

TREL



TEXAS ROCKET ENGINEERING LAB



The University of Texas at Austin
Cockrell School of Engineering

Halcyon Update

Texas Rocket Engineering Lab
December 2024

Program Update

Halcyon is shaping up to be flight-ready by January 6th, the start of our launch window out of Spaceport America. Over the past month we have transitioned fully out of design and initial prototyping to final vehicle assembly and GSE activation. We have made considerable progress on the compact fluids assemblies that live in the composite skirts, have performed dozens of component tests, have completed the primary structure entirely, and activated much of our launch GSE in a first-of-its-kind chill-in test.

We've learned a lot about our systems over the last month and have exited most of the discovery phase of development, we have a clear burndown list of work that needs to get done to fly, and a team that is tracking and owning each item to the finish line.

A notable achievement this month was the completion of our Monte Carlo dispersions and submission of our launch application to the FAA. We are confident in the approach, analysis, and package we delivered. We are awaiting final approvals and agreements between involved parties and expect those to come through in the coming weeks.

Section by Buckner Newberry, Halcyon Chief Engineer

We are generally tracking well towards flight readiness. With finals and holidays coming up, we'll have massive changes in personnel bandwidth. While finals will be a blackout, in the weeks after we will have a small crew remaining in Austin with much more bandwidth to build. This will be a new paradigm for the team, but one we believe will allow for accelerated progress without classes and homework. The team has put in more time this past month than the entirety of previous semesters. Dozens of students have clocked >40 hr/wks. Our team's commitment and velocity is unparalleled at the collegiate level for anything nearing this scale of vehicle development. Next time you hear from us, we'll be out at Spaceport America. While currently planning on launching, if readiness or approvals do not close, we will attempt a static fire of the integrated vehicle. We won't fly until we are absolutely ready. Excitement guaranteed!

November Progress

Propulsion

- First full engine with diverging section nozzle extension assembled
- Engine bay 90% assembled
- Iterated LOx main valve configuration and completed testing
- Initial QD separation development tests completed
- RCS assembly 70% complete
- LOx tank dP propellant measurement system designed
- LOx relief piloted passive vent development tests completed

Structures

- Aluminum fin machined and assembly started
- Full structural test stand construction completed
- Qualification skirt crush test passed (~9000 lbf compression with bounding cutouts)
- Engine bay flight skirt fabricated and bonded onto fuel tank
- Aft LOx skirt access and raceway passthrough ports cut
- Forward LOx skirt extension bonded to composite coupler

Avionics, Software, and GNC

- Initial vehicle-side RF testing complete
- Significant component-level HITL testing complete
- Harness fabrication 50% complete
- Ground software stack tested and validated with GSE systems in-the-loop
- Flight software state machine overhauled and simplified
- Majority of device drivers completed and tested (HOOTL)
- Monte Carlo dispersions completed and final hazard area delivered to FAA
- TVC controller functional and tuning against wind data in progress
- Initial full body CFD completed

Integration, Test, and Launch

- Lab space completely re-configured and basic internal machine shop stood up
- First-ever internal structural compressive test performed using hydraulic actuator system
- Launch GSE activated with LOx fill test attempt (electrical issues prevented completion)

December Goals

Build				
Group	System/Category	8-Dec	15-Dec	22-Dec
Structures	Engine Bay	Fin bracket holes cut, bolted joint coupon test	Integrate 2x access port covers, Order prop frame bolts, fin bracket holes cut	Integration of propulsion frame
	OF	Coupler manufactured	Access port covers integrated	Coupler integration
	NO		Integrate 2x access port covers	
	Raceway	4x raceway covers completed, raceway mounting brackets printed	Final 2x raceway covers completed	Raceway covers integrated
	Recovery	Print nosecone, deployment test		
	Nosecone	Nosecone completed		
Propulsion	Havoc	Flight sequence 1st draft, support igniter testing	Mk1 ablative backup nozzle mfg	Hotfire
	TVC	Inertial test	Inertial test	TVC assembled, inertial and structural testing
	Fins	Assemble 1x fin, fit check	Order 3x more fins	Testing
	QD	Vehicle panel #2 machined on mill, 2x ground panel machined on mill	Integrated separation tests	
	Engine Bay		Final assembly, CdA flows, cryo ATPs	Integration
	OF	Final assembly, RCS testing, dP assembly built	Integration	
	NO	Relief development testing, vent cryo dev testing	Final assembly, cryo ATPs	Integration
	Raceway	Tubes fabricated, tubes integrated		
Avionics	General	Stepper motor testing, Finish harnessing	Full state machine HITL execution, vehicle integration and health checks	Vehicle checkouts (GSW GUI telem readout)

