Phoenix III

Mission Requirements Review (MRR)

Olin Rocketry

10/19/2020

Changelog

Description	Revision	Date
Initial Release	0	10/13/2020

Table of Contents

Project Overview

Phoenix III is a rocket developed under the Andromeda program, to allow our team to participate in the Intercollegiate Rocket Engineering Competition (IREC) / SpacePort America Cup. The competition has a number of different categories and Phoenix III is being developed to compete in the 10,000 ft category. The mission is to design, test, build and launch a rocket to 10,000ft and then recover it successfully. The team aims, through the development of this rocket, to gain valuable skills and experiences that will allow us to succeed in the aerospace industry.

Mission Introduction

The mission is to develop a rocket capable of flying an 8.8lb (4 kg) payload in the form factor of a 3U cubesat to 10,000ft and recover both the rocket and the payload successfully. The rocket will be equipped with an avionics system that will be responsible for triggering the drogue parachute recovery system when apogee is detected, and opening the main parachute at an altitude <1500 ft from the ground. The rocket will need to adhere to all rules and safety specifications as defined in the IREC competition documents.

CONOPS

Phase	Action	Approximate Time
Preflight Assembly	Recovery System Pressurization	T- 30 min
	Avionics Bay Installed	T- 30 min
	Engine Installed	T-20 min
	Rocket Assembly Complete	T- 20 min
Pad Operations	Rocket Transfer to the Pad	T- 10 min
	Recovery System Armed (Manually)	T- 10 min
	Avionics System Armed	T- 10 min
Launch	Engine Ignition	T-0
Ascent	Mach 1	T+ 2.75 sec
Apogee	Apogee	T+ 23 sec
Descent	Main Parachute Deployment	T+ 102 sec
Ground Recovery	Touch Down	T+ 175 sec

Development & Review Timeline

Milestone	Date
Mission Requirements Review (MRR)	Oct 19th 2020
Preliminary Design Review (PDR)	Early December 2020
Critical Design Review (CDR) & Test Readiness Review (TRR)	Late February / Early March 2021
Assembly & Integration	April - May 2021
Flight Readiness Review	June 2021
Competition	Late June 2021

Definition of Subsystems

Payload: The payload subsystem is responsible for creating the boiler-plate payload and its mounts inside the vehicle.

Structures & Recovery:

Structures: The structures subsystem is responsible for the vehicle's aerodynamics, airframe and fin design. Structures is also responsible for the accommodation and mounting of the other subsystems inside the vehicle.

Recovery: The recovery subsystem is responsible for developing a dual event, non-pyrotechnic deployment parachute system. The subteam is only responsible for the mechanical side of the system, as well as the bulkheads that will integrate with the rocket's structure.

Avionics:

Flight Computer: The flight computer subteam has two main responsibilities, to interface with the sensing module for collecting the relevant telemetry to determine when to trigger the recovery system, and to transmit that trigger signal to the electro-mechanical board for recovery activation. The telemetry and positional data will also be saved in an onboard memory card.

Sensing: The sensing subteam is responsible for data logging of the GPS, altimeter, barometer, accelerometer, and other sensors in the avionics bay.

Communications: The communications subteam is responsible for communicating positional data and telemetry through radio between the vehicle and the ground for datalogging and tracking purposes.

Battery Management: The battery management subteam is responsible for managing the power requirements of the avionics system as well as managing the primary and secondary battery packs.

Electro-Mechanical: The electro-mechanical subteam is responsible for interfacing with the recovery system and providing the required power to the recovery mechanisms following receiving the trigger signal from the flight computer.

Engine: The engine subsystem is responsible for the development and testing of the Phobos series of APCP rocket motors for eventual use in the Phoenix III launch vehicle.

