The Terra Nova Project

Critical Design Review

NASA USLI

FSU Panama City Senior Design Rocket Team:

Krieg Conrad, Case Dyer, Austin Zaal, Jonathan Serbest, Matthew Wilson

ROCKET TEAM MEMBERS

KRIEG CONRAD

Team Lead

Oversees project schedule, subsystem integration, finances, hardware acquisition, deliverables, and overall rocket construction.

JONATHAN SERBEST

Safety Officer

Develops and enforces safety procedures, ensures compliance with NASA/NAR/TRA codes, and oversees all hazardous material handling and construction safety.

AUSTIN ZAAL

Recovery Officer

Designs, fabricates, and tests all recovery systems including parachutes, bulkheads, and avionics bay for both subscale and full-scale rockets.

ROCKET TEAM MEMBERS

CASE DYER

Payload System Officer

Leads design, fabrication, and testing of the HAUS payload system, including soil collection mechanisms, capsule integration, and airframe transitions.

MATTHEW WILSON

Electronics Officer

Designs and integrates avionics and payload electrical systems, ensuring redundancy, data integrity, and EMI-free operation.

JAYDEN DUARTE

Publications Officer

Manages outreach, social media, sponsor communication, and STEM engagement documentation for NASA deliverables.

ACKNOWLEDGMENTS

Randy Hanna, EdD

Jim & Sandy Dafoe

Irvin Clark, EdD

FSU PANAMA CITY

ACKNOWLEDGMENTS

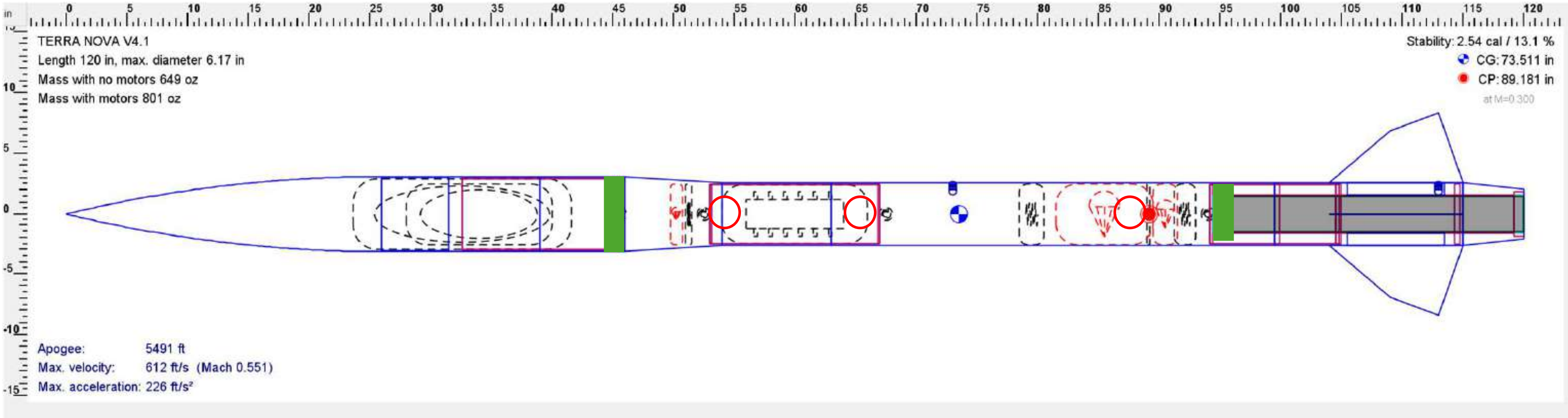
FSU INSPIRE

ASTRO AMERICA

MARITECH

VEHICLE OVERVIEW

VEHICLE DIMENSIONS

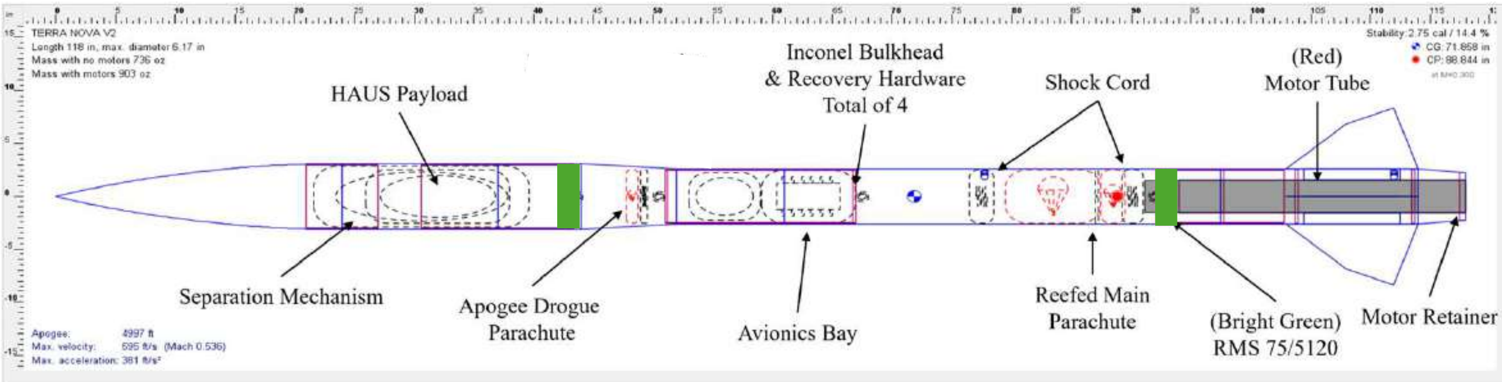


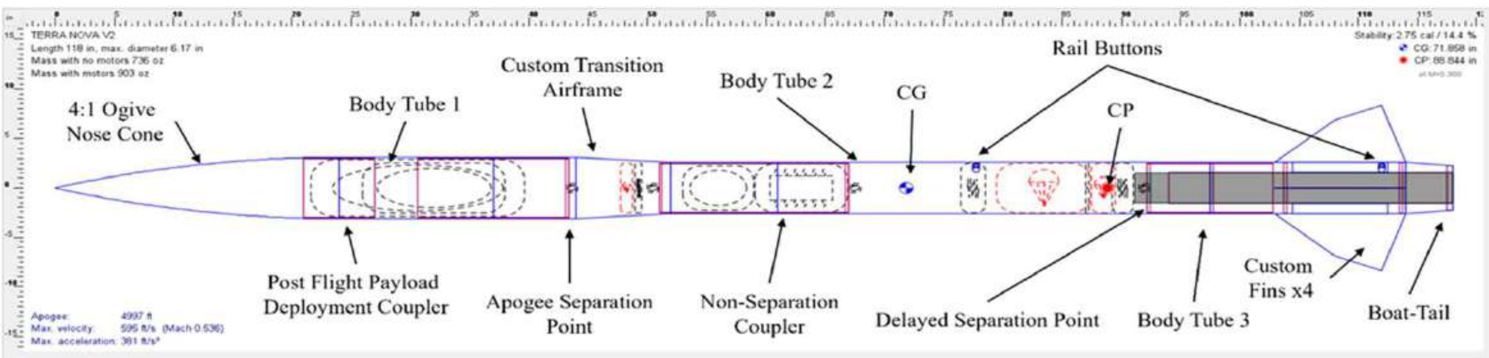
= Energetic Location

= Separation Location

Vehicle Dimensions			
Section	**External Length**	**Weight**	**ID**
HAUS	37”	239 oz	6”
Avionics	60.5”	267 oz	6”-5”
Propulsion	22.5	326 oz (w/motor)	5”
Total	120	833 oz = 52.1 lb.	6” and 5”

KEY DESIGN FEATURES





REQUIREMENTS

TEST PLANS AND PROCEDURES

Category	Completed	In Progress	Planned
Launch Vehicle – Materials	LV-MAT-02	LV-MAT-01	—
Launch Vehicle – Recovery/Avionics	LV-DEP-03, LV-DEP-04, LV-DEP-05, LV-AV-01, LV-AV-02/03	—	LV-DEP-01/02
Launch Vehicle – Flight Test	LV-SFT-01, LV-SFT-02, LV-SFT-03	—	LV-FFT-01, LV-FFT-02
Payload – Interface/Separation	—	—	PL-INT-01/02/03
Payload – Electrical/Software	—	—	PL-ELEC-01/02/03 PL-SW-01/02/03
Payload – Mechanisms/Experiment	—	—	PL-MECH-01/02/03 PL-EXP-01–06