GNC and Software				
Group	System/Category	8-Dec	15-Dec	22-Dec
GNC	Dispersions	Monte Carlo package complete, dispersion validation table		
	TVC control	Controller TAOS integration	TVC profile completed, wind allowable	Gain revisions per TVC testing
	RCS control	Controller TAOS integration		
	General	Stability margin package, verify moment of inertia calculations, look into lockout TVC profiles	Start trajectory revision tools for launch	
	GSW	Fix valve state indicator bug, remove state manager, add GUI autosequence start capability, fix sequence timeout bug, plots GUI streaming to other computers, add GUI autosequence readout	RF integration testing	
SW	FSW	Full nominal HOOTL with new states, thrust termination function complete and tested, TVC controller implemented into C++, test GPS driver, test SV driver, test TVC driver, test recovery igniter drivers	Full nominal mission HITL with controllers, nominal HITL, thrust terminate HITL	Fault case HITLs
	Dispersions	Monte Carlo package complete, dispersion validation table		

Test and Launch				
Group	System/Category	8-Dec	15-Dec	22-Dec
Test and Launch	Water Flow Test Stand		Fluids assembly CdA tests, GSE RP-1 waterflow	
	Engine Test Stand	MOU signed	Stand ready	Hotfire
	Igniter Panel	Igniter testing	Igniter testing completed	
	Vehicle Test Stand	Trailer mounted	GSE COPV fill drain	Mk1 LOx assy fill drain
	Launch Mount	Completed plumbing/harnessing	Integrated 2x QD + 4x release mech testing	
	Water Flow Test Stand		Fluids assembly CdA tests, GSE RP-1 waterflow	

