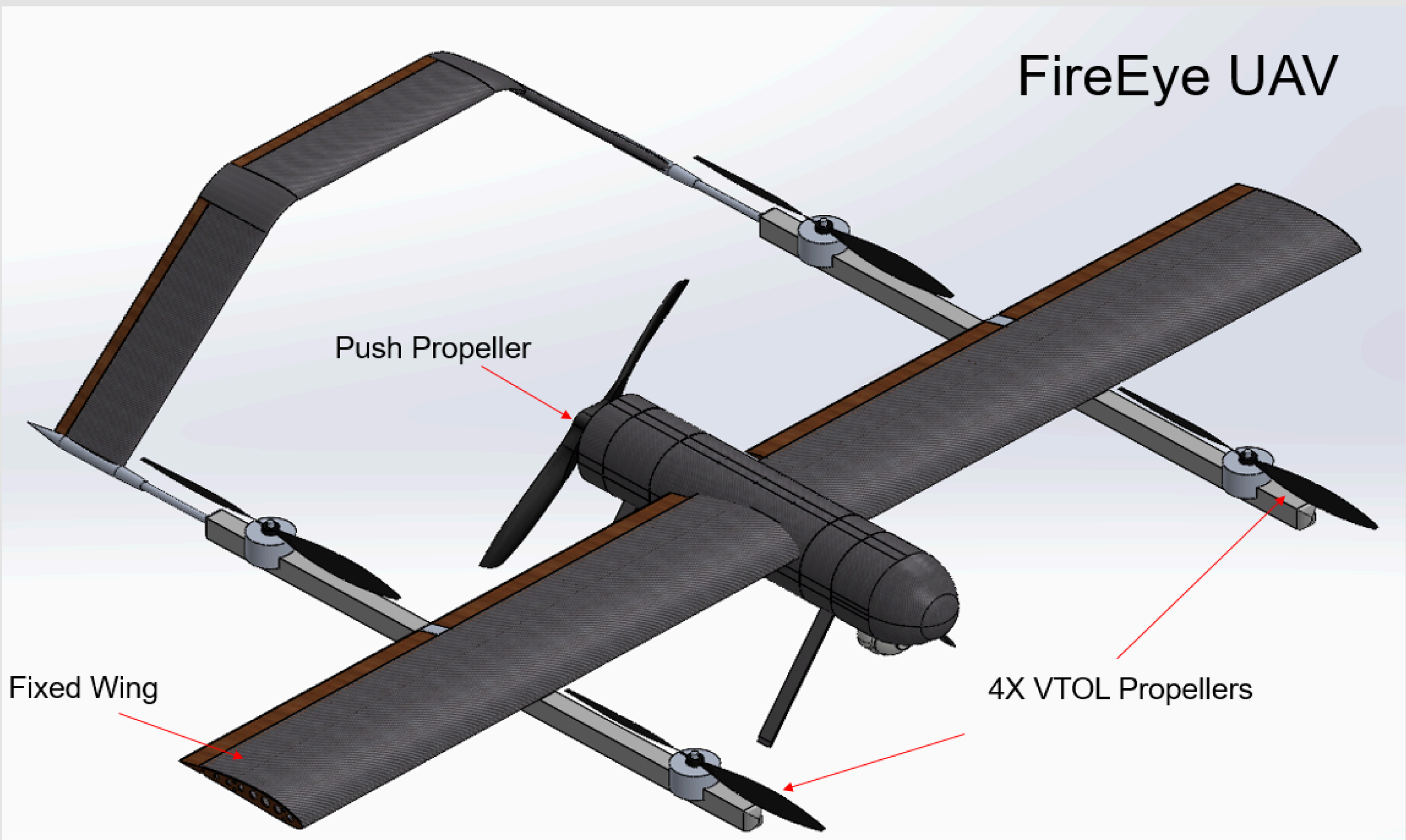


Figure 1. Fire Eye UAV Assembly

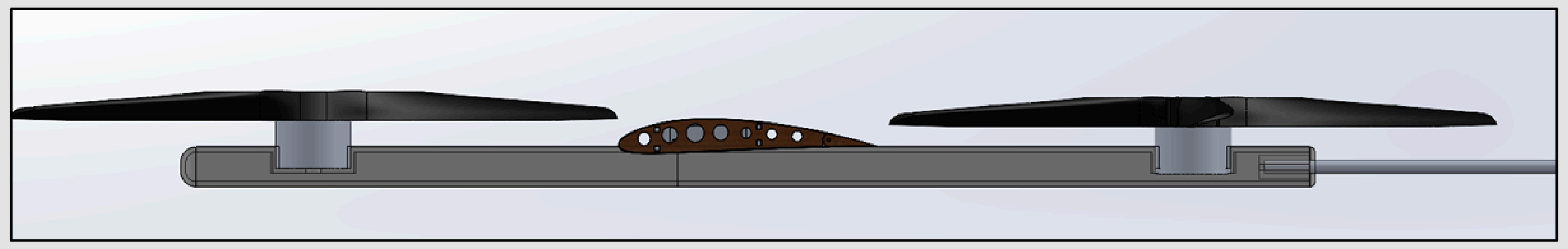


Figure 2. VTOL Boom Design

- The design process began by defining mission requirements and analyzing similar UAV systems, followed by iterative weight estimation to set initial sizing. Key aerodynamic and performance parameters (wing loading, drag polar, thrust needs, and endurance targets)were calculated to guide configuration selection.