STATUS OF REQUIREMENTS VERIFICATION

Launch Vehicle Requirements

Req ID	Requirement (Handbook Derived)	Verification Method	Verification Plan (Section 6.1)	Status	Evidence
HV-LV-01	Launch vehicle is statically stable (≥2.0 caliber)	Analysis + Test	LV-SFT-xx, LV-SFV-01 LV-FFT-xx, LV-FFV-01	Partially Complete	Inspection
HV-LV-02	Vehicle survives ascent and recovery loads	Test + Inspection	LV-SFT-xx, LV-SFV-03 LV-FFT-xx, LV-FFV-03	Partially Complete	Inspection
HV-LV-03	Full-scale vehicle flown prior to FRR	Test	LV-FFT-01 / 02	Planned	Ghantt Chart
HV-LV-04	Vehicle mass and configuration match final design	Inspection	As-built inspection	Planned	Inspection

STATUS OF REQUIREMENTS VERIFICATION

Launch Vehicle Requirements

Team Req ID	Requirement	Verification Method	Verification Plan	Status
TDR-LV-01	Bulkheads maintain SF ≥ 5 vs deployment loads	Analysis + Test	LV-MAT-01	In-Progress
TDR-LV-02	Av-bay separation is reliable and repeatable	Demo/Test	LV-DEP-01/02 + LV-SFT-02/03	In-Progress

STATUS OF REQUIREMENTS VERIFICATION

Recovery System Requirements

Req ID	Requirement (Handbook Derived)	Verification Method	Verification Plan (Section 6.1)	Status	Evidence
HV-REC-01	Dual-deploy recovery system implemented	Test	LV-DEP-01, 02, 03	Partial	Ground test
HV-REC-02	Drogue deploys at apogee	Test	LV-DEP-01, LV-SFT-xx	Partial	Telemetry
HV-REC-03	Main deploys at programmed altitude	Test	LV-DEP-02, LV-SFT-xx	Partial	Telemetry
HV-REC-04	Descent rates within safe limits	Analysis + Test	LV-SFV-05–07	Complete	Flight data
HV-REC-05	Recovery system causes no structural damage	Inspection	LV-SFV-03, 04	Complete	Inspection

STATUS OF REQUIREMENTS VERIFICATION

Recovery System Requirements

Team Req ID	Requirement	Verification Method	Verification Plan	Status
TDR-REC-01	Reefing cut occurs reliably under load	Test	LV-DEP-03	Complete
TDR-REC-02	Packing process is repeatable with clean separation	Demo/Test	LV-DEP-01/02 + LV-DEP-04/05	Partial
TDR-REC-03	Packing configuration prevents entanglement	Demo/Test	LV-SFT-02/03	Planned

STATUS OF REQUIREMENTS VERIFICATION

Payload Mission Requirements

Req ID	Requirement (Handbook Derived)	Verification Method	Verification Plan (Section 6.1)	Status	Evidence
HV-PAY-01	Payload remains retained during ascent	Inspection	PL-INT-01	Planned	Flight Test
HV-PAY-02	Payload deploys after landing	Demonstration	PL-INT-03	Planned	Flight Test
HV-PAY-03	Payload operates autonomously	Test	PL-SW-02	Planned	Flight Test
HV-PAY-04	Payload completes mission ≤15 minutes	Test	PL-EXP-05	Planned	Ground & Flight Test
HV-PAY-05	Payload collects ≥50 mL soil	Test	PL-EXP-01	Planned	Ground & Flight Test
HV-PAY-06	Payload measures and logs pH	Test	PL-EXP-02, PL-SW-01	Planned	Ground & Flight Test
HV-PAY-07	Payload data retained post-mission	Test	PL-SW-01	Planned	Ground & Flight Test

STATUS OF REQUIREMENTS VERIFICATION

Payload Mission Requirements

Req ID	Requirement	Verification Method	Verification Plan	Status
TDR-PAY-01	Payload boots successfully ≥3/3 attempts in flight config	Test	PL-ELEC-01	Planned
TDR-PAY-02	End-to-end mission completes without operator input	Demo/Test	PL-EXP-06	Planned

STATUS OF REQUIREMENTS VERIFICATION

Safety Requirements

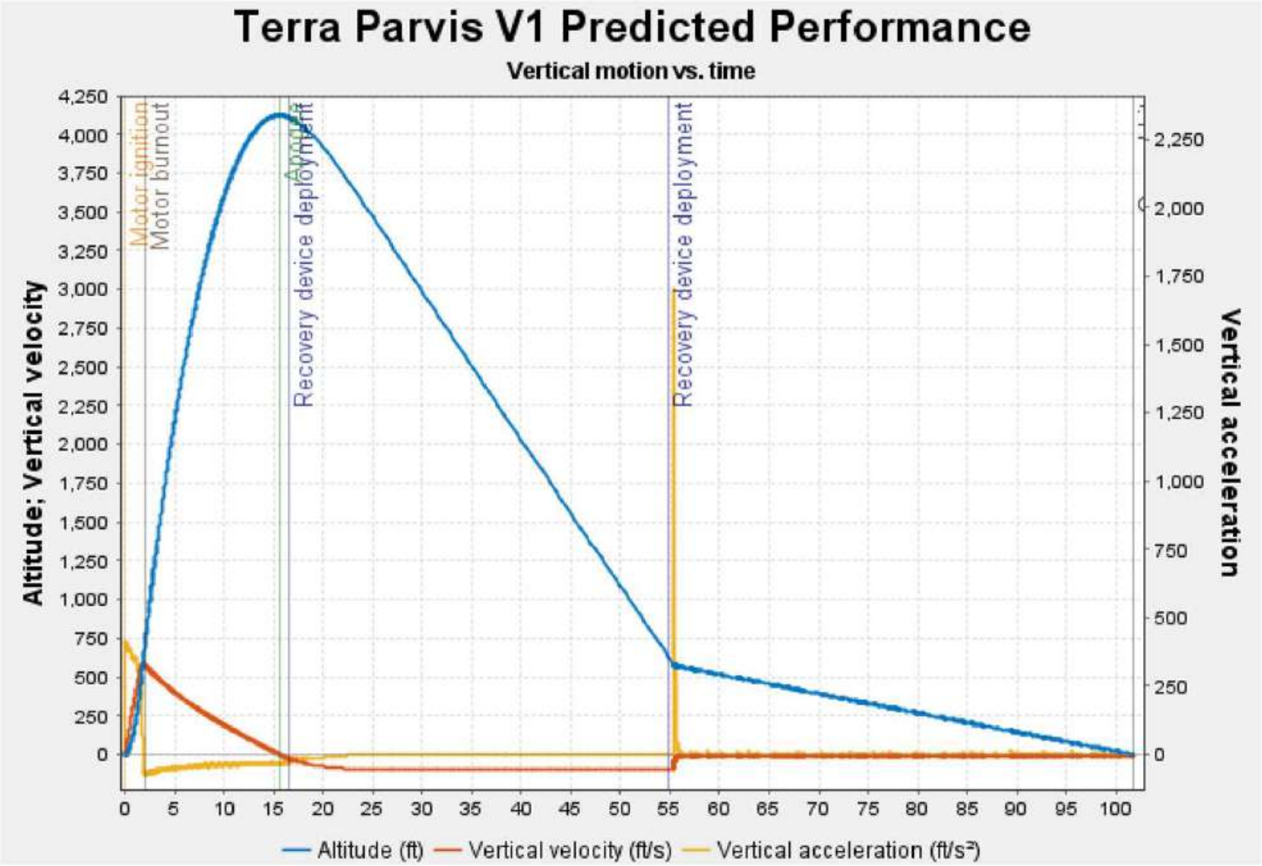
Req ID	Requirement (Handbook Derived)	Verification Method	Verification Plan	Status	Evidence
HV-SAFE-01	Vehicle complies with safety constraints	Analysis	Hazard analysis, FMEA	Complete	Safety docs
HV-SAFE-02	Energetics properly identified and labeled	Inspection	Vehicle drawings	Ongoing	Drawings
HV-SAFE-03	Recovery system minimizes landing energy	Analysis + Test	Descent analysis, flight data	Complete	Calculations

SUBSCALE PERFORMANCE

SUBSCALE FLIGHT 1 PREDICTED PERFORMANCE

Predicted Performance		
Apogee	**Descent Time**	**MAX Impact Energy**
4055 ft	86.4s	15.05 ft-lbs
Velocity off Rod	**Landing Vel**	**Heaviest Section**
93.8 ft/s	12.6 ft/s	6.1 lbs
Prediction Notes		

- Reef system deemed unflyable prior to launch
  - Main Parachute significantly oversized
- Large expected main deployment force (578lbs)