Section by Buckner Newberry, Halcyon Chief Engineer

Image : Halcyon engine bay fluids assembly nearly complete

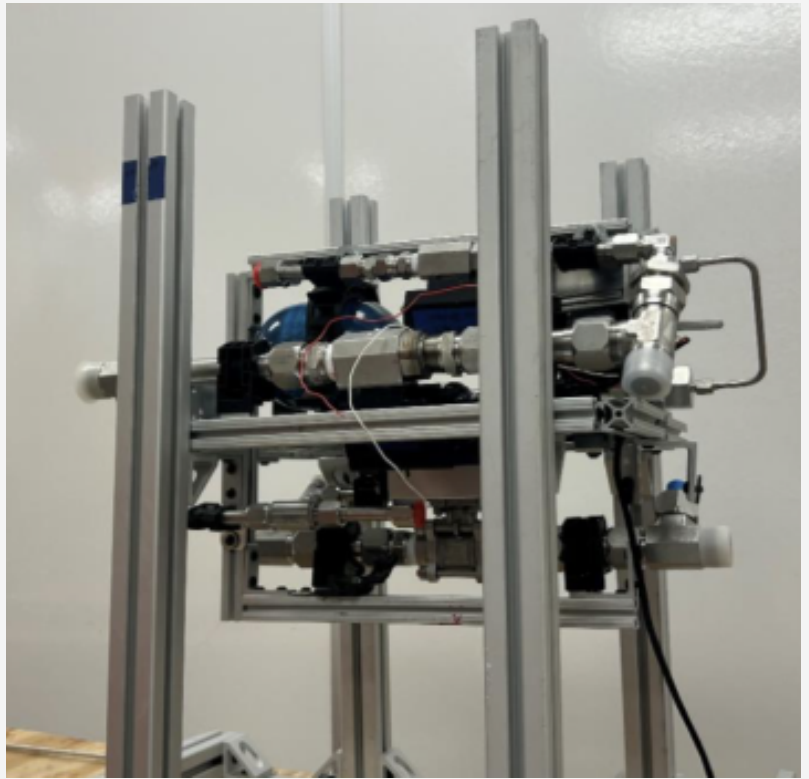


Image above: Havoc SN1 first full assembly with nozzle extension

Image on the right: Liquid oxygen main valve cryogenic testing



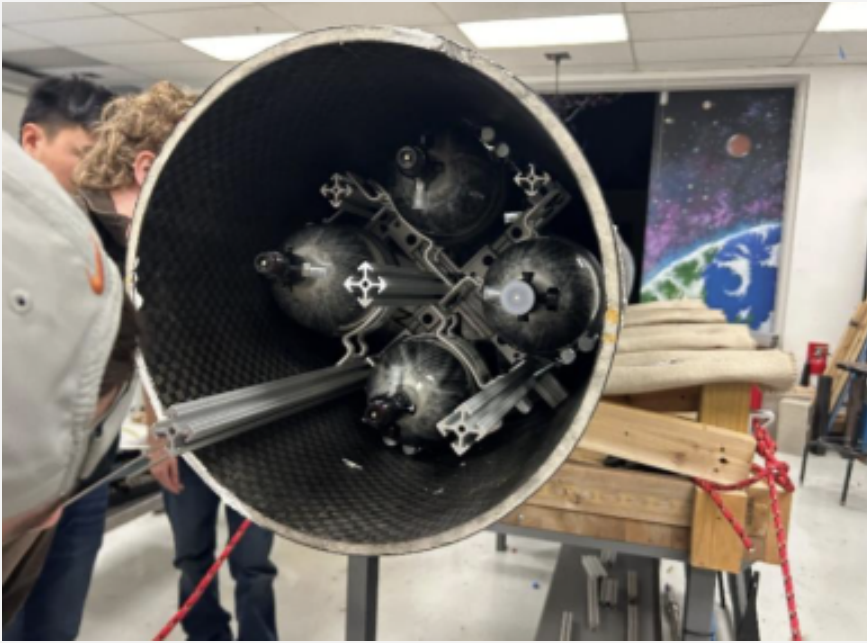


Image above: Initial RCS assembly fit checks

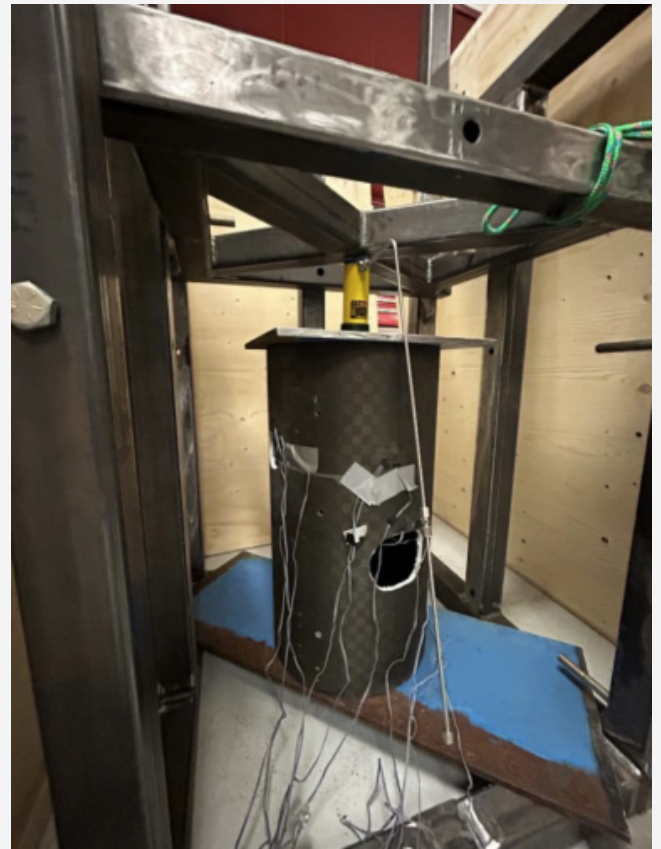
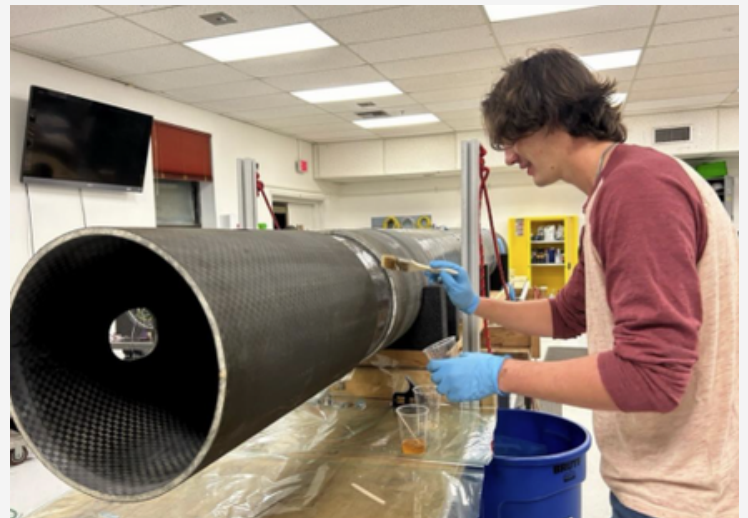


Image above: Qualification skirt compressive testing with hydraulic actuator



Image above : Halcyon Mk1 with fiberglass raceway covers positioned for fit checks

Image on the right: Avi Ettinger (structures member) prepares the forward LOx skirts for bonding



Section by Buckner Newberry, Halcyon Chief Engineer



Image: Halcyon Mk1 with all carbon fiber composite work complete (sans some final cutouts in the forward LOx section)



Image: Taj Lee (Head of Structures) and Jose Juarez (structures member) working on the engine bay skirt bond to the fuel tank



Image: Chase Meech (TREL alumnus, engineer at SpaceX, and welder extraordinaire) standing next to our structural test stand after completing the final welds

