TREL

TEXAS ROCKET ENGINEERING LAB

The University of Texas at Austin
Cockrell School of Engineering

Halcyon Update

Texas Rocket Engineering Lab

November 2024

Program Update

Since deciding to pivot to a blowdown architecture of Halcyon for our first flight a month ago, the team has charged hard on getting the vehicle integrated for flight. While we didn't meet our goal of having integration complete by the end of October, as you'll see below, considerable progress was made, and we are tracking to complete 90% of vehicle integration by the end of November. Recovery and TVC will roll in a little behind that timeline and integrate in early December.

Building the rocket is only part of the battle however, as we need to not only build confidence in our systems through testing but also get the appropriate partners on board to have a place and time to launch Halcyon. We've also made great progress on these fronts. We've had conversations with the FAA, explored multiple potential test and launch sites (more on this soon), and reviewed our flight plans and trajectory analysis with industry experts.

As for validating our hardware – we have been slowly ramping up component level testing and are about to kick off a tanking test campaign to validate our launch fluids/electrical GSE, ground software stack, stage prop modelling, vehicle fluid assemblies, and overall vehicle test operations. This will be a period of extreme learning and maturation of our systems and is crucial to show up to the launch pad with confidence in January.

We've had some delays in getting our flight tanks for the Mk2 vehicle, so minimal work has occurred on that front. This has allowed for intense focus on Mk1 however and will allow us to roll all our learnings from this vehicle build cleanly into Mk2 when it does come. As of now, we're still tracking towards an early January launch of Mk1 to double the collegiate liquid fueled rocket altitude record. Until then, we'll have our heads down pulling the rest of the vehicle together, catch you in a month.

October Progress

Propulsion

· Havoc SN2 TCA assembly and water flush
· All TVC hardware manufacturing in progress
· 2 of 3 intertank fluid assemblies 80% completed
· LOx main valve component cryo test completed
· Initial design for static fins (for burnout stability post-MECO) completed

Structures

· Engine bay test skirt access ports cut and prepped for testing
· Structural test stand welds complete and ready for compressive testing
· Bolted skirt coupons fabricated
· Avionics mounting plate fabricated
· Tanking test LOx COPV proofed
· Aluminum skirt coupler designed
· Raceway tube brackets printed
· Recovery dCDR completed

Flight Control

· Got 3DOF running in Sandia's TAOS software
· Ran sweeps across propellant fill percentages to baseline config for 35 km apogee
· Calculated worst case hazard area from TVC hardover failure
· Finalized master device list and all electrical components ordered
· GSW sequences and aborts tested
· Ground station antenna assembled and tested

Integration

· Built vehicle assembly stand/tooling
· Weighed rocket sections to get accurate dry mass estimate
· Completed vehicle solid body CAD model for CFD aerodynamic parameter refinement

Test & Launch

· Igniter panel build and leak check
· Water flow test stand built and activated
· Hydrostatic proof of tanking test COPV completed
· Hydraulic actuator checkouts for structural compressive testing completed
· All systems built for GSE fill/drain and vehicle cold flow tanking test

Section by Buckner Newberry, Halcyon Chief Engineer

November Goals

Build				
Group	**System/Category**	**10-Nov**	**17-Nov**	**24-Nov**
Structures	**Engine Bay**	Crush testing, flight skirt cut, bolted coupon testing, fin bracket integration		
	OF	Coupler design complete	Coupler manufactured	Coupler integrated
	NO	Coupler config decided, avionics plate complete	Coupler/bonded joint integrated	
	Raceway	Tube mounts on vehicle	Cover layups complete	Raceway covers mounted
	Recovery	Key-locking inserts and eye-bolt holes tapped	Baseplate test, nosecone mounts and hooks manufactured	Final assembly
	Nosecone	Mold complete	Layups complete	Nosecone integrated
Propulsion	**Havoc**	Waterflow complete, igniter cold flows	Igniter testing, hotfire sequence review	Hotfire complete
	TVC		Controller testing on inertial simulator	
	Fins	Design review		Fins manufactured, fins integrated
	QD		Vehicle and GSE QDs assembled	Separation tests, QDs integrated
	Engine Bay	LOx assy test	Final config, checkouts	
	OF	All RCS hardware ordered	RCS integrated	Final config, checkouts, RCS tests
	NO	LOx assy test	Final config, checkouts	
	Raceway	Tubes fabricated	Tubes integrated	
Avionics	**Avionics**	Start main harnesses, assemble PCBs, fix ground antenna, checkouts	Finish harness build, integrated HITL tests	Avionics integrated into vehicle, checkouts

