Milestone Review Flysheet 2019-2020

Institution	University of Illinois at Urbana-Champaign

Milestone	FRR

Vehicle Properties

Total Length (in)	112 in
Diameter (in)	4 in (body) / 6 in (fairing)
Gross Lift Off Weight (lb)	26.8 lb
Airframe Material(s)	Blue Tube (body tube), Fiberglass (fairing), PLA (nose cone; transition)
Fin Material and Thickness (in)	1/8 in Fiberglass
Coupler Length(s)/Shoulder Length(s) (in)	10"/4" (coupler); /3" (nose cone)

Motor Properties

Motor Brand/Designation	AeroTech K1050W
Max/Average Thrust (lb)	488.3/254.7
Total Impulse (lbf-s)	533
Mass Before/After Burn (lb)	4.857/2.068
Liftoff Thrust (lb)	220.3
Motor Retention Method	54mm Aero Pack motor retainer

Stability Analysis

Center of Pressure (in. from nose)	81.9 in
Center of Gravity (in. from nose)	51.4 in
Static Stability Margin (on pad)	5.07 cal
Static Stability Margin (at rail exit)	3.94 cal
Thrust-to-Weight Ratio	10.4 at rail exit
Rail Size/Type and Length (in)	144 in, 1515 rail
Rail Exit Velocity (ft/s)	82.7

Ascent Analysis

Maximum Velocity (ft/s)	607
Maximum Mach Number	0.55
Maximum Acceleration (ft/s^2)	356
Target Apogee (ft)	4450
Predicted Apogee (From Sim.) (ft)	4470

Recovery System Properties - Overall

Total Descent Time (s)	75.2
Total Drift in 20 mph winds (ft)	2200

Recovery System Properties - Energetics

Ejection System Energetics (ex. Black Powder)		Black Powder
Energetics Mass - Drogue Chute (grams)	Primary	2.5 grams
	Backup	3 grams
Energetics Mass - Main Chute (grams)	Primary	5.5 grams
	Backup	6 grams
Energetics Mass - Other (grams) - If Applicable	Primary	2 grams
	Backup	2 grams

Payload Deployment

Location: Air or Ground (if applicable)	Air
Altitude of Deployment (if applicable)	400 ft

Recovery System Properties - Recovery Electronics

Primary Altimeter Make/Model	Perfectflite StratologgerCF
Secondary Altimeter Make/Model	Altus Metrum Telemetrum
Other Altimeters (if applicable)	
Rocket Locator (Make/Model)	Altus Metrum Telemetrum
Additional Locators (if applicable)	Communications Specialists RC-HP
Transmitting Frequencies (all - vehicle and payload)	223.27 MHz; 433 MHz; 900 MHz; 2.4 GHz, 5.8 GHz
Pad Stay Time (Launch Configuration)	2 Hours
Describe Redundancy Plan (batteries, switches, etc.)	Redundant altimeters with separately connected batteries/switches for each unit

Recovery System Properties - Drogue Parachute

Manufacturer/Model			SkyAngle C2	
Size or Diameter (in or ft)			20 in.	
Main Altimeter Deployment Setting			Apogee	
Backup Altimeter Deployment Setting			1 second after Apogee	
Velocity at Deployment (ft/s)			<5	
Terminal Velocity (ft/s)			100	
Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap)			0.75 in. flat Kevlar strap	
Recovery Harness Length (ft)			40 ft	
Harness/Airframe Interfaces		U-bolt on coupler and eye bolt on motor		
Kinetic Energy (Ft-lbs)	Nose Cone	Upper Section	Coupler	Booster Section
	(Still attached)	1874	267	993

Recovery System Properties - Main Parachute

Manufacturer/Model			LOC Precision	
Size or Diameter (in or ft)			80 in	
Main Altimeter Deployment Setting (ft)			700 ft	
Backup Altimeter Deployment Setting (ft)			600 ft	
Velocity at Deployment (ft/s)			100	
Terminal Velocity (ft/s)			18.3	
Recovery Harness Material, Size, and Type (examples - 1/2 in. tubular Nylon or 1 in. flat Kevlar strap)			0.75 in. flat Kevlar strap	
Recovery Harness Length (ft)			40 ft	
Harness/Airframe Interfaces		U-bolt on coupler and eye bolt on upper section		
Kinetic Energy	Nose cone	Upper Section	Coupler	Booster Section

	(Ft-lbs)	37.6	40.7	8.95	33.25

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Payload

	Overview
Payload 1 (official payload)	The official payload will be an unmanned aerial vehicle (UAV), deployed aerially at 400 ft through vertical lowering through the fairing after recovery of the nose cone. The nominal operational period is 12 minutes, wit the UAV descending and navigating to the nearest recovery area by means of GPS and computer vision. Then, the UAV will lower onto the recovery area, retrieving ice samples by way of an actuatable arm. Having retrieved the sample, the UAV will distance itself from the recovery area. The payload will be operated autonomously, with manual control being possible by way of a remote control link operated by a human operator. Telemetry is also provided for, so that ground control may ascertain vehicle health and proper operations throughout the mission.