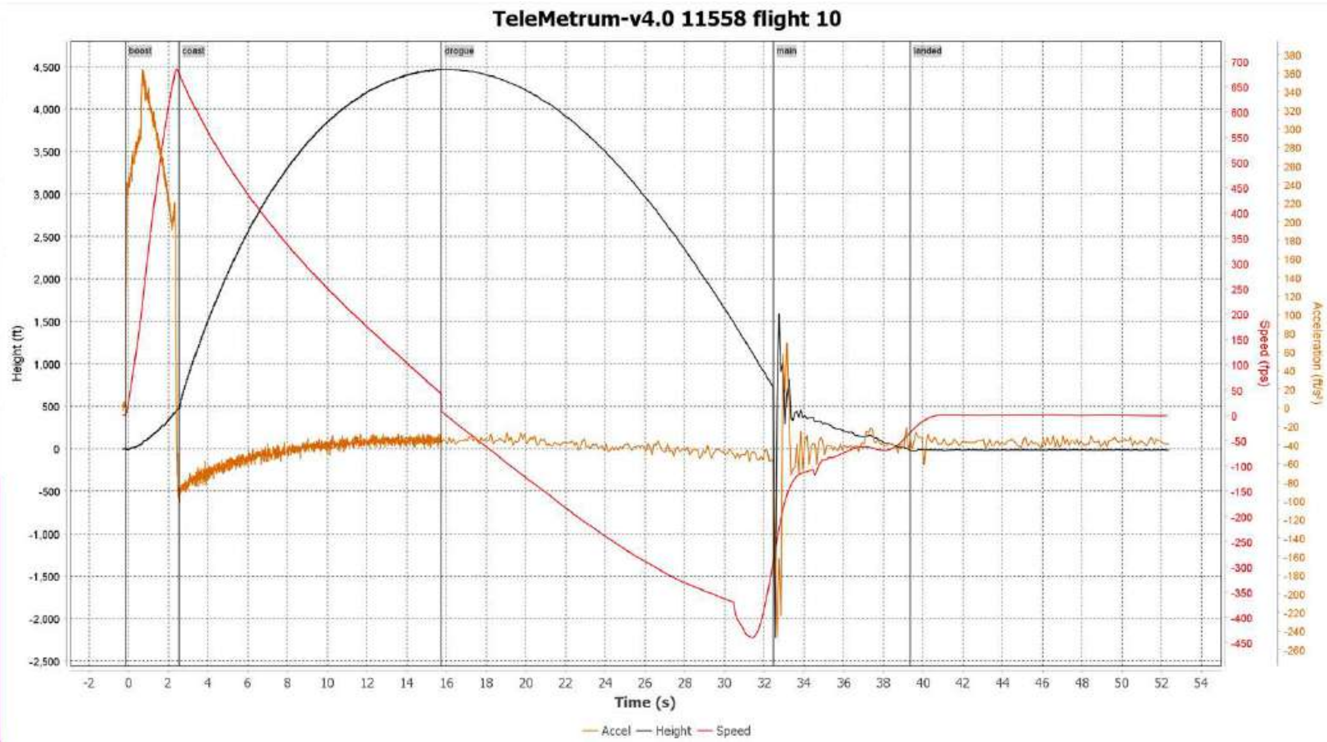
SUBSCALE FLIGHT 1

TERRA PARVIS V1

Key Data		
Apogee	**Descent Time**	**MAX Impact Energy**
4468 ft	23.6 s	500 ft-lbs
Velocity off Rod	**Landing Vel**	**Heaviest Section**
~100 ft/s	70 ft/s	6.56 lbs

Flight Notes

- Reef system not deemed flyable
- Main parachute significantly oversized
- Bulkhead failure led to launch failure
- Extremely high impact energy - failure
- Cardboard airframe intact – PETG/Fiberglass transition failure
- Fin failure upon landing

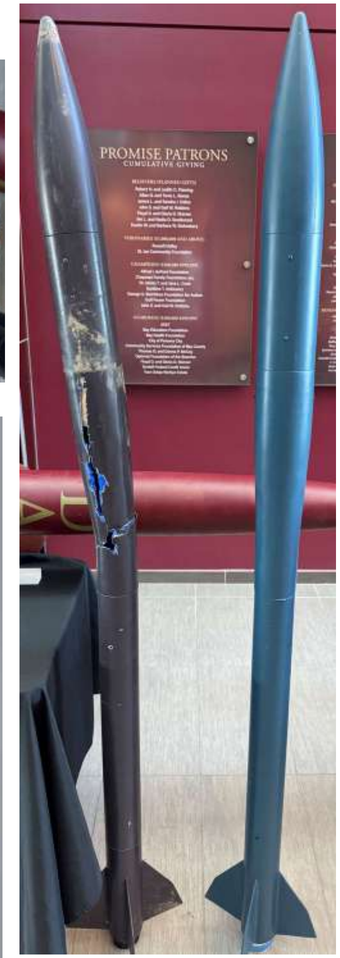


C H A N G E S   M A D E   T O   S U B S C A L E

Bulkheads
- Initially 3D printed PETG
- Failed decisively
- Replaced with ¼” plywood (Chris’ Rocketry)

Airframe
- Initially cardboard tubing
- Transition 3D PETG + fiberglass coating
- Transition failed decisively
- Replaced entire airframe with fiberglass

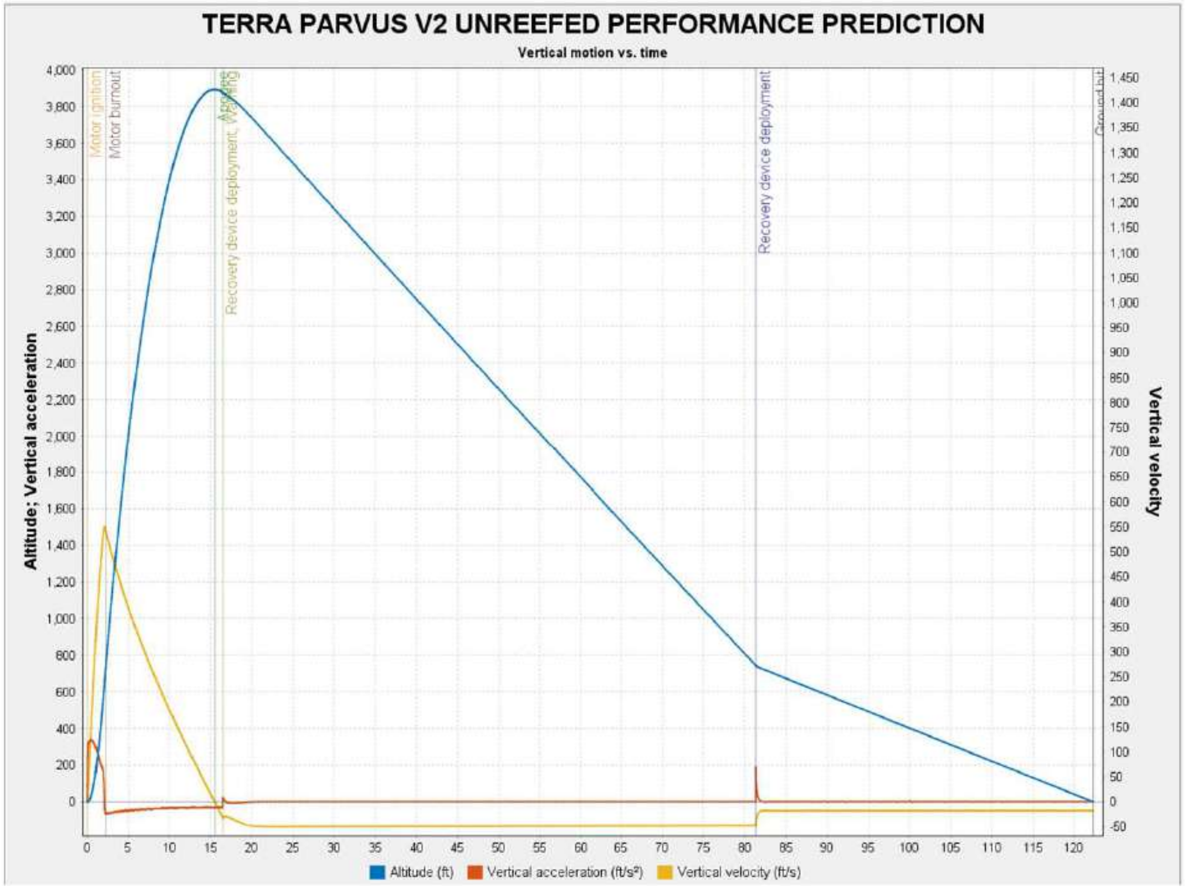
Recovery
- Reefing system not flown in launch 1
- System design overhaul
- First V2 flight – standard dual separation recovery
- Second V2 flight – successful reefing demonstration