Requirements Nomenclature

MIS - Mission Requirement

SYS - System Requirement

STR - Structures Requirement

PAYL - Payload Requirement

PROP - Propulsion Requirement

REC - Recovery Requirement

EMECH - Electro-Mechanical Requirement

BAT - Battery Management Requirement

FCOM - Flight Computer Requirement

SENS - Sensing Requirement

COMMS - Communications Requirement

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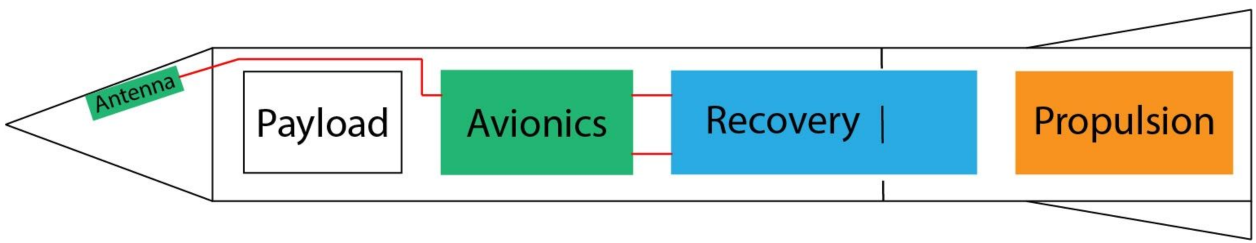
Mission & System Level Requirements

L1 Requirements

ID	Requirement	Description	Verification
MIS_REQ_01	IREC 10k SRAD Solid	The vehicle shall compete in the IREC reaching 10k feet AGL with a SRAD solid motor	Flight
MIS_REQ_02	IREC Excellence	The vehicle shall be designed in accordance with all ESRA documents to insure the safety of the team	N/A
MIS_REQ_03	Olin Rocketry Precepts	The vehicle shall be as student designed and built as possible	N/A

System Integration Diagram



Mass Budget

Subsystem	Mass (kg)	Location Relative to tip of vehicle (in)
Payload	3.99	17.8
Avionics	1	30.2
Recovery	3.996	40.61
Structures	8.90	92.21
Propulsion	8.108	113.52
Total:	**25.99**	
CoM:	**77.12**	**in**
CoP:	**95**	**in**
Stability @ Liftoff	**2.93**	

Power Budget

Subsystem	Total Charge (mAh)	Peak Current (mA)	Life at Peak Current (min)
Flight Computer	225	250	54
Sensing	100	250	24
Communications	600	250	144
Battery Management	100	250	24
Electro-Mechanical	225	1000	13.5

L2 Requirements

ID	Requirement	Description	Verification
SYS_REQ_01	Launch Altitude	The vehicle shall reach plus or minus 100 feet of 10,000 feet AGL while being launched with an elevation of 84 degrees plus or minus one degree.	Analysis
SYS_REQ_02	Energetic Device Arming Sequence	All energetic devices shall be able to be safed	Inspection
SYS_REQ_03	Pressure Vessel Burst Pressure	All SRAD pressure vessels constructed entirely from isotropic materials shall be designed to a burst pressure no less than twice the maximum expected operating pressure.	Analysis
SYS_REQ_04	Flight Hardware Pressure Testing	All flight SRAD pressure vessels shall be proof pressure tested to 1.5 times the maximum expected operating pressure for no less than twice the maximum expected system working time.	Testing
SYS_REQ_05	SRAD Pressure Vessel Relief Devices	With the exception of propulsion, all SRAD pressure vessels shall implement a relief device set to open at no greater than the maximum expected operating pressure.	Inspection
SYS_REQ_06	Materials Selection	PVC, Quantum Tube, and Stainless steel shall not be used in any load bearing capacity.	Inspection
SYS_REQ_07	Stress Factor of Safety	The minimum factor of safety for all load calculations shall be 2.	Analysis

SYS_REQ_08	Thermal Loading	All systems shall go through thermal load analysis	Analysis
SYS_REQ_09	Mass	The vehicle shall not weigh more than 17.893 kg dry	Inspection
SYS_REQ_10	Power	The avionics system shall not use more than 1250 mAh of power	Test
SYS_REQ_11	Single Fault Tolerant Electronics	The avionics system shall be single fault tolerant	Test
SYS_REQ_12	COTS Flight Computer	A COTS flight computer shall be the backup avionics system	Inspection
SYS_REQ_13	Safety Critical Wiring	All safety critical wiring shall implement a cable management solution	Inspection
SYS_REQ_14	Safety Critical Connections	All safety critical connections shall be sufficiently secure	Inspection
SYS_REQ_15	Launch Velocity	The vehicle shall be traveling at least 30.5 m/s when the last launch lug forward of the center of gravity leaves the end of the rail	Analysis
SYS_REQ_16	Flight Stability	The vehicle shall not have less than 2 body calibers between the center of pressure and the center of mass at any point during ascent	Analysis
SYS_REQ_17	Over Stability	The vehicle shall not have a distance between the center of pressure and the center of mass exceeding 6 body calibers at any point during ascent	Analysis
SYS_REQ_18	Center of Mass	The vehicle's center of mass shall not be further than 77.25 in from the tip of the vehicle at any point during the mission	Inspection