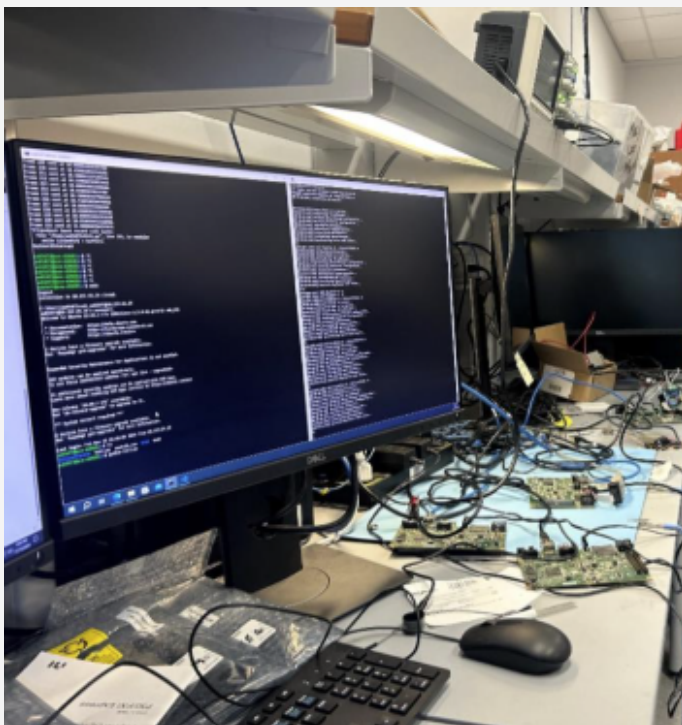
Section by Buckner Newberry, Halcyon Chief Engineer



Image: Initial internal machine shop at Pickle Research Campus facility



Image above: Halcyon GSE LOx fill system test



Section by Buckner Newberry, Halcyon Chief Engineer

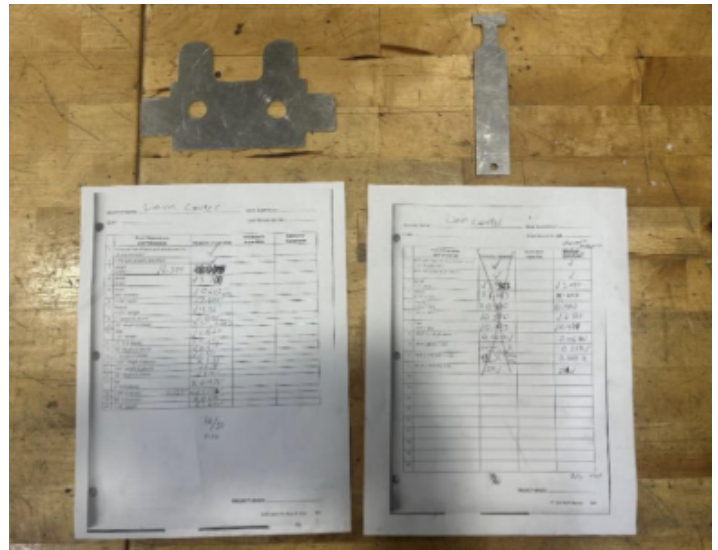
SKUNKWORKS

Program Updates

TREL Skunkworks is winding down for the semester, with everyone in the program preparing for their final presentations. Each member of the program will present to the Chief Engineer and the Program Director to assess their skills learned throughout their time with TREL. Halcyon program heads and team leads will be invited to these presentations and will have the opportunity to choose their favorite candidates to move on to the Halcyon program and join their team. High performing students also can remain in TREL Skunkworks and continue development work that they didn't get to finish. Engineers are also wrapping up their training in both the mechanical and electrical tracks with several engineers having completed their ham radio certifications and machine shop challenges.

Image:

Liam Cooper, a freshman on the LOX Valve team, worked on soft jaws and a "T" slot mill cleaner as part of his mechanical track training.



Additionally, Skunkworks students had the opportunity to tour Firefly's facilities in Cedar Park, Texas, where they got to see the Blue Ghost lunar lander, the first stage of the Alpha rocket, and Firefly's Mission Operations Center.



Image:

Ronil Shah, a freshman on the LOX Valve team, in front of the Firefly Aerospace Blue Ghost Lunar Lander.

The students got to see firsthand how their hands-on training could directly benefit their engineering skillset by learning about such a complex assembly.

Finally, I would like to introduce Trent Mosher, my replacement and future Chief Engineer for the spring 2025 semester of Skunkworks. Trent is currently the lead of the ground station team and is studying aerospace engineering. His experience ranges from research on enzyme and nucleotide kinetics to astrophysics, and his skills cover a wide range of programming languages. I'm extremely excited to see what he will accomplish.

The Nemo Engine (Electric pump-fed engine team)

The Nemo engine team is excited to share that they will soon be performing its first ever cryogenic pump test. In preparation for it, the team conducted test stand cold flows with liquid nitrogen to test its valves under cryogenic conditions and gather system CdAs.



Image: *Pump test cart fed by liquid nitrogen.*

The cryo-shock also allowed test operations to find and correct any leaks before official pump testing. The team also calibrated its venturi flow meter with a previous water-flow test. This flow meter will help determine pump flow rates, and with pump head rise, determine system power. This will be a huge milestone that will allow the team to construct the pump's characteristic curve and characterize its efficiency. The upcoming pump test also requires the in-house manufacturing of precision components such as the pump's copper and graphite ring



Image : Copper ring used on the LOX impeller



Image : Graphite ring used to seal the impeller shaft

Additionally, the team just received a large batch of 3D prints from Freeform. The parts include the pump's impeller, housing, and the Nemo engine injector, which was water-flowed just hours after it was received.