SUBSCALE FLIGHT 2 PREDICTED PERFORMANCE

Predicted Performance		
Apogee	**Descent Time**	**MAX Impact Energy**
3893 ft	107 s	37.97 ft-lbs
Velocity off Rod	**Landing Vel**	**Heaviest Section**
83.6 ft/s	20.5 ft/s	5.82 lbs
Flight Notes		

- Standard dual deployment recovery
    - Wind speed: 12 ft/s



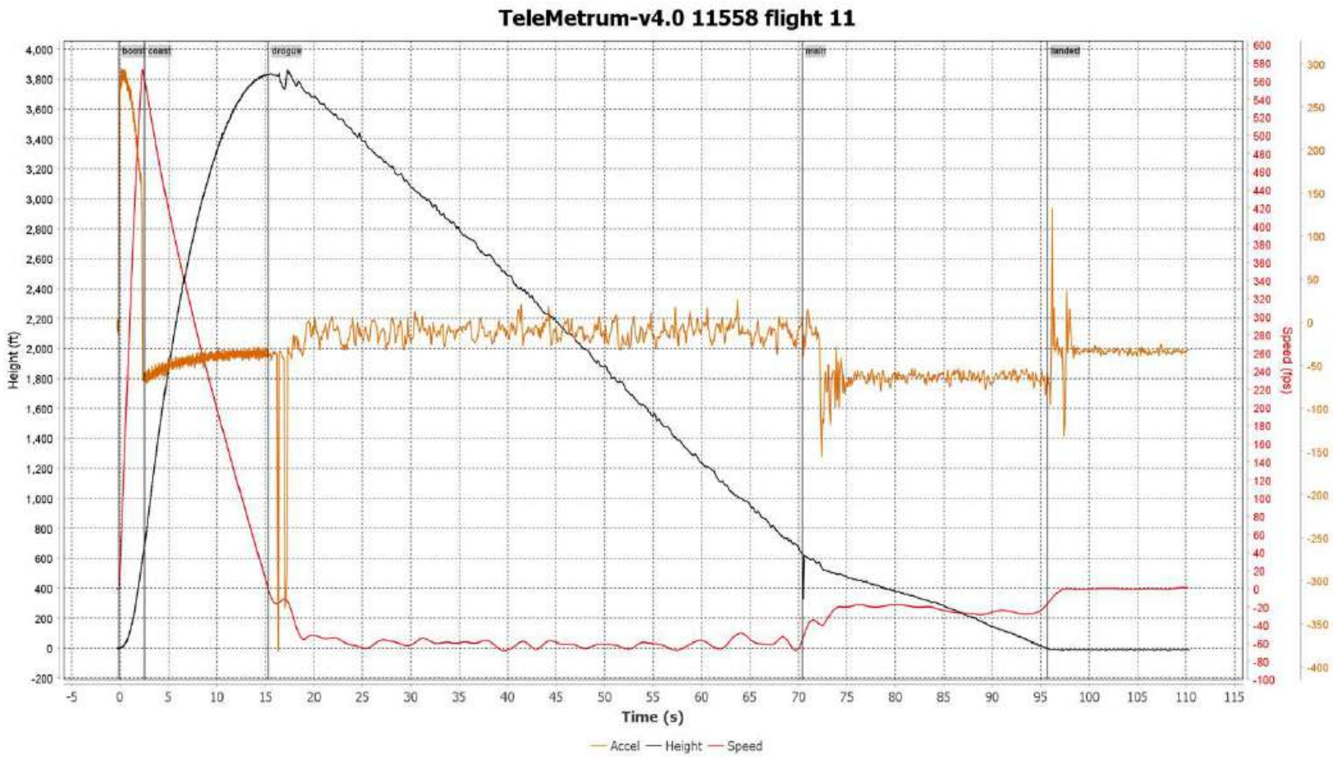
SUBSCALE FLIGHT 2

TERRA PARVIS V2

Key Data		
Apogee	**Descent Time**	**MAX Impact Energy**
3863 ft	80.4s	56.54 ft-lbs
Velocity off Rod	**Landing Vel**	**Heaviest Section**
~80 ft/s	25 ft/s	5.82 lbs

Flight Notes

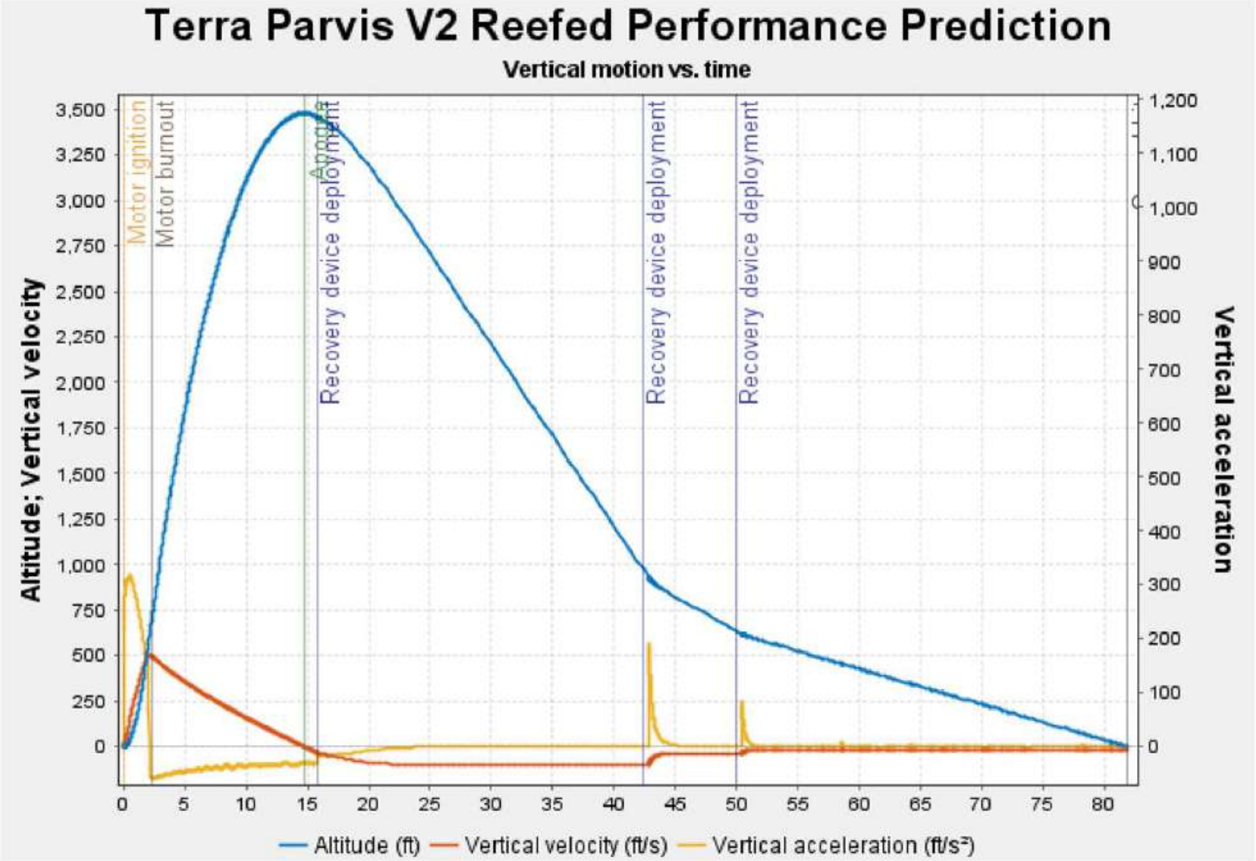
- Standard dual deployment recovery
- Wind speed: 12 ft/s
- Actual Apogee 30 ft above prediction
- Landing speed 4.5 ft/s above prediction
- Launched without reef to guarantee successful launch



SUBSCALE FLIGHT 3 PREDICTED PERFORMANCE

Predicted Performance		
Apogee	**Descent Time**	**MAX Impact Energy**
3477 ft	67.1 s	35.11 ft-lbs
Velocity off Rod	**Landing Vel**	**Heaviest Section**
81.3 ft/s	19.7 ft/s	5.82 lbs
Flight Notes		

