# Milestone Review Flysheet 2019-2020

| Institution | Purdue University |
|---|---|

| Milestone | FRR |
|---|---|

## Vehicle Properties

| | |
|---|---|
| Total Length (in) | 127 |
| Diameter (in) | 6 |
| Gross Lift Off Weight (lb) | 53.2 |
| Airframe Material(s) | Filament-wound fiberglass |
| Fin Material and Thickness (in) | 3/16 G10 Fiberglass |
| Coupler Length(s)/Shoulder Length(s) (in) | 6, 14 |

## Motor Properties

| | |
|---|---|
| Motor Brand/Designation | Cesaroni Technology L1115-0 |
| Max/Average Thrust (lb) | 385.48, 251.78 |
| Total Impulse (lbf-s) | 1128.38 |
| Mass Before/After Burn (lb) | 9.63, 4.22 |
| Liftoff Thrust (lb) | 324.46 |
| Motor Retention Method | Aeropack Motor Retainer |

## Stability Analysis

| | |
|---|---|
| Center of Pressure (in. from nose) | 94.348 |
| Center of Gravity (in. from nose) | 75.569 |
| Static Stability Margin (on pad) | 3.04 |
| Static Stability Margin (at rail exit) | 3.08 |
| Thrust-to-Weight Ratio | 5.77 |
| Rail Size/Type and Length (in) | 15-15, 144 |
| Rail Exit Velocity (ft/s) | 63.5 |

## Ascent Analysis

| | |
|---|---|
| Maximum Velocity (ft/s) | 534 |
| Maximum Mach Number | 0.48 |
| Maximum Acceleration (ft/s^2) | 200 |
| Target Apogee (ft) | 4325 |
| Predicted Apogee (From Sim.) (ft) | 4389 |

## Recovery System Properties - Overall

| | |
|---|---|
| Total Descent Time (s) | 99.3 |
| Total Drift in 20 mph winds (ft) | 2605 |

## Recovery System Properties - Energetics

| | | |
|---|---|---|
| Ejection System Energetics (ex. Black Powder) | | Black Powder (FFFFg) |
| Energetics Mass - Drogue Chute (grams) | Primary | 2 |
| | Backup | 3 |
| Energetics Mass - Main Chute (grams) | Primary | 5 |
| | Backup | 6 |
| Energetics Mass - Other (grams) - If Applicable | Primary | NA |
| | Backup | NA |

## Payload Deployment

| | |
|---|---|
| Location: Air or Ground (if applicable) | Ground |
| Altitude of Deployment (if applicable) | N/A |

## Recovery System Properties - Recovery Electronics

| | |
|---|---|
| Primary Altimeter Make/Model | Altus Metrum Telemetrum |
| Secondary Altimeter Make/Model | Missile Works RRC3+ Sport |
| Other Altimeters (if applicable) | N/A |
| Rocket Locator (Make/Model) | Altus Metrum Telemetrum |
| Additional Locators (if applicable) | N/A |
| Transmitting Frequencies (all - vehicle and payload) | 435, and 902-928 MHz |
| Pad Stay Time (Launch Configuration) | 3 hours |
| Describe Redundancy Plan (batteries, switches, etc.) | Fully redundant and independent systems with individual batteries, switches, wires, and ejection charges |

## Recovery System Properties - Drogue Parachute

| | | | | |
|---|---|---|---|---|
| Manufacturer/Model | | Fruity Chutes Classic Elliptical | | |
| Size or Diameter (in or ft) | | 24" | | |
| Main Altimeter Deployment Setting | | Apogee | | |
| Backup Altimeter Deployment Setting | | Apogee + 1 second | | |
| Velocity at Deployment (ft/s) | | 31.3 | | |
| Terminal Velocity (ft/s) | | 93.9 | | |
| Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap) | | 3/8" Tubular Kevlar | | |
| Recovery Harness Length (ft) | | 30 | | |
| Harness/Airframe Interfaces | | 1/4" SS quick link through looped tether ends and 1/4" SS I-bolts through bulkheads | | |
| Kinetic Energy (Ft-lbs) | Section 1 | Section 2 | Section 3 | Section 4 |
| | 3170.6 | 869 | 1893.8 | N/A |