Images : Nemo pintle injector on the team's water flow cart

The team found that the injector matched design CdAs within 10% and hopes to make this design slightly less restrictive with more prints in the future.

Steel Tank Research

Since the team's recent weld sample testing, they have found that H-shaped welds performed much better than single line welds, with a single line weld using 304 SS and no filler performing the best and a single line weld using 316 SS and no filler performing the worst under ambient conditions in terms of fracture toughness. The team will be testing only a single weld configuration next in which two welds run parallel to each other under ambient and cryogenic conditions. The welds will be on 304 SS material with no filler.

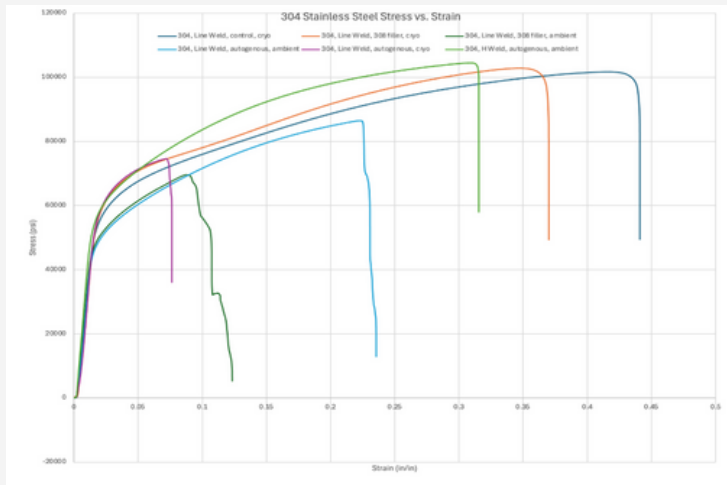


Image: *Stress vs. strain data on 304 stainless samples*

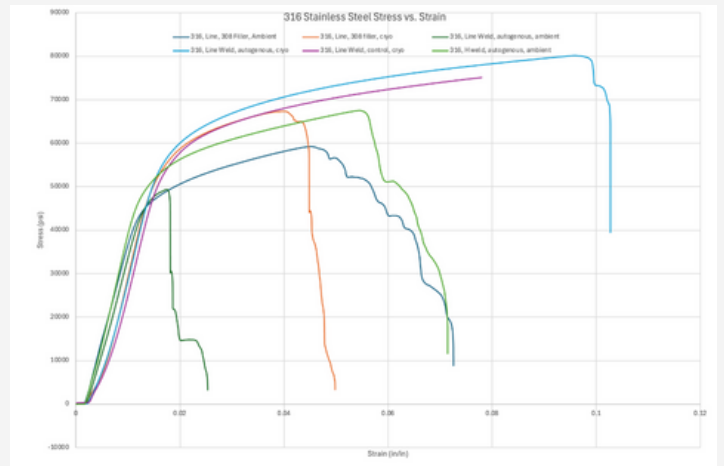


Image: *Stress vs. strain data on 316 stainless samples*

RCS Test Bed

The RCS test bed team has gotten a completely virtual simulation of its pendulum model to work, with plots of angular position and velocity from their program, they can now dial in their control model. The team has also been busy manually testing their pendulum prototype with a model built out of PVC and 3D printed parts with thrusters integrated into the top part of the assembly for control. The thrusters were actuated using the manual override on the system's control solenoids and helped the team determine if the thrust was adequate for control of the pendulum head's weight. The team will be reprinting the nozzle and thruster head assembly to increase the moment of the thrusters for roll control and to reduce strain on the tubing that ports the compressed air to the thrusters.

Image: *Zachary Handel and Daniel Milan perform a manually controlled thruster test on their prototype.*



Antenna Ground Station

The antenna ground station team has been working on completion of its mechanical and electrical assemblies, first working on the mount for the antenna and testing the motors that will drive the antenna to point in various places along Halcyon's flight path. The team has also been troubleshooting various issues with its GPS, testing the communication protocol it will use to communicate with the rocket. The next major milestone for this team is getting the motors to rotate a specific degree commanded amount and then, after performing antenna rigidity testing, get the antenna to point at a specific GPS location.