- Reef System Included
- Wind speed 12 ft/s



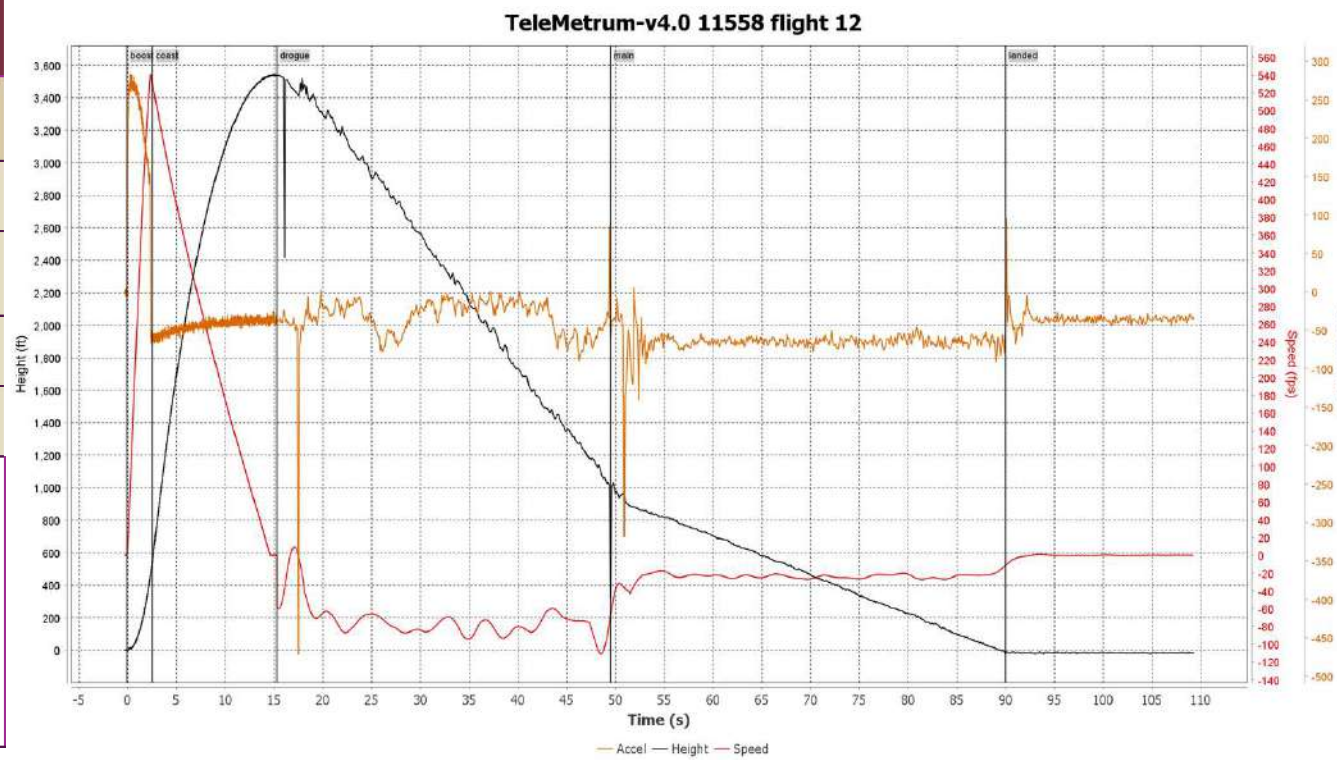
SUBSCALE FLIGHT 3

TERRA PARVIS V2

Key Data		
Apogee	**Descent Time**	**MAX Impact Energy**
3510 ft	74.7s	56.54 ft-lbs
Velocity off Rod	**Landing Vel**	**Heaviest Section**
~80 ft/s	25 ft/s	5.82 lbs

Flight Notes

- Wind speed: 12.7 ft/s
- Actual Apogee 33 ft above prediction
- Landing speed 5.3 ft/s above prediction
- Premature reef event due to separation pressurization



RECOVERY IMPLICATIONS

Parachute Sizing
- Comparing sim data to results shows potential underestimation of descent rates

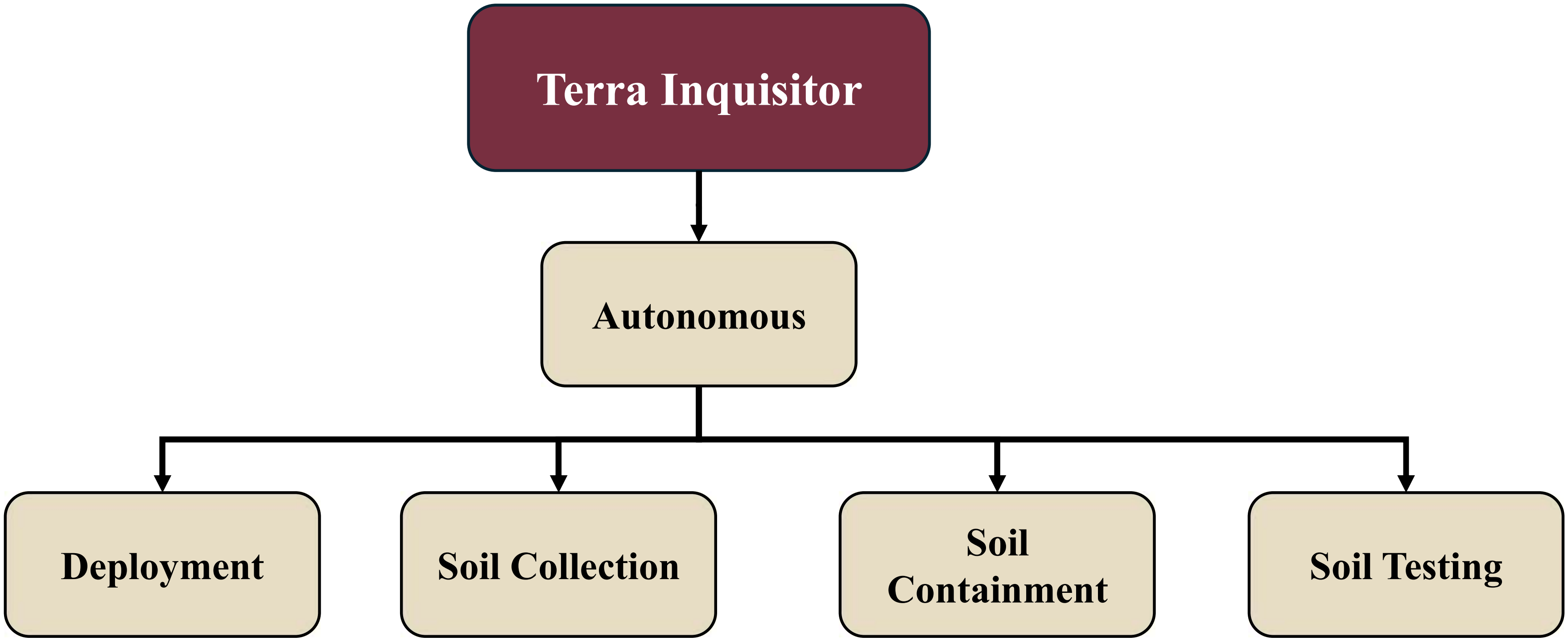
Reefing System
- Reefing system proven to be usable in flight
- Premature cutting needs to be addressed
- Parachutes proven able to handle high loads

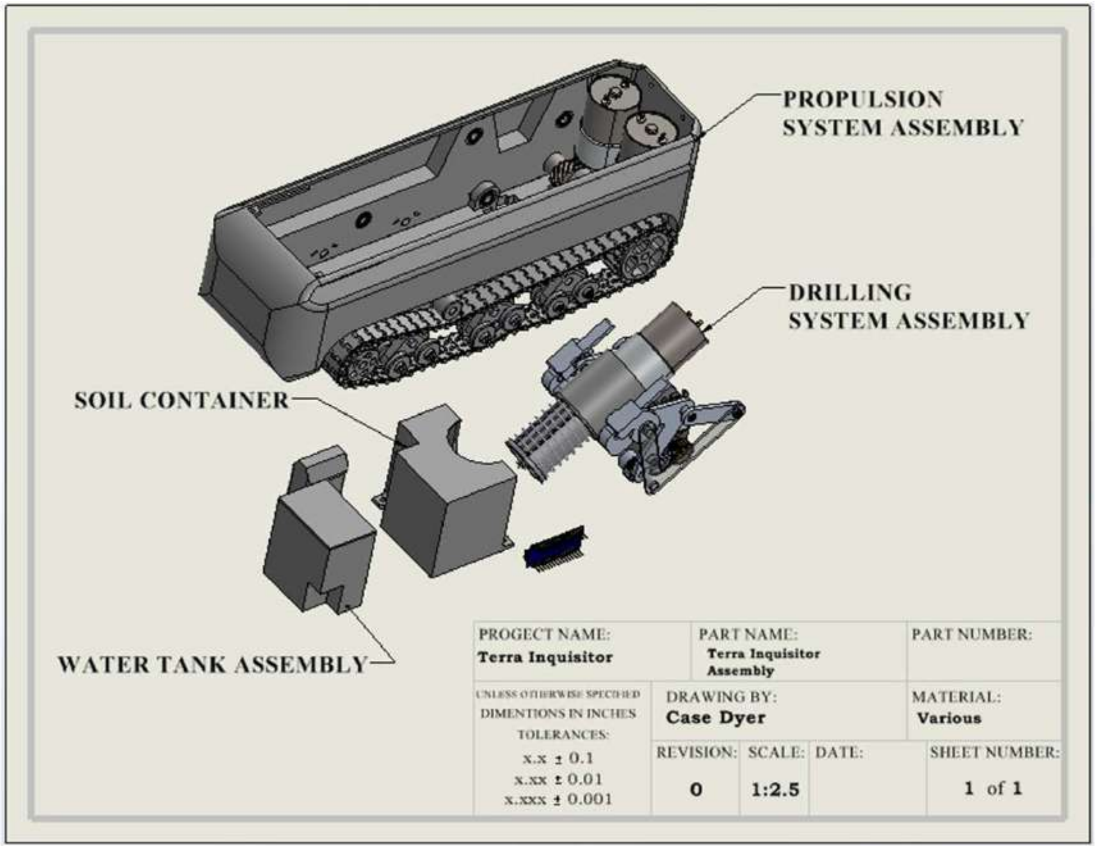
Deployment
- CO2 separation proven viable