- MATLAB-based VTOL and cruise propulsion models were integrated with CAD mass estimates to refine MTOW, thrust, power, and fuel/battery requirements. The system was iterated until all mission requirements(VTOL lift and climb, coverage area of 25 sqkm, and ≥4-hour endurance) were satisfied with proper margins.

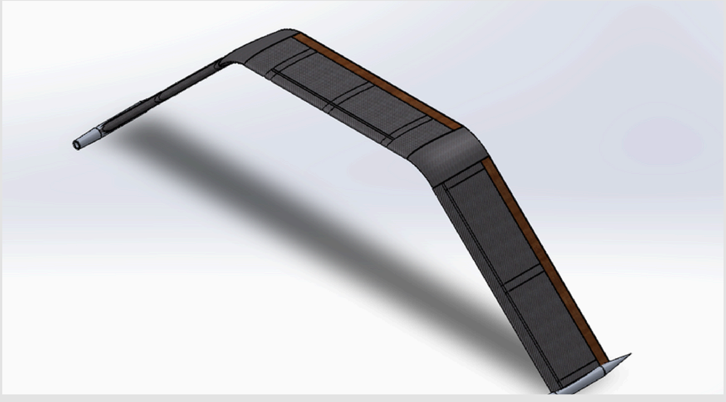


Figure 3. V Tail Design

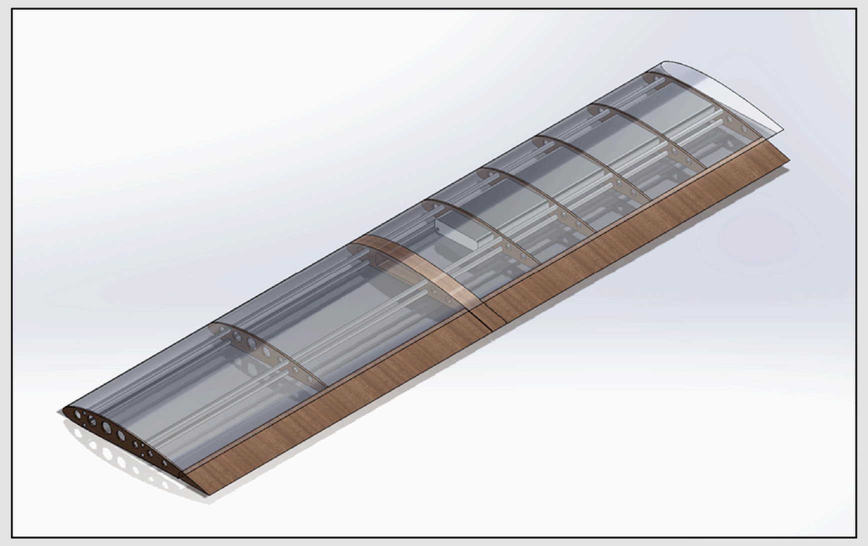
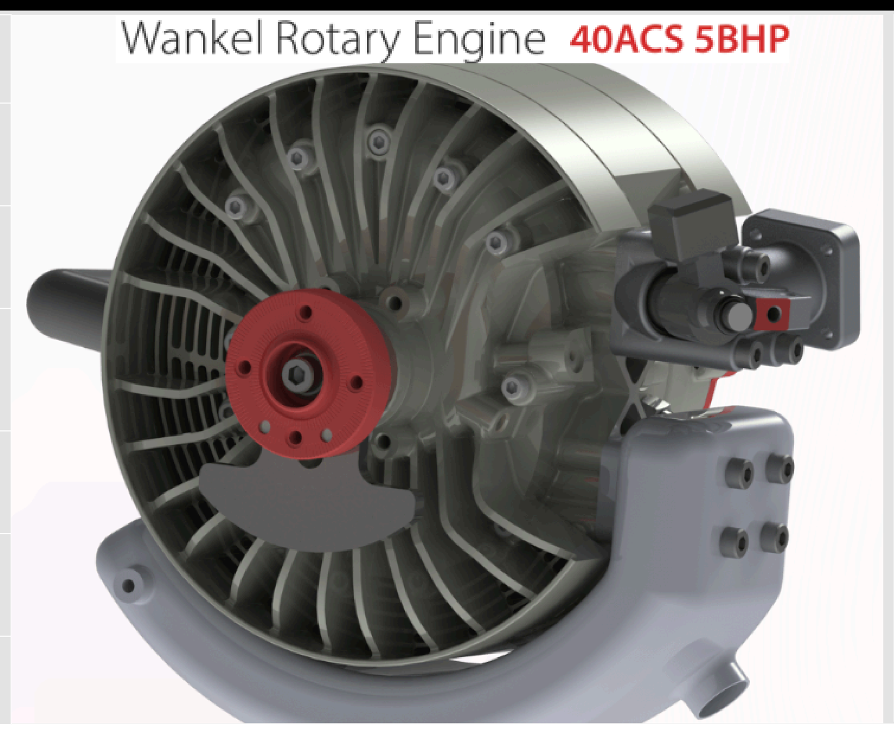