Section by Buckner Newberry, Halcyon Chief Engineer

GNC and Software				
Group	**System/Category**	**10-Nov**	**17-Nov**	**24-Nov**
GNC	**Dispersions**	IIP_transient dispersion, prop fill dispersions, engine thrust dispersions, Monte Carlo plots	Add wind dispersions	
	TVC control		Controller done, TAOS integration	
	RCS control	Controller done	TAOS integration	
	Range	Determine optimal pitched trajectory at SA, run sim with new trajectory		
	General	35 km fins burnout stability margin with new Cg, new inertia tensor, necessary rail length for passive stability	35 km fins burnout stability margin (final fins)	
SW	**GSW**	Tanking test, integrated RF testing	Complete GUIs, complete control app, igniter testing	Hotfire testing
	FSW	RCS function complete, integrated RF testing, all drivers completed, Full nominal HOOTL	Thrust termination function complete, thrust terminate HOOTL, TVC hardware device written	TVC controller implemented into C++, Full nominal mission HITL with controllers, thrust terminate HITL

Test and Launch				
Group	**System/Category**	**10-Nov**	**17-Nov**	**24-Nov**
Test and Launch	**Water Flow Test Stand**	Havoc water flow	Fluids assy CdA tests	QD separation testing
	Hydro Cart	EB crush testing	Baseplate test	
	Engine Test Stand		Reactivation, integration into VTS	Hotfire
	Igniter Panel	Concrete shell staging, finish igniter Jbox, cold flows	Igniter testing	Integration into VTS/ETS
	Vehicle Test Stand	LN2 tanking test	RP-1 water flows	
	Launch Mount	Piston system build and test	Release mech integration and testing	Complete plumbing/harnessing integration

Section by Buckner Newberry, Halcyon Chief Engineer

***Image above**: Halcyon engine bay fluids assembly in progress*

***Image above**: Fluids member Gael Nuño (left) and Fluids Lead Engineer Urvi Alamela (right) reassemble LOx valves after cleaning*

***Image above**: Component Test member Emre Cetin (center) explains test stand instrumentation configuration*

***Image on the right**: Vehicle Test Stand fluids RE Evan Long in front of some of Halcyon's launch GSE*

Section by Buckner Newberry, Halcyon Chief Engineer

***Image above**: Structures manufacturing member Jose Juarez cleans up engine bay qualification skirt access port holes ahead of compression testing*

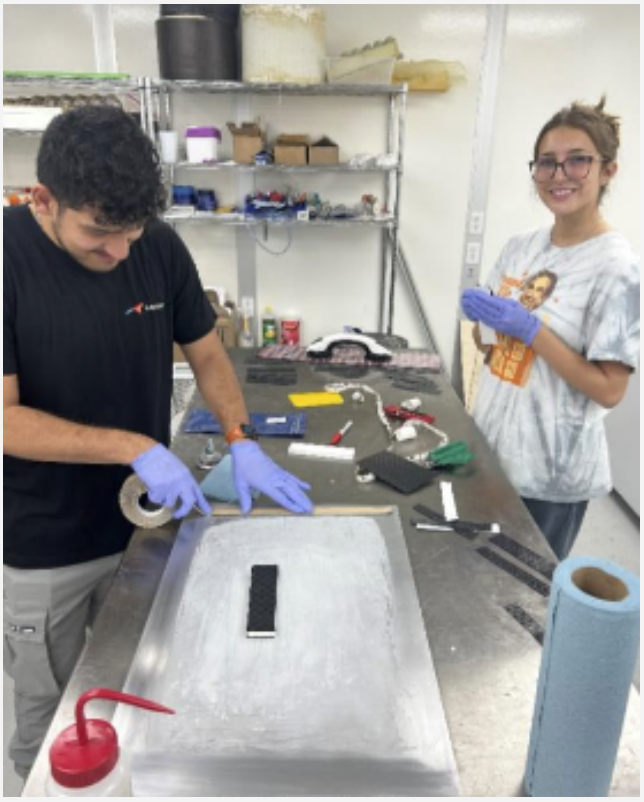

***Image above**: Structures manufacturing members Jose Juarez (left) and Elizabeth Villa (right) prep a composite coupon for curing ahead of testing*