New Reefing Initiation
- Inspired by subscale data
- Pressurization by CO2 release was read by Reefing electronics
- Effect: computer reads altitude significantly lower than actual value
- Considering using a timer rather than altimeter
- Computer detects separation, then begins a 4 second countdown

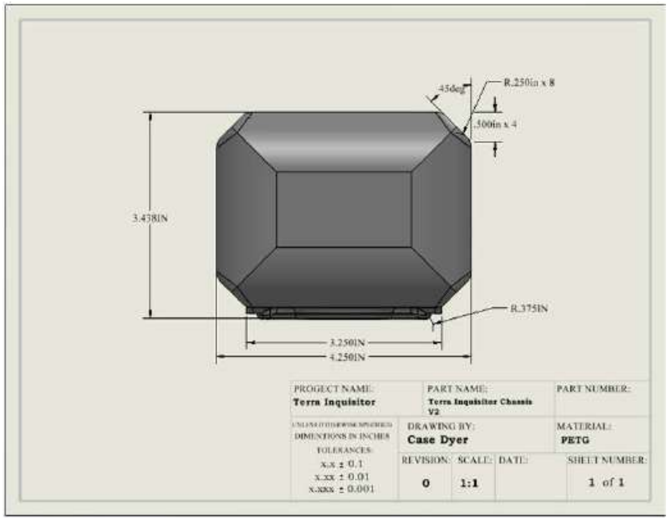
P A Y L O A D

PAYLOAD FUNCTIONAL DECOMPOSITION

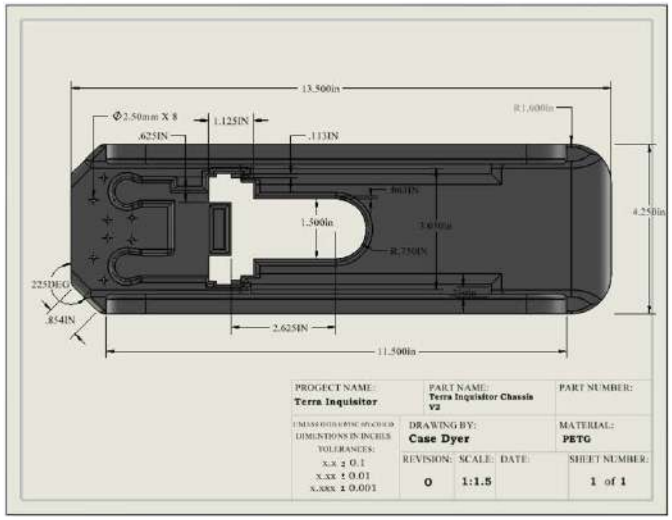



PROPULSION SYSTEM ASSEMBLY
DRILLING SYSTEM ASSEMBLY
SOIL CONTAINER
WATER TANK ASSEMBLY
PROGECT NAME: Terra Inquisitor
PART NAME: Terra Inquisitor Assembly
PART NUMBER:
UNLESS OTHERWISE SPECIFIED DIMENTIONS IN INCHES TOLERANCES:
x.x ± 0.1
x.xx ± 0.01
x.xxx ± 0.001
DRAWING BY: Case Dyer
MATERIAL: Various
REVISION: 0
SCALE: 1:2.5
DATE:
SHEET NUMBER: 1 of 1