Figure 4. Wing Construction

Parameter	Value
Wing Area	2.5 m²
Wing span	4.3 m
Aspect Ratio	10
Total length	2.98 m
Payload Capacity	10 kg
Coverage Area	25 sq. km
MTOW	100 KG
Calculated TOW	93 KG

PROPULSION SIZING

Parameter	Value
Prop diameter	VZ 42*16.5"
Req. thrust (climb)	31.16 kgf
Per-rotor thrust (design)	35.12 kgf @ 60% throttle
Climb time to 122 m	48.6 sec
Battery energy (24S)	7.10 kWh
VTOL System	20.75 kg



Parameter	Value
Prop diameter	Mejzlik 32×12
L/D	11.2
P_req (15% power margin)	3.45 kW
Engine avail	3.66 kW
Fuel mass (4 h + 15%)	5.56 kg (7.52 L)
Cruise system (Gasoline)	8.90 kg

AVIONICS SUBSYSTEM SELECTION

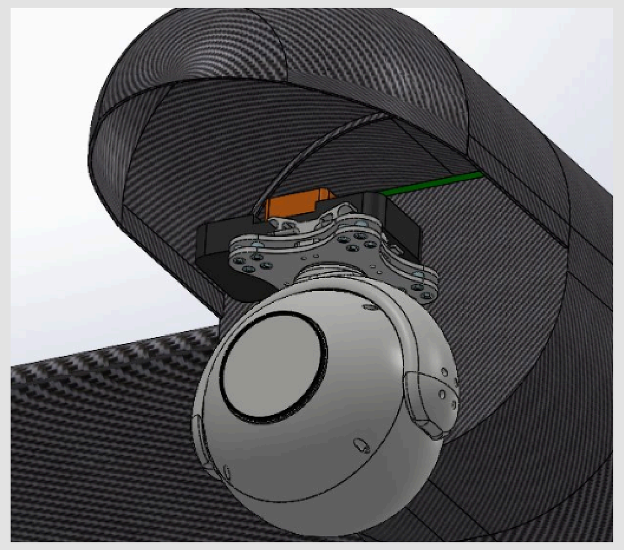
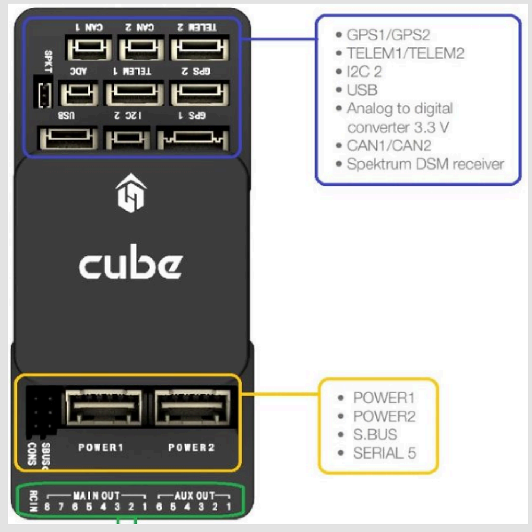