Image: Ground Station members test their GPS antenna and software

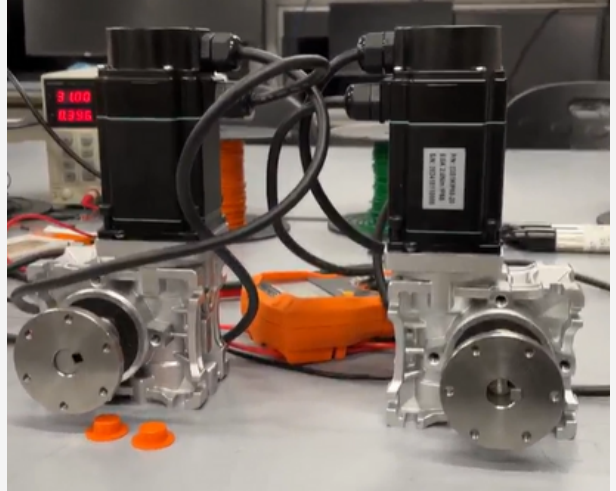


Image: The stepper motors following a control test using hardware and software developed by Dora Chang and Tiffany Chen

Propellant Measurement

The propellant measurement team has made several key milestones lately. First, the team has been able to integrate their data processing software into their LabVIEW program, reducing the time it takes to post-process test results. Second, the team has completed several flow tests that are helping them characterize frictional losses on their purge line. This has been particularly important because the team is working to integrate their system onto the Halcyon rocket in time for Mk1 launch. Third, the team has taken its first dP measurements under cryogenic conditions that mimic what Halcyon would see during its propellant load. The data resolution from these first tests isn't as fine as the team would like as they refine their model, and so in the coming week they will be performing additional testing with higher resolution instrumentation.



Image: Gordon Lee operating the test rig's LabVIEW console

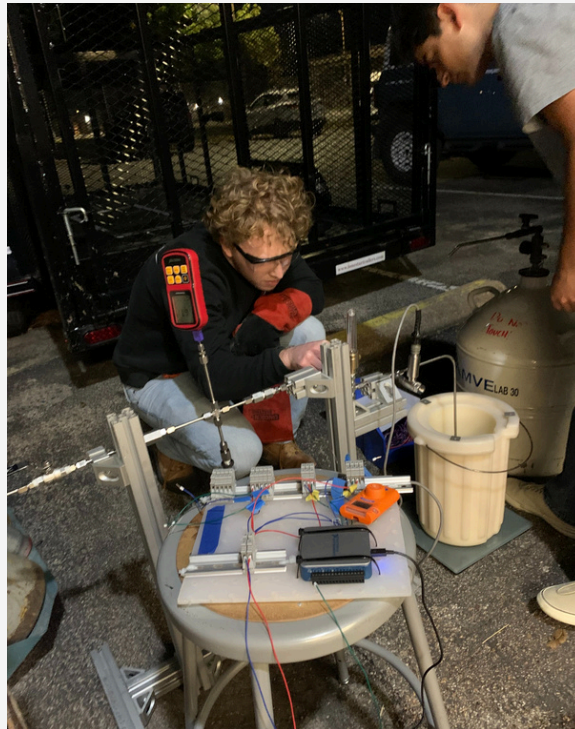


Image: Caelix Kidwell and Josue Renteria during a cryogenic test

Custom Liquid Oxygen Valve

The valve team has been working through a redesign following a review of their technical drawings and manufacturing plan. Since then, the valve's poppet and seat and piston seals have been modified to accommodate a lower cracking pressure. Additionally, the team has received raw materials for machining the valves body and assembling it.

Farewell

Leading the TREL Skunkworks team has been a tremendous joy this fall semester. I have had the privilege to talk to industry experts like Tom Mueller on the Nemo engine design, watched the incredible growth of some of the smartest freshmen I have ever met at UT, and shaped many future architecture decisions for Halcyon Mk3 and beyond. It has been an incredible opportunity to lead this team. I'm looking forward to graduation this semester and starting as a Raptor Systems Development engineer at SpaceX. I could not have gotten such an opportunity without the years of support from my mentors and the encouragement I got when I first entered TREL as a propulsion engineer in fall 2020. I will be monitoring TREL closely in my years following graduation. I'm excited to see what comes next!