## Recovery System Properties - Main Parachute

| | | | | |
|---|---|---|---|---|
| Manufacturer/Model | | Skyangle Cert 3 XXL | | |
| Size or Diameter (in or ft) | | 120" | | |
| Main Altimeter Deployment Setting (ft) | | 800 | | |
| Backup Altimeter Deployment Setting (ft) | | 700 | | |
| Velocity at Deployment (ft/s) | | 93.9 | | |
| Terminal Velocity (ft/s) | | 13.5 | | |
| Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap) | | 3/8" Tubular Kevlar | | |
| Recovery Harness Length (ft) | | 60 | | |
| Harness/Airframe Interfaces | | 1/4" SS quick link through looped tether ends and 1/4" SS I-bolts through bulkheads | | |
| Kinetic Energy (Ft- | Section 1 | Section 2 | Section 3 | Section 4 |

| | | | | | |
|---|---|---|---|---|---|
| | Energy (Ft-lbs) | 65.4 | 17.8 | 39.1 | N/A |

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## Payload

| | |
|---|---|
| Payload 1 (official payload) | **Overview**<br>The primary payload experiment for the 2019-2020 PSP-SL team is an autonomous unmanned aerial vehicle (UAV), designed to collect a simulated lunar ice sample after the flight of the rocket. The UAV employs a quad-rotor design with foldable wings, allowing the UAV to fit inside rocket's airframe. The UAV is securely held inside the rocket with a sophisticated retention and deployment system. This system utilizes a worm-screw and stepper motor design to actively retain the UAV system inside the rocket throughout the course of the flight. The system uses a servo motor in conjunction with a 6 DOF IMU to reorient the internal structure of the payload bay after landing. The stepper motor finally separates the payload bay, exposing the UAV for flight. The UAV deploys from the rocket, beginning an autonomous search for an ice mining recovery area. The UAV employs a computer-vision system and grid-based search algorithm to look for recovery areas. After identifying a recovery area, the UAV descends, landing on the simulated lunar ice. The UAV actuates its cylindrical-scoop based ice mining system, storing more than 10 mL of ice. Finally, the UAV flies away from the recovery area, completing its mission. |
| Payload 2 (non-scored payload) | **Overview**<br>The secondary payload experiment is a small camera, whose purpose is to record the flight of the rocket from on-board the launch vehicle. The footage from this camera will yield important data for PSP-SL regarding the conditions of the vehicle throughout the course of the flight. Additionally, the footage will be used for educational engagement in outreach events sponsored by PSP-SL in the greater West Lafayette community. |

## Test Plans, Status, and Results

| | |
|---|---|
| Ejection Charge Tests | Airframe separation via ejection charge (black powder) ignition has been tested on the ground. Each canister passed this test if its ignition resulted in at least six feet of separation of the avionics bay from the corresponding airframe for at least one amount of black powder equal to or greater than five grams for the upper airframe canisters and two grams for the lower airframe canisters. This test was conducted on the 26th of January, and all of the success criteria were met. |
| Sub-scale Test Flights | Data detailing a successful sub-scale launch will be compiled by the team's deadline of 01/03/2020. To obtain this data, the team will launch at this date at the latest; however, the team hopes to do so long before this date, and plans to have its sub-scale launch vehicle built by mid-November. Finishing construction by this time will give the team the opportunity to launch at four separate launch events: Midwest Power, two Rocketeers of Central Indiana sport launches, and an Indiana Rocketry launch. |
| Vehicle Demonstrati-on Flights | The vehicle demonstration flight, conducted on February 15th was unsuccessful. Boosting and coasting phases were successful, however at apogee, the lower airframe/shock cord/ drogue were not properly attached to the eye bolt on the avionics bay and there for separation occured. The main parachute charges did deploy and the avionics bay did separate but due to a lack of additional weight from the lower airframe and the main being packed too tightly, the main parachute did not open by the time the nose cone, upper airframe, payload, and avionics hit the ground ballistically. The nose cone sustained some minor radial damages and due to safety concerns a new nose cone was purchase. The payload was nearly all destroyed besides a few components. the upper airframe did not sustain any damages and was deemed reusable for the second iteration of the launch vehicle. The avionics bay sustained heavy damages: the coupler was damaged and deemed not reusable, the Telemetrum sustained minor damages, the threaded rods and all 3D printed components were destroyed, and both bulkplates were deemed reusuable. The lower airframe has not been found even after over eight hours of line-searching. |
| Payload Demonstrati on Flight | The final payload design was flown on the vehicle demonstration flight, with the hopes of conducting both flights at the same time, and was destroyed after the nosecone and upper airframe came in ballistically. The payload has since been completely rebuilt and will fly on the reflight of the demonstrion flight on March 7th. |