Figure 5. Avionics Bay Bottom View

Figure 6. Avionics Board



PAYLOAD SUBSECTION DESIGN

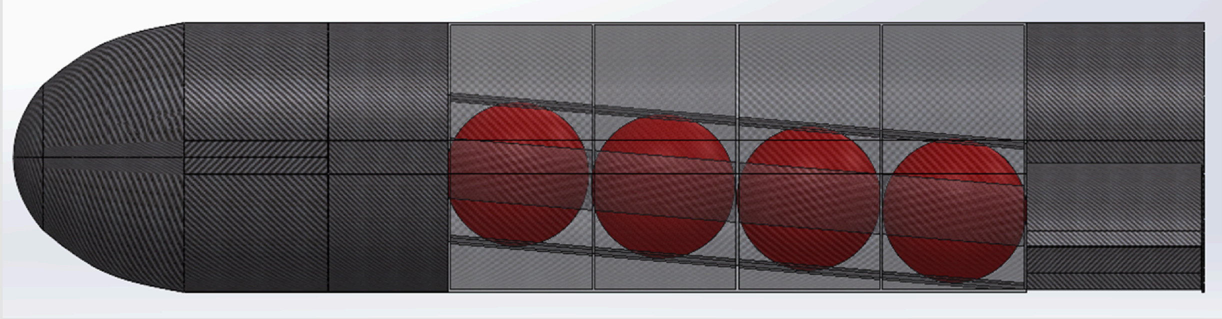


Figure 7. Ramped Deployment Mechanism

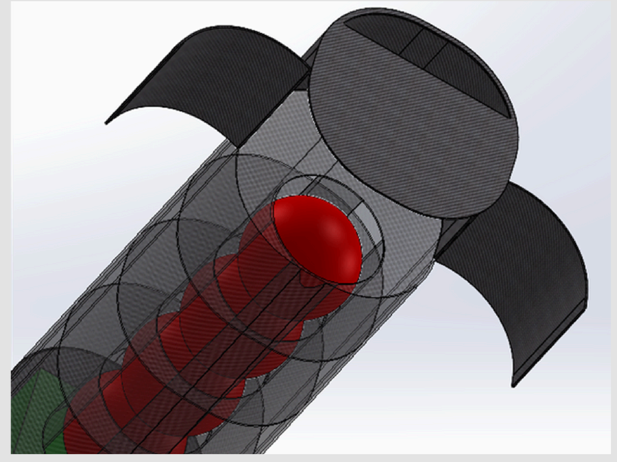


Figure 8. Rear Door Exits

EXPECTED PERFORMANCE

Parameter	Value
Cruise Speed	25 m/s
Endurance	4 hours
Cruise Altitude	122 m
Turning Radius	2.59 m
Stall Speed	18.2 m/s
Dash Speed	25.09 m/s
Maximum Forward Thrust (at h=122m)	117.65 N
Maximum Vertical Thrust (Sea Level)	1823.662 N = 185.9 kgf

BSAE

Preliminary Design of a 2-D Subsonic Wind tunnel

by Dararath Run

CALIFORNIA STATE UNIVERSITY LONG BEACH

Personal Project - Fall 2025 VIEW RESEARCH DOCUMENT

ABSTRACT

- This work presents the preliminary aerodynamic design of a subsonic wind tunnel intended for experiments in lift, drag, and basic external aerodynamics.
- The tunnel features a 1 m × 1 m test section operating at a design Mach number of 0.6, sized using quasi-one-dimensional isentropic analysis and established design guidelines.
- The final geometry satisfies laboratory space constraints and is validated using 2-D CFD simulations, showing good agreement with analytical predictions.

MOTIVATION

- Wind tunnels provide repeatable, real-world aerodynamic data that complements and validates computational methods.
- Many aerodynamic phenomena such as separation, stall, and wake behavior remain difficult to capture accurately with CFD alone.
- A dedicated subsonic wind tunnel enables controlled testing of airfoils, wings, and bluff bodies under realistic flow conditions for research and education.