***Image above**: View of the forward Ox intertank fluids assembly in progress*

***Image on the right**: COPV undergoing hydrostatic proofing ahead of use in testing Halcyon cryogenic fill/drain operations*

Section by Buckner Newberry, Halcyon Chief Engineer

***Image**: Havoc SN2 (Mk2 engine, Mk1 backup) undergoing water flush testing of its regenerative cooling circuit post-manufacturing*

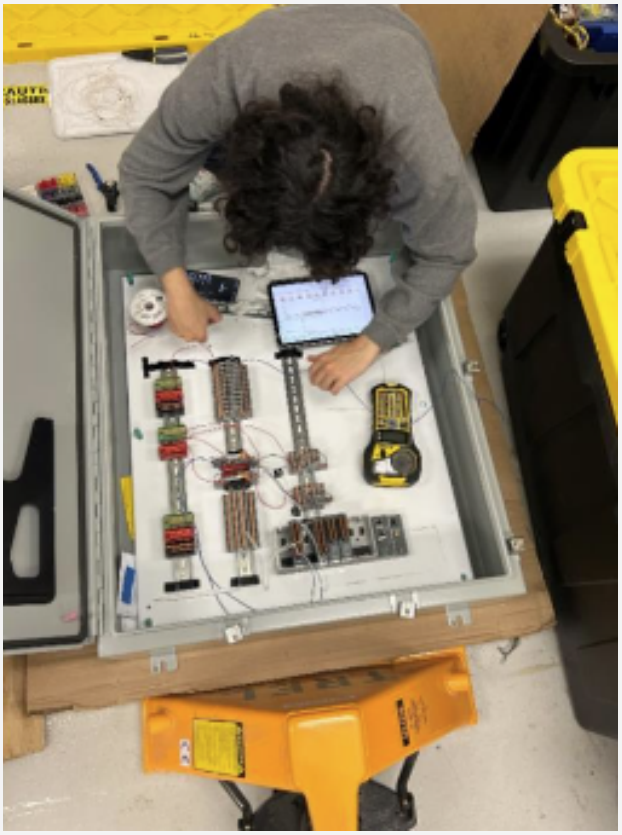

***Image**: Engine Test Stand member Andres Menendez wires an electrical junction box (JBox) for use on torch igniter testing*

***Image**: Engine bay fluids/fins mounting structure*

Section by Buckner Newberry, Halcyon Chief Engineer

***Image**: Amogh Herle, Airframe Lead Engineer, cutting steel plate for use in compressive testing of composite skirts.*

SKUNKWORKS

TREL Skunkworks has been hard at work this past month, achieving key milestones towards our research and development goals. All the new Skunkworks teams have completed their design reviews and are now full steam ahead on the build of their very first prototypes. These teams have also spent a considerable amount of time training. National Instruments kindly visited UT campus to hold a LabVIEW training event, where students got to use cDAQ hardware and read data from various sensors under NI engineer guidance.