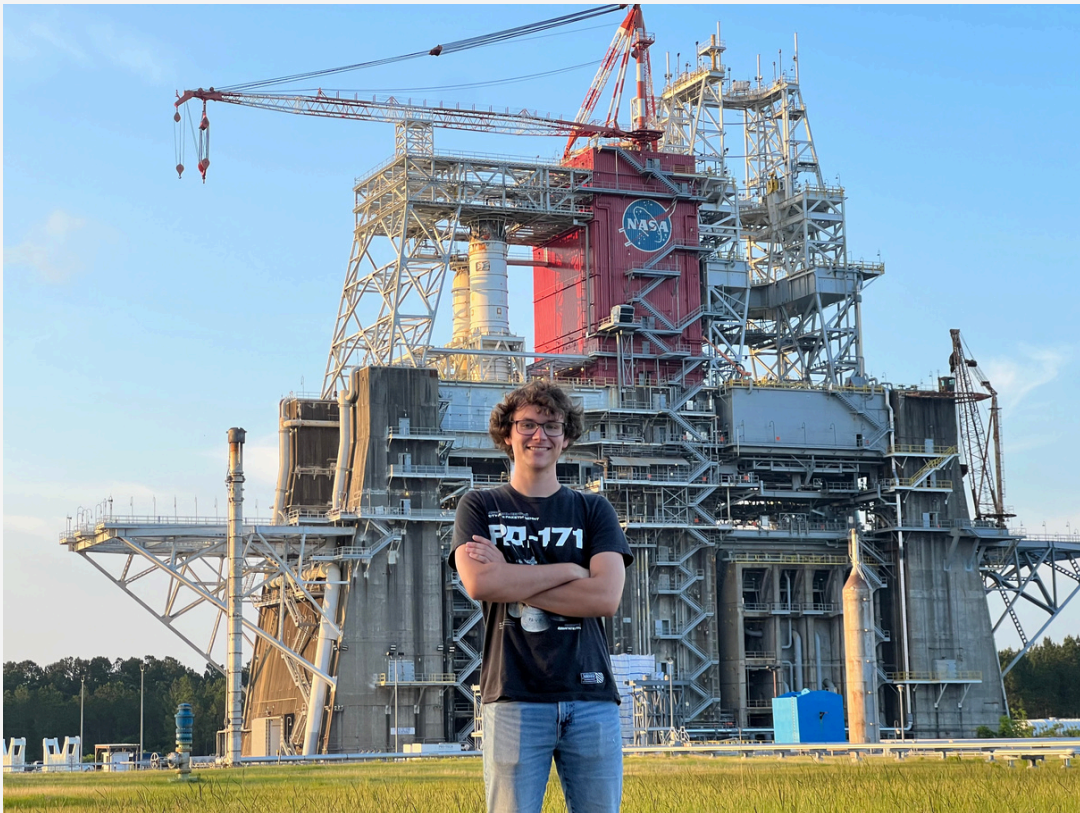


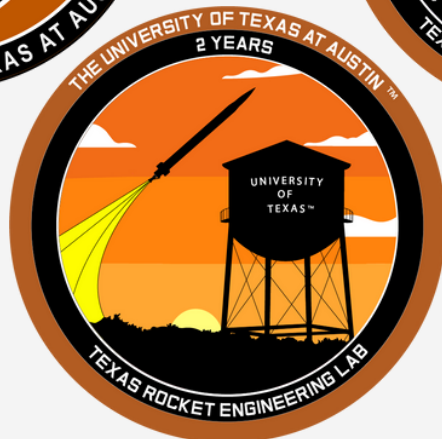
Image: Zachary Muckler, ASE Class of 2024. TREL's Skunkworks Chief Engineer

OPERATIONS

As the semester comes to a close, TREL Operations remains in full swing in preparation for our January launch and upcoming Spring Recruitment. Over the last month, we have made considerable progress in polishing our branding, alongside creating exceptional new merchandise designs for our Halcyon and Skunkworks programs. Our website has also gone through a revamp; please find our new website at texasrocketlab.ae.utexas.edu. Additionally, we continue to strive toward the creation of a documentary outlining our process to launch. Finally, we're looking to take on new large initiatives in the next semester, notably preparations for a Liquid Rocketry Competition and Conference we hope to host in the next year.

We will be conducting Spring Recruitment in the second week of the upcoming semester and are planning to host info sessions and open applications at that time. New applicants are highly encouraged to come out to an info session as the team will be outlining what we're looking for in our applications and what open positions are available. All information and updates regarding recruitment will be posted on our Instagram (@texasrocketlab).

New merchandise will be available on our website (<https://texasrocketlab.ae.utexas.edu/>) soon. The Marketing & Communications team has also created a series of patches and challenge coins, awarded to our members based on years in the lab and notable achievements. Take a moment to check out the stunning new designs, pictured below. Last but definitely not least, get excited for the Halcyon Documentary – set to be released post-MK2.



Looking toward the next semester, our Corporate Development, Marketing & Communications, Internal Development, and Finance Teams will be taking on the joint effort of planning a Liquid Rocketry Competition coupled with a conference. We aim to offer awards in several categories pertaining to launch vehicles — maximum mass-to-altitude, maximum thrust-to-weight ratio, minimum propellant residual amount, and most accurate landing/recovery. Additionally, we aspire to offer categories related to hotfires, namely; longest hotfire, most successful hotfires in one week, and highest thrust hotfire. The initiative remains in the works, but more details to come in early 2025.

To close off, I want to take a moment to thank my exceptional Operations Team. The TREL Program would not be where it is today without the vital work they do behind the scenes.

Emma Cionca
TREL Chief of Staff

Operations Shoutout **Rohan Kurup, *Finance Lead***

“Since joining TREL in Spring 2024, Rohan has been a tremendous asset to every team he has been a part of. Starting as a technical writer on the Marketing & Communications Team, Rohan transitioned to becoming the lead of the Finance Team, where he has been a rock for the team and the TREL program as a whole, developing and optimizing the purchasing system while ensuring all the engineering teams are meeting their hardware needs. Rohan has meticulously managed the TREL budget, playing a critical role in facilitating the purchasing, receiving, and documentation of hardware in accordance with our spending goals. He has been an invaluable member of the team, consistently reliable and dedicated. Rohan’s exceptional work ethic and commitment to excellence make him a cornerstone of our success, and he continues to set a high standard for all of us.”