	Overview
Payload 2 (non-scored payload)	

Test Plans, Status, and Results

Ejection Charge Tests	The required black powder charges will be determined through calculations and then real-world ejection charge tests. The shear pins will be tested during this to ensure expected resistance to shock force as well as expected shear force during ejection.
Sub-scale Test Flights	The half-size subscale vehicle was launched on January 6, 2020. The expected altitude with conditions was 1486 feet, and the measured altitude was 1529 feet. The stability margin, mass distribution, and thrust profile were, in general, similar to the full scale. Primary ejection charges for the drogue and main were activated by a StratologgerCF. Secondary charges were set to fire later via a TeleMetrum. All charges were activated succesfully at the expected times. The main parachute did not deploy; investigations revealed that it was packed too tightly and did not slide out as planned. It was instead pushed further into the body by the charges. The appropriate considerations were made to prevent this in the future.
Vehicle Demon-stration Flights	The Vehicle Demonstration Flight was conducted on February 23, 2020. The expected altitude with thesmooth vehicle was 3800 feet. The actual altitude was measured to be 3705 feet. Primary ejection charges for the drogue and main were activated by a StratologgerCF. Secondary charges were set to fire later via a TeleMetrum. All charges were activated succesfully at the expected times. Both parachutes deployed, though the drogue was delayed in unfurling and then tore two of its shroud lines due to higher than anticipated loads. The drogue has now been changed to a parachute that is expected to withstand the forces in the event the same thing were to occur.
Payload Demon-stration Flights	The Vehicle Demonstration Flight attempted to demonstrate the payload retention system, which failed to retain a dummy payload. As a result, a second flight is required. This will be in satisfaction of the Payload Demonstration Flight. It is currently scheduled for March 14, 2020.

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Transmitter #1

Location of transmitter:	Avionics Coupler		
Purpose of transmitter:	Recovery Transmitter		
Brand	Altus Metrum	RF Output Power (mW)	40
Model	TeleMetrum	Specific Frequency used by team (MHz)	433
Handshake or frequency hopping? (explain)	Fixed frequency		
Distance to closest e-match or altimeter (in)	0 in. (it is an altimeter)		
Description of shielding plan:	Blue Tube and plywood bulkheads (no freq. shielding)		

Transmitter #2

Location of transmitter:	Fairing Avionics Bay		
Purpose of transmitter:	Communications device for UAV deployment		
Brand	Digi	RF Output Power (mW)	250
Model	Xbee Pro XSC S3B	Specific Frequency used by team (MHz)	900
Handshake or frequency hopping? (explain)	Multiple Channels are Available		
Distance to closest e-match or altimeter (in)	19 in.		
Description of shielding plan:	Blue Tube, fiberglass tube, and plywood bulkheads (no freq. shielding)		

Transmitter #3

Location of transmitter:	Nose Cone		
Purpose of transmitter:	Tracking of nose cone		
Brand	Communications Specialists	RF Output Power (mW)	30
Model	RC-HP	Specific Frequency used by team (MHz)	223.27
Handshake or frequency hopping? (explain)	Fixed Frequency		
Distance to closest e-match or altimeter (in)	3 in.		
Description of shielding plan:	3D printed, wood-reinforced nose cone and plywood bulkhead (no freq. shielding)		

Transmitter #4

Location of transmitter:	Payload		
Purpose of transmitter:	Telemetry		
Brand	HolyBro	RF Output Power (mW)	100
Model	Telemetry Radio V3	Specific Frequency used by team (MHz)	433
Handshake or frequency hopping? (explain)	Frequency hopping, MAVLink Protocol		
Distance to closest e-match or altimeter (in)	8 inches		
Description of shielding plan:	Carbon fiber plates (no freq. shielding)		

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Transmitter #5			
Location of transmitter:	Ground		
Purpose of transmitter:	Drone controller		
Brand	FrSky	RF Output Power (mW)	100
Model	Taranis X9D RC Radio	Specific Frequency used by team (MHz)	2400
Handshake or frequency hopping? (explain)	Frequency hopping		
Distance to closest e-match or altimeter (in)	N/A		
Description of shielding plan:	None		

Transmitter #6			
Location of transmitter:	Payload		
Purpose of transmitter:	Video telemetry from drone		
Brand	AKK	RF Output Power (mW)	250 (user-limited)
Model	X2 FPV Video Transmitter	Specific Frequency used by team (MHz)	5800
Handshake or frequency hopping? (explain)	5740-5860 selectable		
Distance to closest e-match or altimeter (in)	8 inches		
Description of shielding plan:	Carbon fiber plates (no freq. shielding)		

Additional Comments

The data contained in this flysheet is what is currently expected to fly during Launch Week. The first test flight differed slightly. As described in the FRR, changes must be made to ensure safety. These changes are reflected here. Further changes, if any arise before the FRR Addendum, will be noted in detail in the FRR Addendum. That data will describe the as-flown system from the second test flight, as that system will be the same that will fly during launch week.