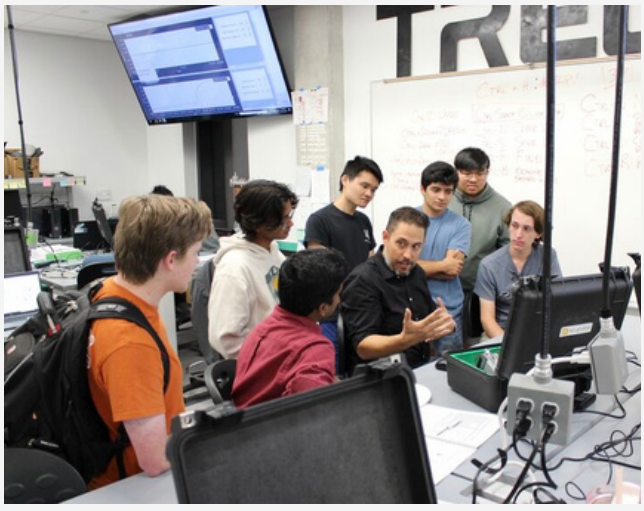

***Image**: Norm Kirchner, NI Engineer, with Skunkworks students*

Section by Zachary Muckler, Chief Engineer

This event was a huge hit among the students, who had completed LabVIEW Core 1 and DAQ training in the weeks leading up to the event. For example, students on the Ground Station team learned how to use LabVIEW software to communicate with other controllers like Arduino and Raspberry Pi Nano. Additionally, Skunkworks students have been spending time in the Mechanical Engineering machine shop. Skunkworks students are shop certified, have gotten manual mill and lathe training, and even weld training.

***Image**: Jamie Svrcek leading a class on welding.*

***Image**: Sean Yu practicing MIG welding on carbon steel.*

Welding and machining skills are in high demand for TREL. The lab has an increasing need to weld structures for testing and would benefit greatly from the simplified component design welding may bring. Additionally, in-house manufacturing could greatly speed up TREL's component development cycle.

Section by Zachary Muckler, Chief Engineer

The Nemo Engine (Electric pump-fed engine team)
The Nemo rocket engine has made several key development milestones this past month. These include:

1. In-person hardware demo with Tom Mueller.
2. Designing and building an igniter test stand and conducting a successful torch igniter hotfire.
3. Sending injector, combustion chamber, and pump components off for 3D printing.
4. Completing the fabrication of LOX pump seal test-rig.
5. Testing motor controller circuit.

Last weekend, the Nemo engine team successfully tested the gaseous oxygen/kerosene torch igniter. This test did not come without a few hurdles. The team designed and built the panel in a span of a few weeks and wrote the software that ran the system's console and sequence software in a few days. The igniter was designed and built in-house, and before test, was proofed to several hundred psi. The team conducted a purge cold-flow to verify sequence, then a GOX and kerosene cold-flow before stepping into test. The first attempt of the igniter resulted in a no-light, and after determining this issue was related to the spark's required breakdown voltage, the team followed the test with a successful 1-second burn. This is the first time TREL has successfully tested a torch igniter at UT's Pickle Research Campus.