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## Transmitter #1

| | | | |
|---|---|---|---|
| Location of transmitter: | Transmitter #1 is located in the upper-section of the payload bay, within the rocket's nose cone. | | |
| Purpose of transmitter: | Transmitter #1 receives a deployment signal from the ground station, initiating the deployment of the payload. | | |
| Brand | XBee | RF Output Power (mW) | 165 |
| Model | Pro 900-HP | Specific Frequency used by team (MHz) | 902-928 |
| Handshake or frequency hopping? (explain) | Transmitters #1 and #2 are assigned 64-bit addresses in the manufacturing process. Each transmitter will be programmed to only send and receive data from the other transmitter. In this way, a basic handshake will be made between each transmitter. | | |
| Distance to closest e-match or altimeter (in) | 48 | | |
| Description of shielding plan: | Shielded packaging and short connections | | |

## Transmitter #2

| | | | |
|---|---|---|---|
| Location of transmitter: | Transmitter #2 is located at the ground-control station operated by the payload team. | | |
| Purpose of transmitter: | Transmitter #1 sends a deployment signal to the payload, initiating the deployment procedure. | | |
| Brand | XBee | RF Output Power (mW) | 165 |
| Model | Pro 900-HP | Specific Frequency used by team (MHz) | 902-928 |
| Handshake or frequency hopping? (explain) | Transmitters #1 and #2 are assigned 64-bit addresses in the manufacturing process. Each transmitter will be programmed to only send and receive data from the other transmitter. In this way, a basic handshake will be made between each transmitter. | | |
| Distance to closest e-match or altimeter (in) | N/A | | |
| Description of shielding plan: | Shielded packaging and short connections | | |

## Transmitter #3

| | | | |
|---|---|---|---|
| Location of transmitter: | Transmitter #3 is located in the Telemetrum in the avionics bay | | |
| Purpose of transmitter: | Transmitter #3 is responsible for recording the altitude of the rocket and triggering the ejection of the parachutes. | | |
| Brand | TI | RF Output Power (mW) | 40 |
| Model | CC1200 | Specific Frequency used by team (MHz) | 434.55 |
| Handshake or frequency hopping? (explain) | The transmitter will utilize a basic handshake between the altimeter and laptop on the ground to track the flight of the vehicle and deploy the parachutes when necessary. | | |
| Distance to closest e-match or altimeter (in) | 1.5 | | |
| Description of shielding plan: | Shielded boxing, short connections | | |

## Transmitter #4

| | | | |
|---|---|---|---|
| Location of transmitter: | On-board the UAV | | |
| Purpose of transmitter: | Send and receive telemetry from the UAV to the GCS throughout the payload mission | | |
| Brand | 3D Robotics | RF Output Power (mW) | 100 |
| Model | 3DR Telemetry Kit | Specific Frequency used by team (MHz) | |

| | |
|---|---|
| Handshake or frequency hopping? (explain) | This transmitter utilizes a handshake based on an internal parameter in the Pixhawk flight computer and the GCS. The "MAV_SYS_ID" parameter is set to 154 on both of these devices, ensuring that it cannot communicate with other flight computers set with different ID values. |
| Distance to closest e-match or altimeter (in) | This transmitter is powered off when inside the launch vehicle. |
| Description of shielding plan: | EMI protective material is wrapped around high-current wires on the UAV as well as major UAV electrical components. |

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## Transmitter #5

| | | | |
|---|---|---|---|
| Location of transmitter: | | | |
| Purpose of transmitter: | | | |
| Brand | | RF Output Power (mW) | |
| Model | | Specific Frequency used by team (MHz) | |
| Handshake or frequency hopping? (explain) | | | |
| Distance to closest e-match or altimeter (in) | | | |
| Description of shielding plan: | | | |

## Transmitter #6

| | | | |
|---|---|---|---|
| Location of transmitter: | | | |
| Purpose of transmitter: | | | |
| Brand | | RF Output Power (mW) | |
| Model | | Specific Frequency used by team (MHz) | |
| Handshake or frequency hopping? (explain) | | | |
| Distance to closest e-match or altimeter (in) | | | |
| Description of shielding plan: | | | |

## Additional Comments