DESIGN OBJECTIVES

- Deliver a steady, uniform subsonic flow in a 1 m × 1 m test section at Mach 0.6 for external-aerodynamics experiments.
- Size the contraction and diffuser to balance flow quality, pressure recovery, fan power, and overall tunnel length within space constraints.
- Validate the preliminary design using quasi-1D analysis and CFD, establishing a foundation for future structural and detailed design work.

DESIGN METHODOLOGY AND OVERVIEW

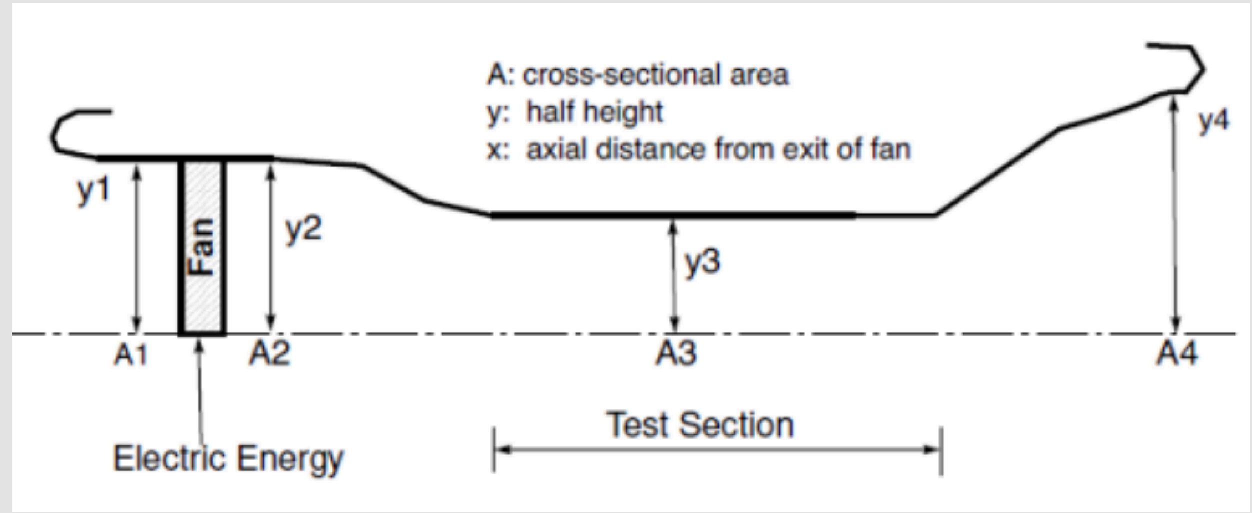


Figure 1. Design Sketch of windtunnel

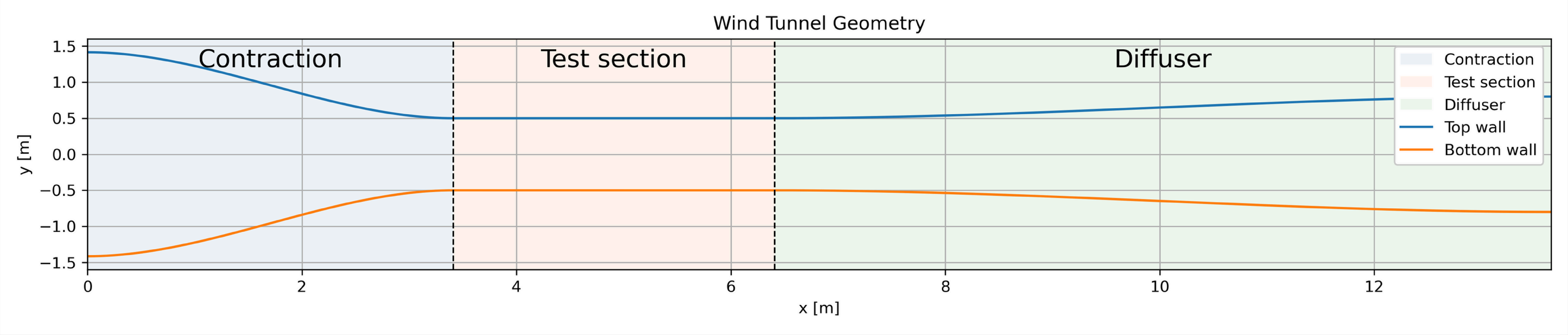


Figure 2. Python generated wind tunnel

- The wind tunnel was designed using a quasi one dimensional approach that links tunnel area changes to target flow conditions and practical facility constraints. The process started by defining performance requirements for the test section, then sizing the contraction and diffuser using established aerodynamic guidelines to manage flow quality and pressure recovery. A smooth wall contour was generated in Python using a cubic half height function to create continuous geometry transitions, and the resulting layout was iterated until the full tunnel fit within the lab envelope. The final geometry was then checked and refined using two dimensional CFD to verify the velocity field and identify any regions of separation or nonuniformity.

