[RFS] E-2 Testing Day

Why is this testing event critical this semester?

- Launch set for December 3rd, important for continuity of the team as next semester will be focused on another goal
- If no launch this semester, different types of gas cylinders will accumulate in our space, which is less safe
- A successful launch would come with a $20k reward, which we need to finance our work for our larger scale rocket next semester/year

Goal of the event:

- Demonstrate that the E-2 system is ready for launch
- Demonstrate that the pad crew is comfortable with logistics

General logistics

Activity	Acceptance coldflow of Eureka-2 for flight, set December 3rd ▪ In our case, a cold flow is a test that involves flowing propellant substitutes (LN2 instead of propane and LOx) through our system without igniting them to collect performance data. ▪ It is qualified as an "acceptance coldflow", given it will be final qualification test of our rocket before launch.
Date	Monday Nov 27, 8am-5pm
Location	▪ System located in front of our RFS space ▪ Only pad crew is allowed to approach the system during the first set of procedures. Once tank are pressurized, all personnel must be inside our RFS workspace, with the door closed shut. The system can be visually observed through our live camera system.

Operating staff	• 4 pad student staff (with EH&S training for pressure and cryo)
	• 4 dashboard student staff
	  ○ Remotely checking the health of the system
	  ○ Reading out procedures
	• Rest of the team helping with set up
	  ○ Not operating with cylinders / cryogens / dashboard
	• Supervisors from COE and/or EHS
	  ○ As many as recommended

Criteria for success	• Completed full run-through of launch procedure with launch personnel • "Good" data, which is defined as matching previous hotfire tests and simulations
Associated "hazards"	▪ High pressure gasses (GN2) ▪ Cryogens (LN2) ▪ Lifting of rocket (estimated mass = 50.5 kg)
Summary of new safety measures	▪ No flammable gases, only LN2 will flow through our system ▪ Presence of supervisor(s) ▪ Standard work hours operations (8-5) ▪ No testing of our igniter (which uses a small rocket motor), but of a singular electrical match as substitute ▪ Multiple safety reviews to verify our system and procedure before the actual test

Prior safety checks and meetings

Check	Location	Date	Attendees	Goal

Safety review of the physical system	Hesse Aerospace Lounge	As the earliest convenience	Student shop representatives: ▪ Scott McCornick ▪ Michael Neufer ▪ More personal as recommended EH&S representative(s) ▪ Alan Bolind ▪ More personal as recommended SEB representatives: ▪ Sohom (Propulsion lead) ▪ Claire (Avionics Lead) ▪ Asa (Structures Lead) ▪ Lilly Etzenbach (CEO) ▪ William Bradford (CE) ▪ Maddie Ng (CSO)	▪ Review the safety mechanisms of the system ▪ Sanity check harnessing and plumbing ▪ Verify the physical system for the actual testing day
Safety review of the procedures	In person / online	As the earliest convenience	Student shop representatives: • Scott McCornick • Michael Neufer • More personal as recommended EH&S representative(s) • Alan Bolind • More personal as recommended SEB representatives: • SEB leadership team • SEB pad crew • SEB dashboard crew	• Review the safety mechanisms and how we handle all failure cases of the system • Sanity check order and safety of operations • Verify the procedure for the actual testing day • Note: this safety review can be combined to the physical system review, depending on what is recommended by EH&S
Safety report (following the template issued by the Friend of Amateur Rocketry site)	Online document	/	/	▪ Provide a concise list of all the safety mechanisms implemented in the system ▪ Similar to E-1 safety design document: SEB_Eureka_1_Design_Document.pdf
Final system leak checking and avionics checkouts	RFS	Weekend prior to testing day	Requires the use of low pressure compressed gas (under 110 psi). Can be supervised if needed.	▪ Check the system for leaks before the test ▪ Check that all actuators/sensors/aborts function as required

Safety features overview

System / Team	Items

Avionics & Controls	• Procedure for pressurization of tanks and flow automation sequence are fully remote: once tanks are full (not pressurized), all personnel leaves the pad
	• Ground station has 2 laptops running dashboard for redundancy, and dashboard is monitored by 2 or more people at all times
	• All system data (pressures, temperatures, continuity and current draw of actuators, status of actuators) is displayed on dashboard, in real time
	• All actuators on the system are controlled remotely through dashboard
	• Before using any pressure and cryogens with the system, we conduct a full checkout of every valve (tank vent solenoids, pressurant flow RBV, electronic regulators, main valve solenoids, RBVs for fill, vents) and sensors (pressure transducers, motor encoders) on the system
	• Tank vent solenoids will automatically cycle to open and close if pressure in tanks hits or exceeds 550 PSI
	  ○ Our tanks have been hydrotested to 900 PSI, so this is well within the range
	• Between pressurant flow RBV and electronic regulators, there are 2 steps before any pressurant can flow into tanks
	• System has automated aborts:
	  ○ In the case of tank overpressure
	  ○ In beginning flow procedure

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<tr><td>Propulsion</td><td>
The propulsion system has numerous safe guards to keep personal safe.
Pressurant Fill Procedures:

Fill DOT tank to 4500 PSI, tank has 5x factor of safety minimum
2 Redundant valves in between run tanks and pressurant tank
Personnel monitor pressure on both sides to confirm high pressure transducer is accurate

Cryogenic Fill Procedures:

Fill tanks with vents fully open

Vents larger than inlet holes, so over-presserization past dewar pressure is not possible
Pad team regulates dewar liquid valve to ensure fill pressure remains within tank nominal rating (200 psi)

PPE is worn when opening and closing valves

Valves only venting gas, extremely minimal risk of cryogenic contact

Fill Lines have vents

Fill Lines can completely be vented before they are disconnected from the rocket and dewar

Tanks chill down to ambient pressure

Tank pressurization procedure

All systems monitored remotely, no personnel near system
Both tanks for E-2 are COTS
Redundant valve 1 opens, and tank pressure is monitored to make sure there is no failure in second stage redundant valves

General System Hardware Safety

High flow rate COTS burst disks on system sized to match regulator orifice size
High flow COTS relief valves on system slightly smaller than regulator orifice sizing due to availability
All lines operating at or below rated working pressure
Tanks operating at above rated pressure have been hydrotested and are only pressurized remotely

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<tr><td>Pad</td><td>

All pad crew staff has the appropriate PPE

Long sleeve anti-absorbent shirts
Googles and face shield
Cryo apron and gloves
Earplugs during fill
Note: we have additional PPE items for supervisors as needed

All pad crew staff has completed the EH&S cryo and high pressure training
All pad crew staff has completed the procedures at least 20 times by now (around 14 cold flows and exactly 7 hotfires)

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<tr><td>Procedure</td><td>Hotfire 11 Test Procedure without igniter and with LN2 as substitutes for propane and Lox</td></tr>
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