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:



Noah Wilmot, Assistant Chief of Staff / Launch Site and Regulatory Lead :

“Noah joined TREL just this semester, and has since put several unique hats on, and has worn them all without flinching. He is acting as the Assistant Chief of Staff, handling significant portions of administrative work necessary to keeping the lab moving and functioning. He also joined the Integration team to head up our launch site and regulatory efforts- playing a critical role in pulling together the FAA flight package submission. Finally, since joining the Integration team, Noah has flexed to help whenever he is needed, including beyond his assigned scope. Noah embodies the “Get Sh*t Done” attitude of TREL and has made an invaluable member since joining us. ”

-Nominator

Section by Buckner Newberry, Halcyon Chief Engineer

HELP US LAUNCH

With launch less than one month away, we are making progress faster than ever. Our members have shown relentless dedication throughout this semester to see MK-1 come to fruition and we are closer than ever to launching. They have dedicated countless hours of their time to the lab on top of being full-time students. While our members are what makes TREL special, none of what we have accomplished could have been possible without donations from our generous sponsors who have shown endless support for our mission.

We are proud to represent one of the top aerospace programs in the country. In order to continue pushing the boundaries and redefining what it means to be a collegiate rocket lab, we need your support to help us launch and open the doors to new possibilities.

Interested in sponsoring? Contact Us

Program Director Email: jamie.huffman@utexas.edu

TREL Email: trel-communications@utexas.edu

Industry Relations Coordinator: andrea.tinning@utexas.edu

COMING SOON

HALCYON MK-1 ROCKET MODEL

Introducing the exclusive Halcyon MK-1 Rocket Model- a stunning, detailed replica of our cutting-edge rocket. The rocket is vapor-smoothed MJF printed black nylon 12 and is about 11" long, 3/4" diameter. The stand is MJF printed black nylon 12 and is about 4" long, 1" tall, 1" wide. With a \$150 donation, this model rocket can be yours!

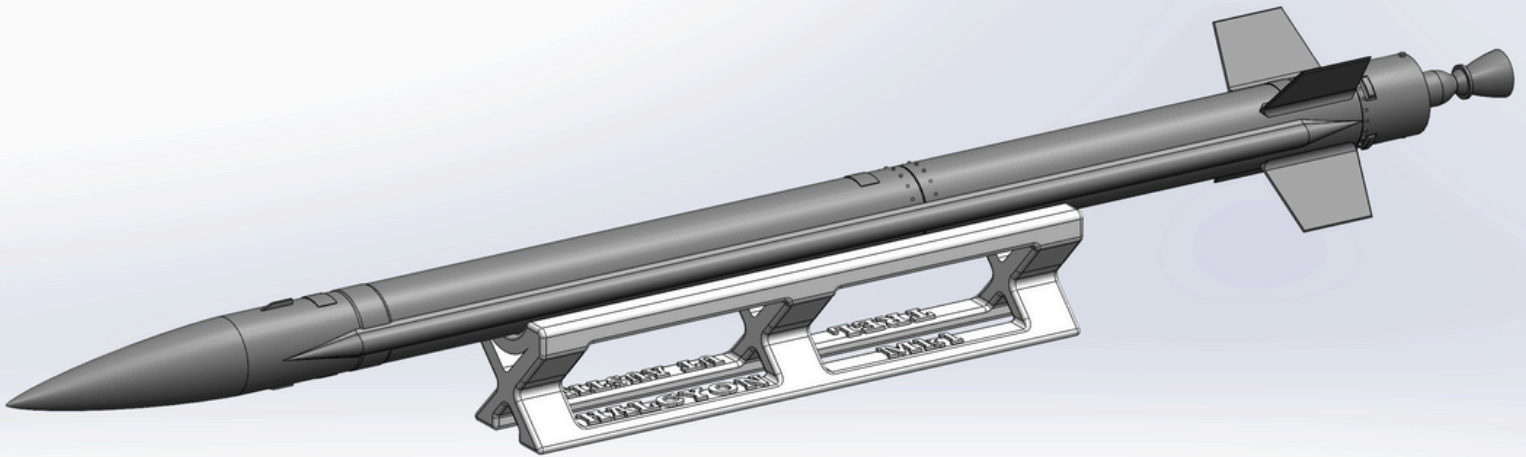
Proceeds will go toward the lab and our upcoming launches.

If you are interested, fill out this form and you will be given priority:

<https://forms.gle/RtkHHxFJvttafSqWA>

Contact us for more information:

trel-communications@utexas.edu



(NOTE: The rocket will be a polished black color and the stand will be matte black)