Payload

L3 Requirements

ID	Requirement	Description	Verification
PAYL_REQ_01	Payload Mass	The payload shall be no less than 3.99 kg in mass	Analysis & Inspection
PAYL_REQ_02	Payload Accessibility	The payload shall be easily removed for weighing at competition	Inspection
PAYL_REQ_03	Restricted Materials	The payload shall not contain hazardous materials or live, vertebrate animals	Inspection
PAYL_REQ_04	Form Factor	The payload shall have the form factor of CubeSats and shall, when assembled, be no smaller than the 3U form	Inspection

Structures & Recovery

Structures

L3 Requirements

ID	Requirement	Description	Verification
STR_REQ_01	Adequate Venting	The vehicle shall be adequately vented to prevent unintended internal pressures and separation	Inspection
STR_REQ_02	Materials Selection	PVC, Quantum Tube, and Stainless steel shall not be used in any load bearing capacity.	Inspection
STR_REQ_03	Thermal Analysis	All individual structures parts and the subsystem as a whole shall go through thermal analysis	Analysis
STR_REQ_03	Eyebolts	All load bearing eyebolts shall be of the closed-eye, forged type.	Inspection
STR_REQ_04	Coupling Tube Length	All coupling tubes shall extend no less than one	Inspection

		body caliber on either side of the joint.	
STR_REQ_05	Launch Lugs	All launch lugs shall be attached via a hard point	Inspection
STR_REQ_06	Aft Most Launch Lug	The aft most launch lug shall support the fully loaded vehicle's weight in the vertical position	Analysis
STR_REQ_07	Launch Lug Sizing	The launch lugs shall fit into an 80/20, 1515 variety launch rail	Inspection
STR_REQ_08	Launch Lug Quantity	There shall be at least two launch lugs	Inspection
STR_REQ_09	Identification Markings	The team ID shall be prominently displayed on the vehicle	Inspection
STR_REQ_10	Name Markings	The Olin college named logo along with the rocket name shall be displayed on the vehicle	Inspection
STR_REQ_11	Center of Pressure Location	The center of pressure shall never be forward of 95 in from the tip of the vehicle	Analysis
STR_REQ_12	Maximum Mass	The structures of the rocket shall have no more than 8.899 kg of mass	Inspection
STR_REQ_13	Nosecone RF Transparency	The nosecone shall be RF transparent so that an antenna from avionics can be mounted there	Testing
STR_REQ_14	Motor Retention	Some form of motor retention shall be incorporated at the bottom of the vehicle to prevent the engine from falling after powered flight	Inspection
STR_REQ_15	Stress FoS	The minimum factor of safety for all stress calculations shall be 2	Analysis
STR_REQ_16	Fin Flutter	The minimum factor of safety for dynamic fin loading shall be 2	Analysis

Rationale

Structures

1. Set by IREC to ensure accurate barometer readings and prevent separation issues
2. Set by IREC to limit the use of materials with poor shock loading characteristics or that fail violently
3. Ensures the system can withstand the temperatures achieved during flight
4. Set by IREC to reduce the risk of eyebolt failure
5. Set by IREC to reduce the risk of launch lug tear-out
6. Set by IREC to reduce the risk of derailing during launch
7. Set by IREC to ensure the rocket is compatible with the competition launch rails
8. Set by IREC to keep the rocket stable on the rail until it achieves aerodynamic stability
9. Set by IREC for easy identification of the rocket
10. Set by IREC for easy identification of the rocket
11. Set to maintain the minimum required stability; calculated based on the vehicle's current center of mass
12. Set based on the maximum mass of the rocket taking into account the mass needed by other subsystems
13. Set so the nose cone can house the antenna
14. Set to reduce the risk of the engine being lost after powered flight
15. This requirement is set as a minimum factor of safety by the team
16. Provides a check on the dynamic forces felt by the fins specifically