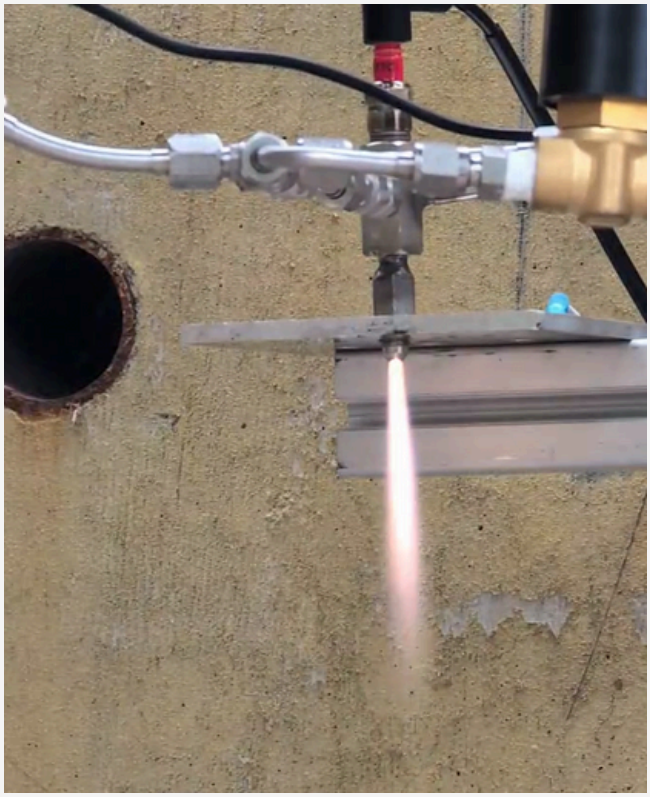

Image : *1-second duration test of Nemo's torch igniter*

Section by Zachary Muckler, Chief Engineer

The Nemo component RE's have also been hard at work completing designs for the engine's injector, pump, and combustion chamber. Last week, the team sent a total of 16 parts to Nemo's metal 3D printing provider, Freeform. The company has been an enormous help in the fabrication process. The team has also been hard at work machining key components for an upcoming LOX pump seal test, set to take place this week.

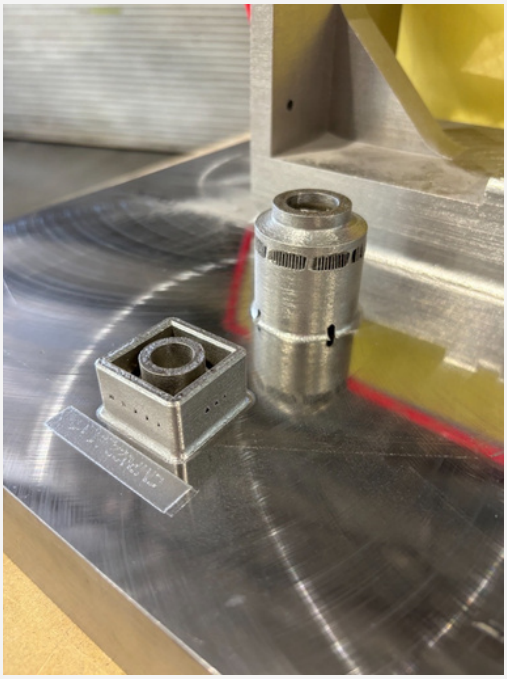

Image : *Test pieces printed by Freeform*

Image : *Pump motor plate being turned on a lathe.*

The team would also like to thank Tom Mueller for his time and expertise during an in-person visit to Pickle Research Center. Tom got to see the team's prototype pump components and review additional upgrades made to their design following an initial review early this Fall. The team made significant upgrades to its injector and pump design as a result, and they are excited to see how their new hardware will perform.

Image: *The Nemo engine team with Tom (middle), Halcyon team leads, and Program Director Jamie Huffman (left).*

Section by Zachary Muckler, Chief Engineer

Steel Tank Research

The steel tank team achieved a key milestone this week by conducting ambient and cryogenic tensile testing of various welded test coupons.

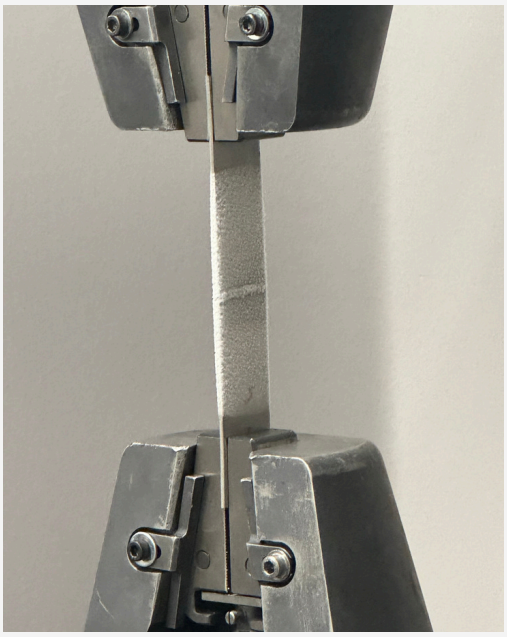

Image: *A horizontal weld under uniaxial tension after coming out of a bath of liquid nitrogen.*

Image: Taj Lee, Ryan Bateman, and Jose Juarez prepare samples for testing

The team measured two different types of welds: a single horizontal weld and an “I” shaped weld. These patterns are designed to mimic welds that would be common on a stainless-steel tank design. Using unmodified samples as experiment controls, the team can use the stress-strain data to determine the stiffness of each weld and compare their stress data to calculations they performed by “treating the weld as a line.” Properties like the filler material used and the type of stainless steel can also be modified and traded to determine the best material type for future tank designs.