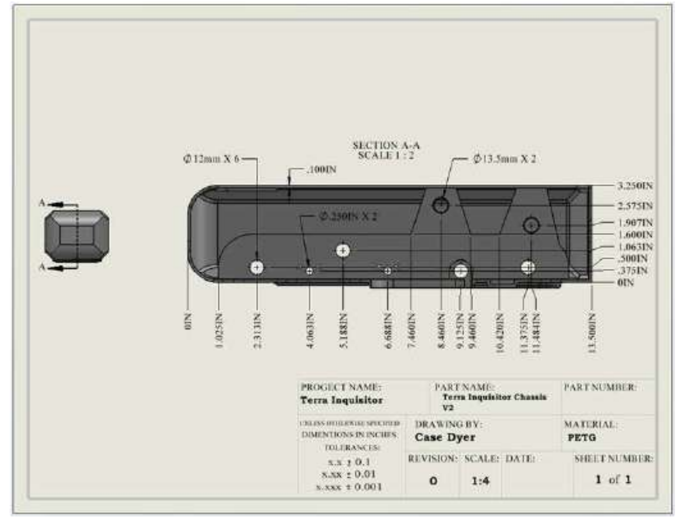
CHASSIS DIMENSIONS



Terra Inquisitor Front View

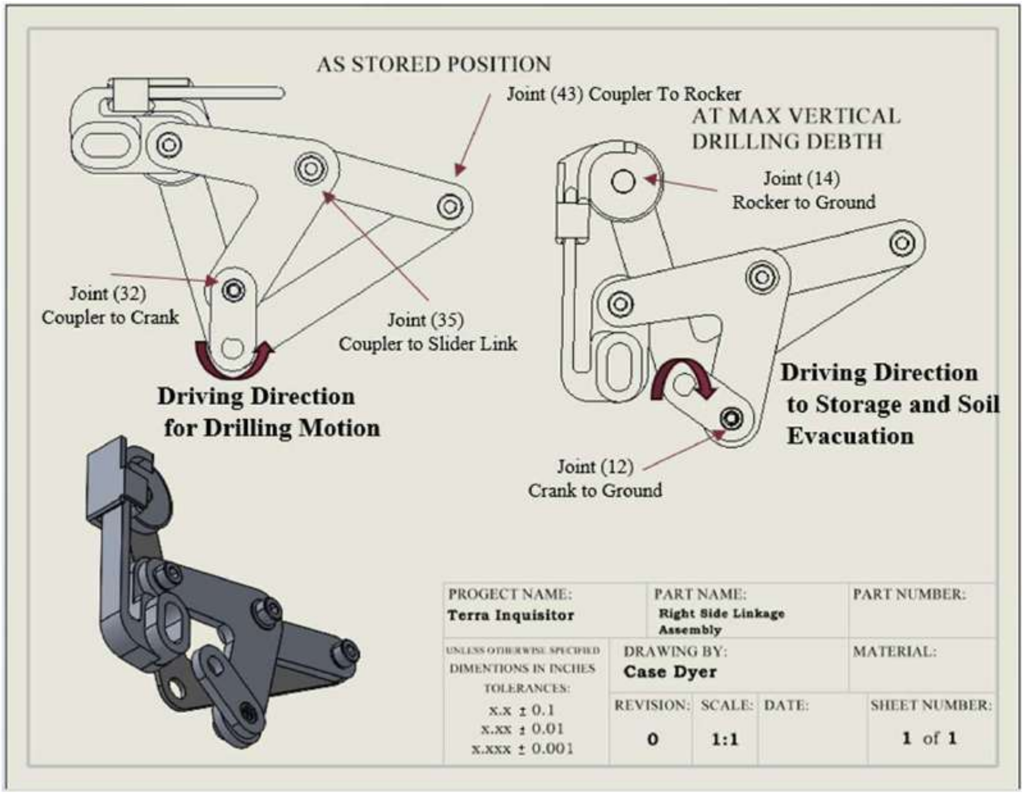


Terra Inquisitor Front Cross-Sectional View

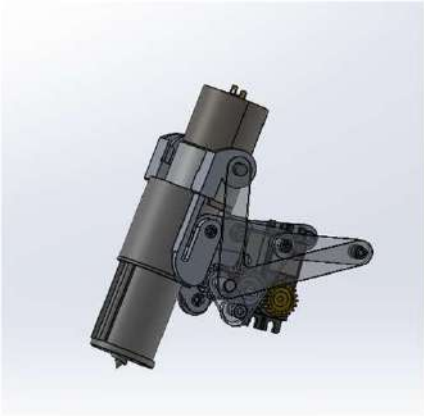


Terra Inquisitor Side Cross-Sectional View

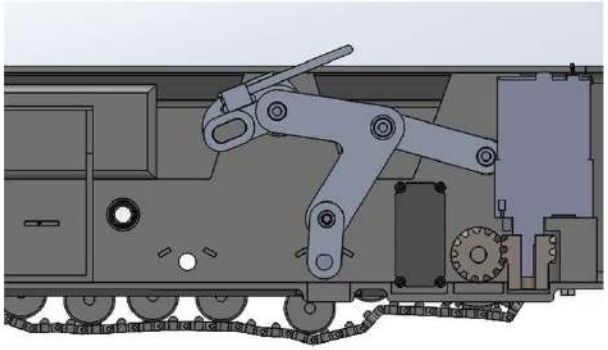
L I N K A G E   A S S E M B L Y



Right Side Drill Linkage Assembly

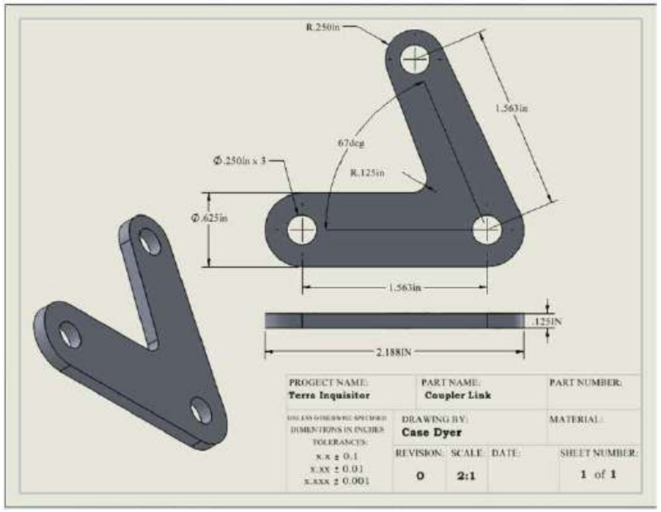


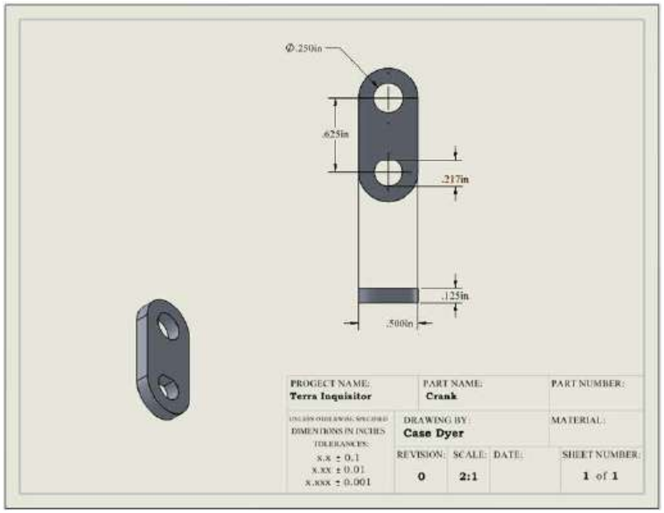
Terra Inquisitor Drill Assembly

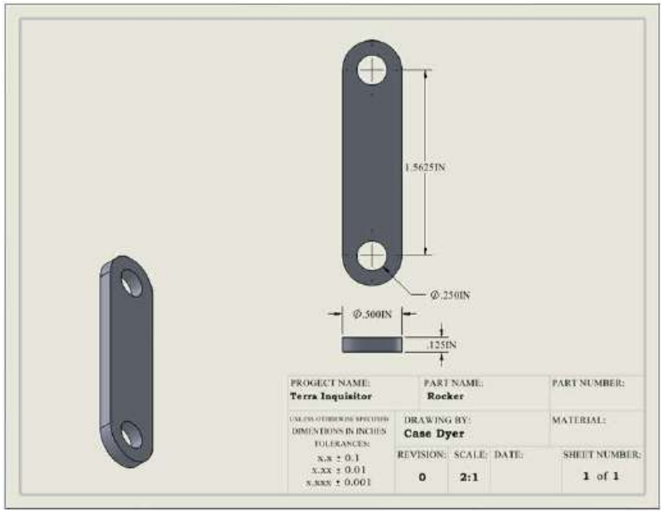


Terra Inquisitor Drill Linkage Inside Payload

LINKAGE DIMENSIONS







Coupler Drawing

Gamma Angle of 67°

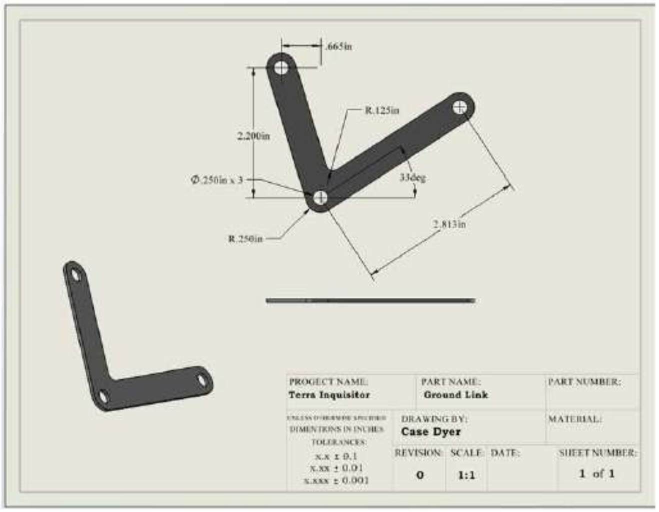
Crank Drawing

Primary Link Length = .625"

Rocker Drawing

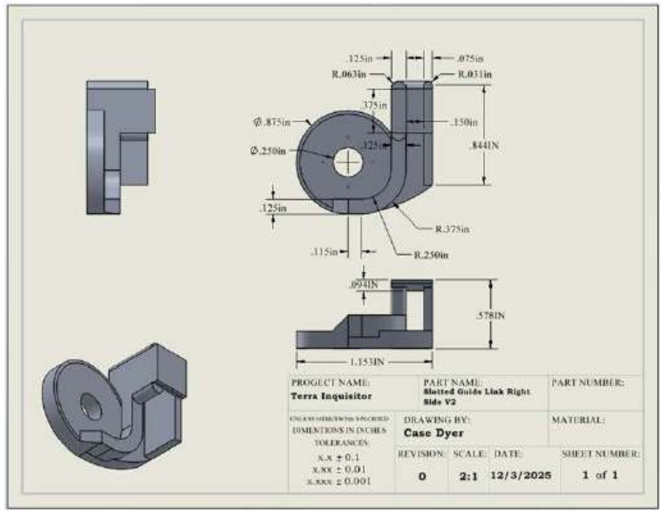
Primary Link Length = 1.5625"