Recovery

L3 Requirements

ID	Requirement	Description	Verification
REC_REQ_01	Dual Event Recovery	The vehicle shall be recovered with a dual event style parachute landing	Inspection
REC_REQ_02	Drogue Decent Speed	The vehicle shall descend between 23 m/s and 46 m/s under the drogue chute	Analysis
REC_REQ_03	Swivel Links	The recovery system shall implement swivel links between connections	Inspection
REC_REQ_04	Parachute Coloring	The main and drogue chutes shall be drastically different colors	Inspection
REC_REQ_05	Recovery System Testing	All elements of the recovery system shall be ground tested while	Testing

		under control of avionics, where the flight computer is in simulated flight	
REC_REQ_06	Energetic Device Arming	All energetic devices shall be able to be safed	Inspection
REC_REQ_07	Arming Access	All arming features shall be easily accessible from the exterior of the vehicle	Inspection
REC_REQ_08	Pressure Vessel Burst	All SRAD pressure vessels constructed entirely from isotropic materials shall be designed to a burst pressure no less than twice the maximum expected operating pressure.	Analysis
REC_REQ_09	Flight Hardware Pressure Testing	All flight SRAD pressure vessels shall be proof pressure tested to 1.5 times the maximum expected operating pressure for no less than twice the maximum expected system working time.	Testing
REC_REQ_10	Pressure Vessel Relief Device	All SRAD pressure vessels shall implement a relief device set to open at no greater than the maximum expected operating pressure.	Inspection
REC_REQ_11	Drogue Activation Device	The drogue deployment shall be activated by a solenoid receiving 4 amps for 10 seconds	Testing
REC_REQ_12	Main Chute Activation Device	The main chute deployment shall be activated by a nichrome burn wire receiving 2.4 amps for 8 seconds	Testing
REC_REQ_13	Maximum Mass	The subsystem shall have a maximum mass of 4 kg	Inspection
REC_REQ_14	Materials Selection	PVC, Quantum Tube, and Stainless steel shall not be used in any load bearing capacity.	Inspection
REC_REQ_15	Thermal Analysis	All individual recovery	Analysis

		parts and the subsystem as a whole shall go through thermal analysis	
REC_REQ_16	Stress FoS	The minimum factor of safety for all stress calculations shall be 2	Analysis