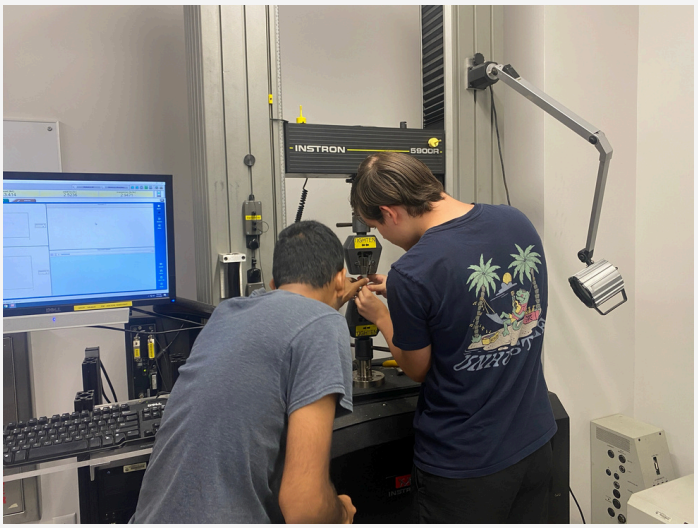

Image: *Ryan Bateman preparing a sample for test.*

Image: *“I” shaped weld failing at the bottom horizontal weld.*

Section by Zachary Muckler, Chief Engineer

RCS Test Bed

The RCS test bed team has been hard at work tackling one of the most difficult problems of designing a rocket – controls. The team has been able to build a 3D model based on Euler angles, Euler equations of rotational motion, and python to simulate the physical environment their 3D inverted pendulum will be in. The team has also completed a fluids model for their system and designed a thruster that will produce 1-2lbf of thrust to help the pendulum balance itself. Also, the pendulum's mechanism uses several concentric rings that hold a pneumatic rotational coupler at its center, which will help move bulky components like valves and microcontrollers to a station next to the pendulum mechanism, simplifying their design.

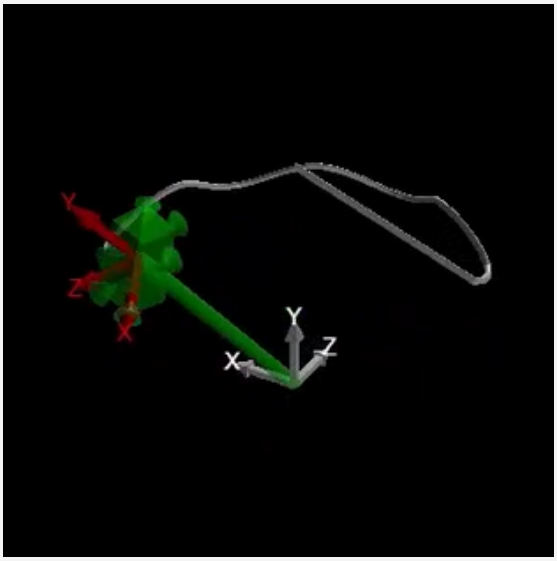

Image on the left: *A simulation by Bradford Le modeling the pendulum's nutation, precession, and roll about a fixed point.*

Image on the right: Zachary Handel demonstrates a concentric ring design for the pendulum's base.

The team is tackling feedback control next and will have their model ready in time for testing with cold gas this month. The team has added the feature to lock individual degrees of freedom so that they can start with simple roll control first, and then move on to rotation about the X and Z axes.

Antenna Ground Station

The antenna ground station team received their very first components like their tripod, motors, gear box, and anchors for their first system assembly. The team is on track to deliver a fully functional ground station on time for Halcyon Mk1 launch and has spent most recent weeks focusing on software. The team has opted to use an Arduino and C based architecture and will be using the motors they received this week to troubleshoot various parts of their program.