- Figure 1 shows the overall tunnel layout with the main sections and station locations from the fan through the contraction, test section, and diffuser. Figure 2 shows the Python generated tunnel contour, highlighting the contraction into the constant area test section followed by the diffuser expansion. Together, the figures summarize a complete wind tunnel flow path designed to deliver a uniform, controlled test section flow while maintaining manageable pressure losses and a compact footprint.

ASSESSMENT AND VERIFICATION

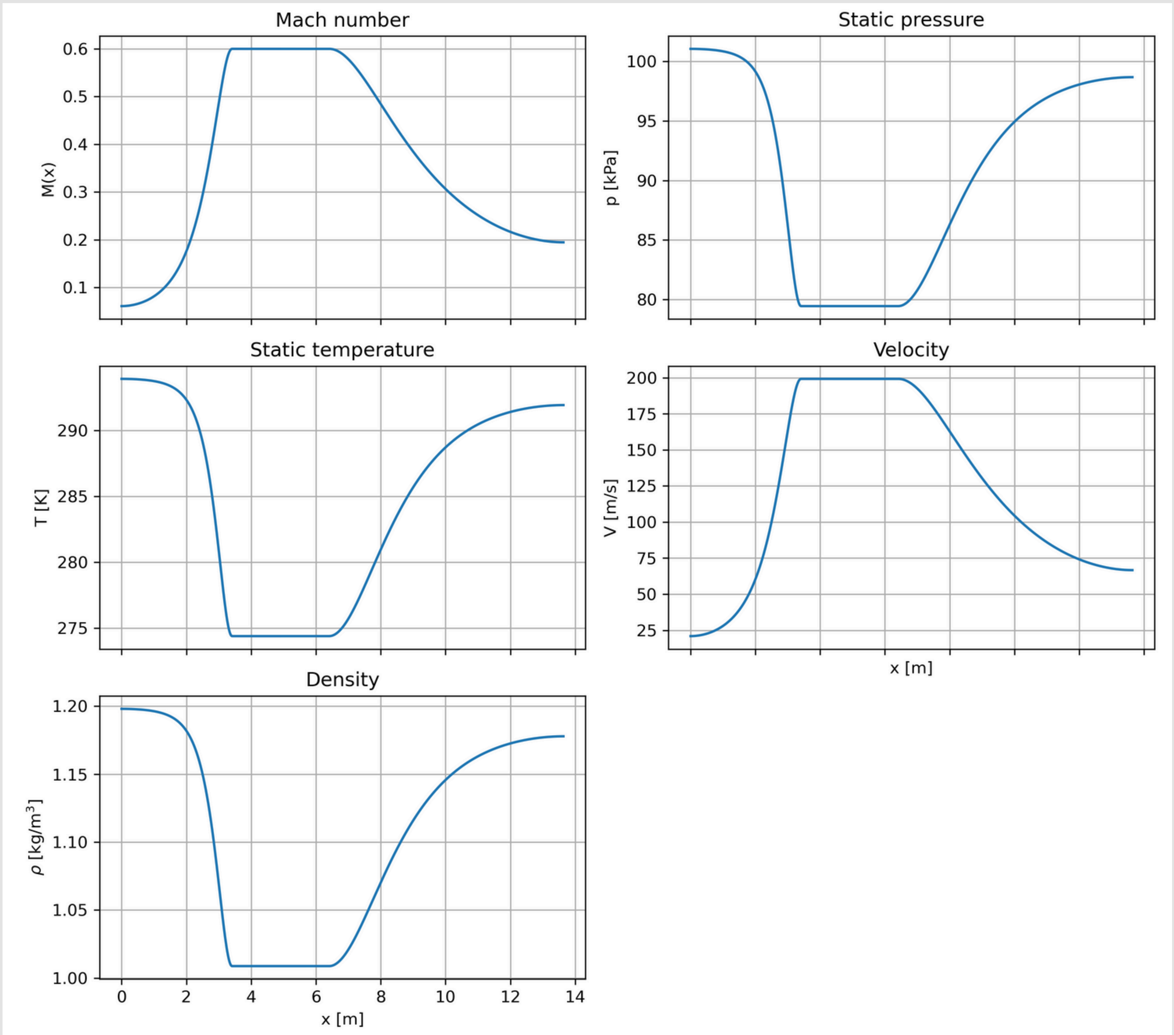