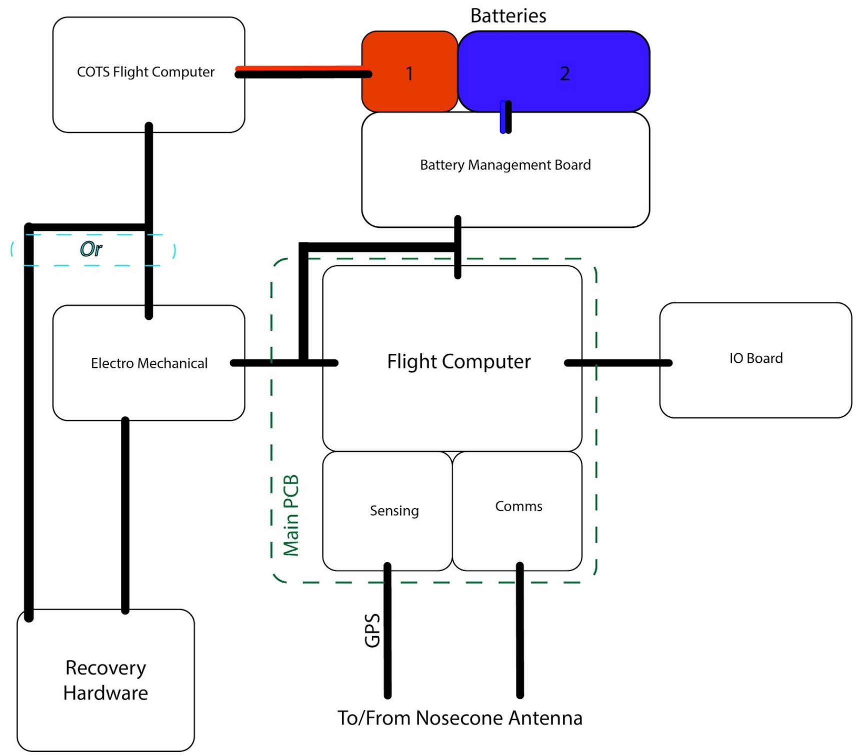
Rationale

Recovery

1. This is the recovery system type required by IREC
2. Set by IREC to prevent a ballistic descent, ensure the main parachute deployment, and limit wind drift
3. Set by IREC to prevent twisting of parachute cords during descent
4. Set by IREC to ensure each phase of recovery is distinctive, as visible from the ground
5. Set by IREC to reduce the risk of system failure during the flight due to a design issue
6. Set by IREC to prevent unintended triggering of energetic systems, especially during ground handling
7. Set by IREC to limit interaction with rocket while energetic systems are armed
8. Set by IREC as a minimum factor of safety
9. Set as a minimum safety demonstration by IREC, to ensure the system will not burst under pressure in flight conditions
10. Set by IREC to reduce the risk of failure due to overpressurization
11. Set as an alternative to a black powder deployment system and to ensure continuity with the avionics system
12. Chosen as a simpler alternative to a mechanical deployment system that could reliably release under the force of the drogue chute and to ensure continuity with the avionics system
13. Set based on the maximum mass of the rocket taking into account the mass needed by other subsystems
14. Set by IREC to limit the use of materials with poor shock loading characteristics or that fail violently
15. Ensures the system can withstand the temperatures achieved during flight
16. This requirement is set as a minimum factor of safety by the team

Avionics

Avionics Block Diagram



Flight Computer

L3 Requirements

ID	Requirement	Description	Verification
FCOM_REQ_01	Drogue Deployment Event	The flight computer shall execute the drogue deployment event at or near apogee	Analysis & Testing
FCOM_REQ_02	Main Chute Deployment Event	The flight computer shall execute the main chute deployment event no higher than 457 m AGL	Analysis & Testing
FCOM_REQ_03	External Connections	The flight computer board shall have direct connections to the battery managements, electro-mechanical, and IO boards	Inspection
FCOM_REQ_04	Sensor Input Protocol	The flight computer shall process IC2 from the	Inspection

		sensors onboard	
FCOM_REQ_05	Maximum Current Draw	The flight computer shall not draw more than 250 mA	Testing
FCOM_REQ_06	Overall Charge Draw	The flight computer shall not draw more than 225 mAh over the course of the mission	Testing

Rationale

1. FCOM_REQ_01 Is put into place by IREC for the safety of participants at the event, in the event that a rocket is sent to 10,000 ft successfully but unable to deploy its drogue chute, the rocket would effectively become a kinetic missile with everyone beneath it at risk of being hit. The closer to apogee that the chute is deployed ensures the safety of all participants -- the further we veer from apogee the greater the risk the drogue chute or attachment for the chute will shear.
2. FCOM_REQ_02 exists by IREC as both a courtesy to us and everyone else in our surrounding launch area. The latter being most important, as if we were to launch the main parachute too early there would be very little way of knowing where the rocket would be landing due to the powerful winds at that elevation.
3. FCOM_REQ_03 An IO board will be incorporated into the avionics package for arming and disarming the rocket. This is mandated by IREC for the safety of everyone, and allows us to follow standard launch procedures that prevent us from launching a rocket with inactive avionics, as well as prevent a recovery misfire. This requirement is also set to ensure a continuity between avionics subteams.
4. FCOM_REQ_04 exists so that we are using a set standard for reading sensor inputs from our modules. In our own case we are using I2C from our IMU, GPS & Altimeter
5. FCOM_REQ_05 prevents the avionics system from overdrawing on the battery management subteam
6. FCOM_REQ_06 prevents the avionics system from draining the batteries before the conclusion of the mission

Sensing

L3 Requirements

ID	Requirement	Description	Verification
SENS_REQ_01	Sensors Onboard	Sensor data shall be provided to the flight computer via IC2	Testing
SENS_REQ_02	Maximum Current Draw	The combined sensors shall not draw more than 250 mA	Testing
SENS_REQ_03	Overall Charge Draw	The combined sensors shall not draw more than 100 mAh over the course of the mission	Testing
SENS_REQ_04	GPS Data	GPS data shall be collected and sent to comms	Testing