Propellant Measurement

The propellant measurement team has been inching closer and closer to TREL's first propellant measurement system, making significant progress. The team first demonstrated the ability to collect data from various pressure transducers and delta pressure transducers, measuring the differential pressure of water and filtering that data various ways using Savitsky-Golay and Butterworth filters. The team mastered this skill and moved on to a purged dP design, tested it with water, and has since spent the past weekend preparing for their first purged dP test with cryogenic liquid nitrogen.

Section by Zachary Muckler, Chief Engineer

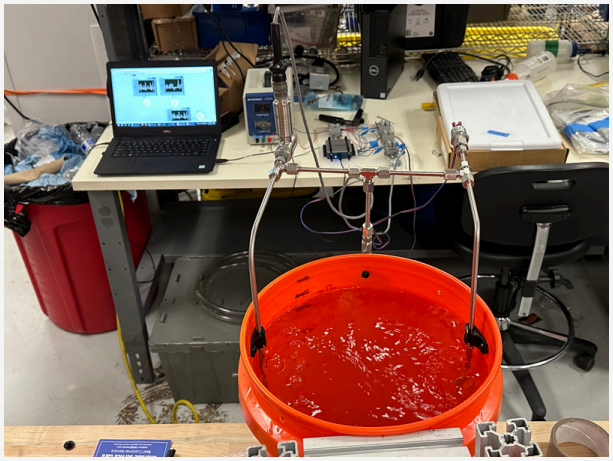

Image: Propellant measurement completing a purged dPtest.

Image: Jervis Benjamin preparing the LN2 test rig**.**

Image: Caelix Kidwell and Josue Renteria preparing for a purged dP testing with LN2.

Image: Jervis Benjamin and Josue Renteria cutting a tube.

Custom Liquid Oxygen Valve

The valve team has been working hard designing their very first prototype valve. This valve will serve as a test bed for their spring and seal design. Namely, the team will demonstrate how well their Teflon based piston seal design works under static hydro conditions, dynamic hydro conditions, static and dynamic pneumatic conditions, and then a cryogenic liquid nitrogen test. The valve will initially be made of 6061 Aluminum and take the shape of a sleeve valve. The team is working hard this week to push out engineering drawings and start fabrication

Section by Zachary Muckler, Chief Engineer

Image: Liam Cooper asks questions during a valve demonstration.

Looking Ahead

There are four weeks until the last class day at UT. As the semester draws to a close, teams will be pushing hard to complete key tests and submit their end-of-semester presentations. These will be given to the team leaders of the Halcyon program so they can choose which members of Skunkworks get to move on to other projects within TREL. One way in which Skunkworks members can highlight their achievements is through a point-based system called Skunkworks Rewards. Students that complete training and submit photos of the hardware they're working on get points, which can bring benefits to their teams like budget increases and specific mentions to Halcyon team leads. The highest scorers so far are in a 4-way tie! I'd like to congratulate the following students for their hard work and dedication to TREL Skunkworks this past month. These students have submitted outstanding portfolios and completed several LabVIEW and machine shop trainings.

Name	Team
Tiffany Chen	Ground Station
Dora Chang	Ground Station
Thompson Le	Valve Team
Sujan Goruganti	Ground Station
Daniel Milan	RCS Testbed

Section by Zachary Muckler, Chief Engineer

INGENUITY AWARDS

During our bi-weekly all hands meetings we started giving out an “Ingenuity Award” for a member who goes above and beyond what is expected of them - we want to shout them out here as well:

Tyler Requa, Recovery Lead Engineer:
“Tyler led his teams to develop an innovation nose cone separation system that embodies the ideal spirit of scrappiness. By utilizing old school technology typically used on bicycles they’ve engineered a clever forward-thinking mechanism that advances rocket technology. Additionally, he’d done a great job of balancing CAD, 3d printing mockups, and just going for it throughout the design campaign. Finally, Tyler has the most beautiful and articulate tickets in the entire lab .”
-Nominator

Gael Nuno, Fluids Team Member:
“Gael has consistently put in dozens of hours pers week to bring Fluids from PID to reality on Mk1. He has been showing up to PRC at least 4x a week for workdays and has been crucial in Fluids integration. ”
-Nominator

Section by Buckner Newberry, Halcyon Chief Engineer