Figure 3. Python Assessment

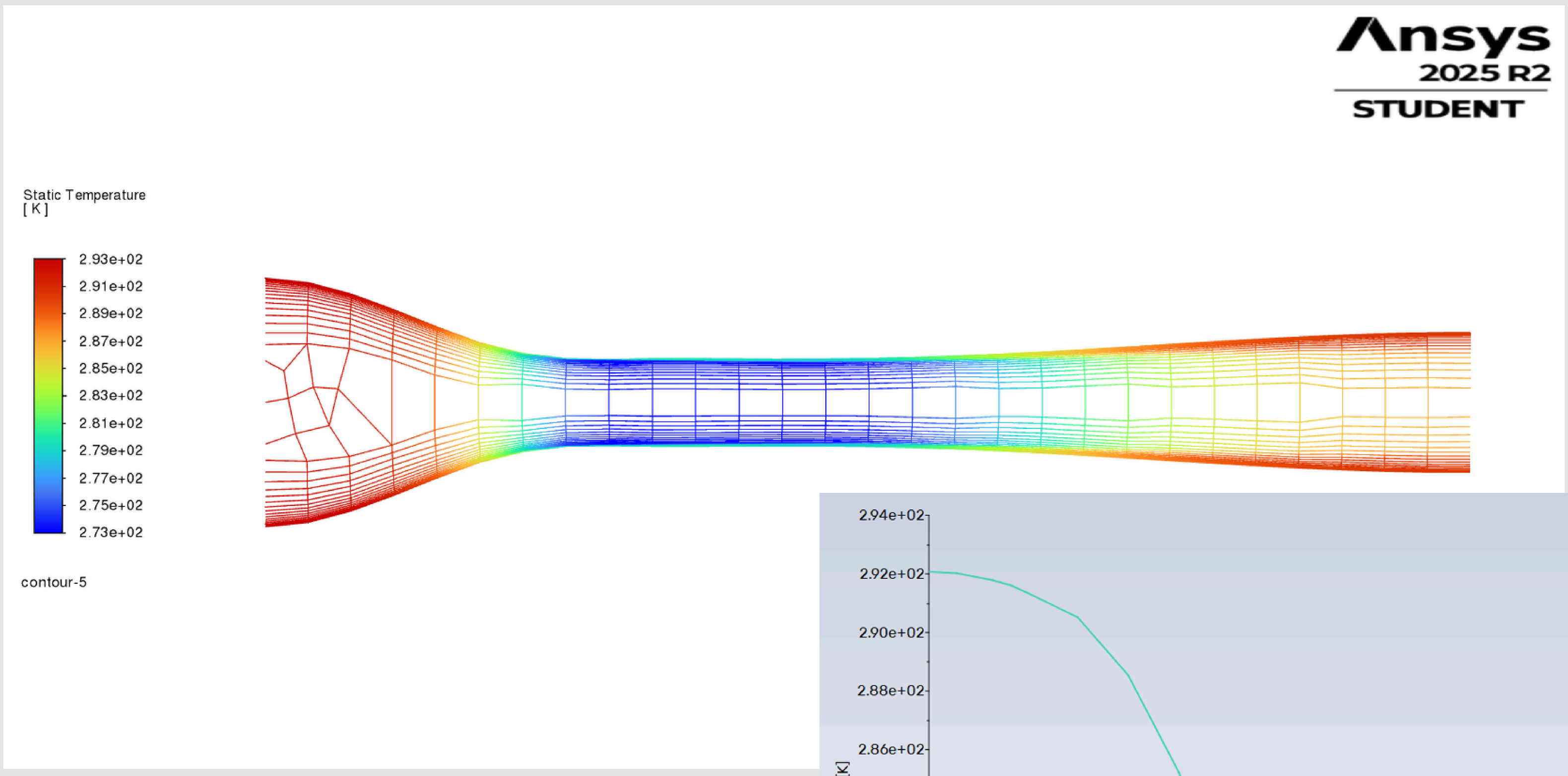


Figure 4. ANSYS contour plot for static temperature

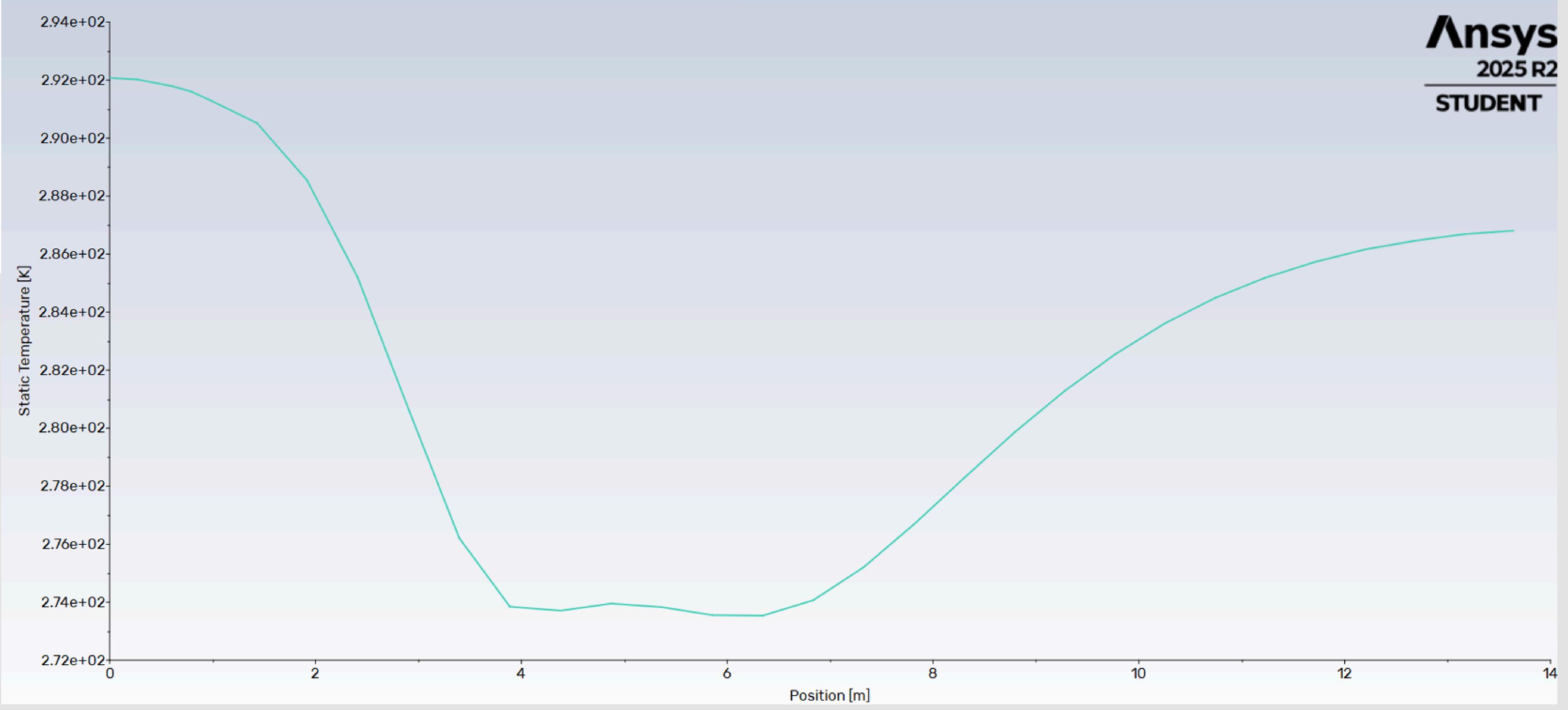


Figure 5. ANSYS centerline plot for static temperature

- Figures 3 to 5 present the assessment and verification of the wind tunnel flow behavior using both a Python based quasi one dimensional model and Ansys CFD. In Figure 3, the Python assessment predicts a smooth acceleration through the contraction to the target test section condition, followed by nearly steady properties through the constant area test section and a gradual deceleration with pressure and temperature recovery in the diffuser. Verification was then performed in Ansys by examining both the static temperature contour (Figure 4) and the centerline static temperature profile (Figure 5). The CFD results reproduce the same overall trends and transition regions seen in the Python output, providing confidence that the tunnel geometry and flow assumptions produce the intended test section environment and that the diffuser expansion recovers conditions without introducing major nonuniform behavior.