Rationale

1. SENS_REQ_01 exists to make sure we have a proper signal chain so the parachute can be released at the proper time (at apogee) and to provide continuity with the flight computer subteam
2. SENS_REQ_02 exists to provide the battery management subteam a hard number so we will not draw more amps then the battery system can provide.
3. SENS_REQ_03 prevents the avionics system from draining the batteries before the conclusion of the mission
4. SENS_REQ_04 In order to retrieve the rocket it is necessary to track the rocket's GPS data. The inclusion of a GPS onboard is also required by IREC.

Communications

L3 Requirements

ID	Requirement	Description	Verification
COMMS_REQ_01	Frequency Agility	Within our given bandwidth, the communications system shall be able to change transmitting frequency rapidly	Inspection
COMMS_REQ_02	Communication Protocol	The GPS location shall be transmitted using ARPS protocol with a transmit rep of 2 seconds	Inspection
COMMS_REQ_03	Communication System Testing	The communication system shall be tested at 2 miles line of sight	Testing
COMMS_REQ_04	Antenna Connections	The communication system shall use a set of terminals on the main flight computer board	Inspection
COMMS_REQ_05	Maximum Current Draw	The communication system shall not draw more than 250 mA	Testing
COMMS_REQ_06	Overall Charge Draw	The communication system shall not draw more than 600 mAh over the course of the mission	Testing

Rationale

1. IREC requires us to be able to shift transmitting frequency within our given bandwidth. We will be given the bandwidth ahead of time however we must be able to switch our operating frequency while preparing for launch.
2. IREC has told us which communication protocol to use so that our signals can be picked up by their large antenna setup
3. This requirement also comes from IREC to ensure we have tested our GPS tracking system
4. This ensures that there are connections for the antennas onboard the main PCB
5. COMMS_REQ_05 prevents the avionics system from overdrawing on the battery management subteam
6. COMMS_REQ_06 prevents the avionics system from draining the batteries before the conclusion of the mission

Battery Management

L3 Requirements

ID	Requirement	Description	Verification
BAT_REQ_01	Output Terminals	The battery management board shall have a set of terminals for the COTS flight computer	Inspection
BAT_REQ_02	Output Connection	The battery management board shall have a direct connection to the flight computer board	Inspection
BAT_REQ_03	Power Scheme	The battery management board shall have two seperate power flows, one for the COTS computer and one for all other boards	Inspection
BAT_REQ_04	Battery Life	The batteries shall provide at least 2500 mAh of power	Testing
BAT_REQ_05	Battery Quantity	The battery management board shall manage two separate batteries with a third serving as the backup to both	Inspection
BAT_REQ_06	Battery Draw	The battery management board shall be able to supply an expected maximum of 2500 mA.	Analysis
BAT_REQ_07	Maximum Power Draw	The battery management board shall not draw more than 250 mA during the mission	Testing
BAT_REQ_08	Overall Power Draw	The battery management board shall not draw more than 100 mAh over the course of the mission	Testing

Rationale

Because the flight computer will be distributing power to all other subsystems, we must have a direction connector to the flight computer, which calls for terminals on the BMS board for the flight computer (BAT_REQ_01, BAT_REQ_02). It is an IREC requirement that we instill a redundant system which requires a separate power system. To fill this requirement, we have designed a battery pack that contains two parallel groups of Lithium battery cells. One group will go to the COTS flight computer and the other group will go to our custom board system (BAT_REQ_03). We will also have an additional pack as a backup (BAT_REQ_05). The current battery pack can supply a maximum of 2000mA and the total system requires 960mA (BAT_REQ_06).

Electro-Mechanical

L3 Requirements

ID	Requirement	Description	Verification
EMECH_REQ_01	Downstream Activation Scheme	The electro-mechanical board shall have two sets of wire terminals	Inspection
EMECH_REQ_02	Drogue Activation Power	The "drogue" set of wire terminals shall provide 4 amps for 10 seconds	Testing
EMECH_REQ_03	Main Chute Activation Power	The "main chute" set of wire terminals shall provide 2.4 amps for 8 seconds	Testing
EMECH_REQ_04	Battery Connection	The electro-mechanical board shall be connected directly to the battery management board through the man flight computer PCB	Inspection
EMECH_REQ_05	Flight Computer Connection	The electro-mechanical board shall be connected directly to the main flight computer trigger output	Inspection
EMECH_REQ_06	Trigger Condition	The electro-mechanical board shall be triggered by an output high signal from the flight computer	Analysis
EMECH_REQ_07	Maximum Current Draw	The electro-mechanical board shall not draw more than 4.5 amps during the mission	Testing
EMECH_REQ_08	Overall Charge Draw	The electro-mechanical board shall not draw more than 225 mAh over the course of the mission	Testing

Rationale

In order to have a complete circuit that enables the flight computer to deploy the recovery system via the electro-mechanical board it shall have two sets of wire terminals (EMECH_REQ_01). With the goal of ensuring complete redundancy for the recovery hardware deployment, we shall provide power to the transistor logic directly from the power management board (EMECH_REQ_04) (through traces on the main PCB) and provide deployment controls directly from the main flight computer (EMECH_REQ_05). For simplification and redundancy purposes, there will be a single high signal from the main flight computer to the electromechanical board that would command the transistor logic to deploy the recovery system (EMECH_REQ_06).

Propulsion

L3 Requirements

ID	Requirement	Description	Verification
PROP_REQ_01	Non-Toxic Propellant	The propellant shall be APCP	Inspection
PROP_REQ_02	Combustion Chamber Burst Design	The combustion chamber shall be designed to a burst pressure no less than twice the maximum expected operating pressure	Analysis
PROP_REQ_03	Combustion Chamber Testing	The flight combustion chamber shall be proof pressure tested to 1.5 times the maximum expected operating pressure for no less than twice the maximum expected system working time	Testing
PROP_REQ_04	Flight Design Hot-Fire	The final engine design shall be statically tested with a hot-firing	Testing
PROP_REQ_05	SRAD Motor Constraints	The motor shall be designed and manufactured in-house	Inspection
PROP_REQ_06	Total Impulse	The engine shall provide at least 10,000 N*s of total impulse	Testing
PROP_REQ_07	Liftoff Thrust	The engine shall provide at least 3,900 N of thrust at liftoff	Testing
PROP_REQ_08	Maximum Dry Mass	The engine shall have a	Inspection

		maximum dry mass of 3.342 kg	
PROP_REQ_09	Form Factor	The engine shall fit the form factor of a COTS 98mm motor	Inspection
PROP_REQ_10	Materials Selection	PVC, Quantum Tube, and Stainless steel shall not be used in any load bearing capacity.	Inspection
PROP_REQ_11	Thermal Analysis	All individual propulsion parts and the subsystem as a whole shall go through thermal analysis	Analysis
PROP_REQ_12	Stress FoS	The minimum factor of safety for all stress calculations shall be 2	Analysis

Design Rationale

1. For health reasons, we have decided to work with a propellant that does not cause toxic exhaust. This will not significantly impact performance, and make it easier to acquire permission to manufacture and test.
2. This requirement is set as a minimum factor of safety by IREC
3. This requirement is set as a minimum safety demonstration by IREC, to ensure the system will not burst under pressure
4. This requirement is set as a minimum safety demonstration by IREC as a final check on the engine
5. This is required for the SRAD category, as well as being chosen to fulfill our own learning goals as much as possible
6. This requirement was set by comparison to other successful rocketry teams (specifically MIT's Project Raziel, https://wikis.mit.edu/confluence/display/RocketTeam/Project+Raziel) as well as OpenRocket simulations of the planned mass budget
7. Given the mass of our rocket and the IREC requirement of a minimum of 32 ft/s off-rail velocity, we calculated this minimum thrust.
8. This requirement is set as a part of our system's mass requirement.
9. The pandemic has limited our accessibility to shop spaces, so we are using an off-the-shelf COTS 98mm motor for the next year. To avoid redesign and possible re-purchase of an engine casing, we are making it the same diameter as the off-the-shelf motor.
10. This requirement is set as a safety factor by IREC, as many of the materials become dangerous in the case of an explosion.
11. This requirement is set to ensure that no part will crack/break under thermal stress.
12. This requirement is set as a minimum factor of safety.