LINKAGE DIMENSIONS

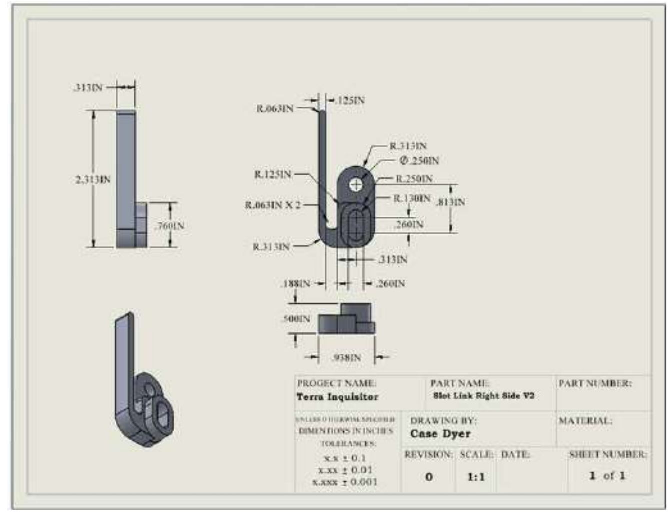


Ground Representation

Rotate Axis of 33°

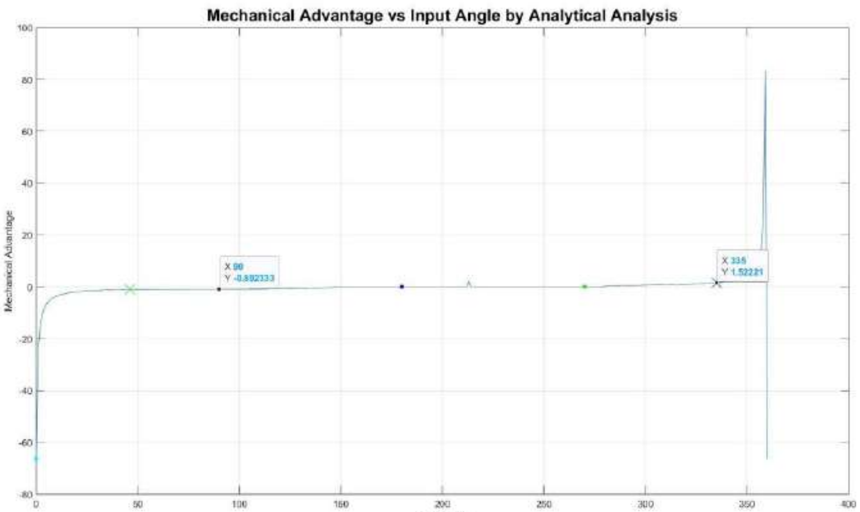


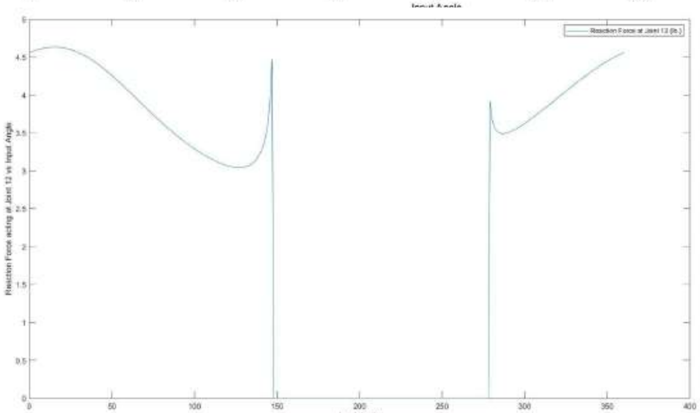
Slot Guide Drawing

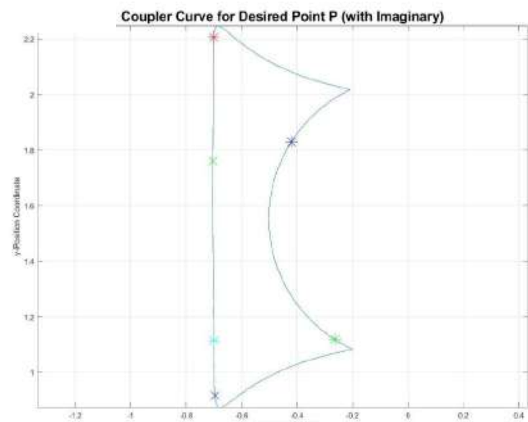


Slider Link Drawing

LINKAGE PERFORMANCE







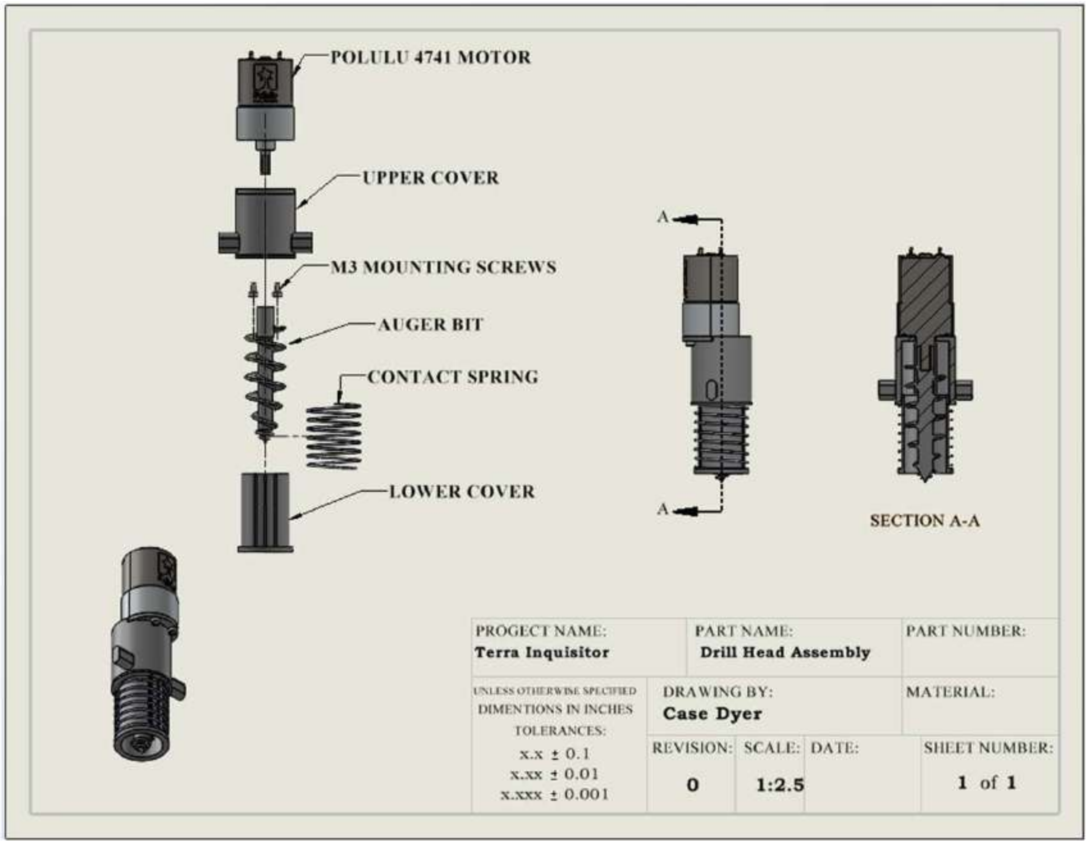
Vertical Distance
- 1.3”

Mechanical Advantage
- **Peak:** 66
- **Average During Drilling Range:** 4.4
- **Minimum During Drilling Range:** 1.5

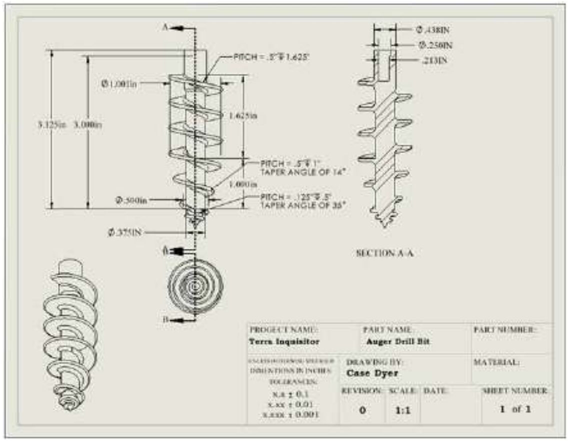
Max Linkage Force
- 5.24 lb.
- $\tau = 676\, psi\ for\ a\ 6mm\phi\ shaft$
- Using 304 Stainless Steel SF = 25

Assuming:
- Input Angular Velocity: ½ rad/s = 29°/s
- Initial Angular Acceleration: ½ rad/s^2
- Required force to drill: 6 lb.

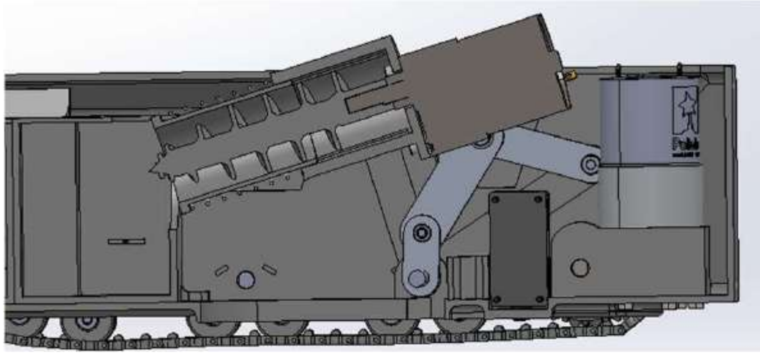
DRILL ASSEMBLY



Right Side Drill Linkage Assembly



Terra Inquisitor Auger



Terra Inquisitor Assembly Inside Payload

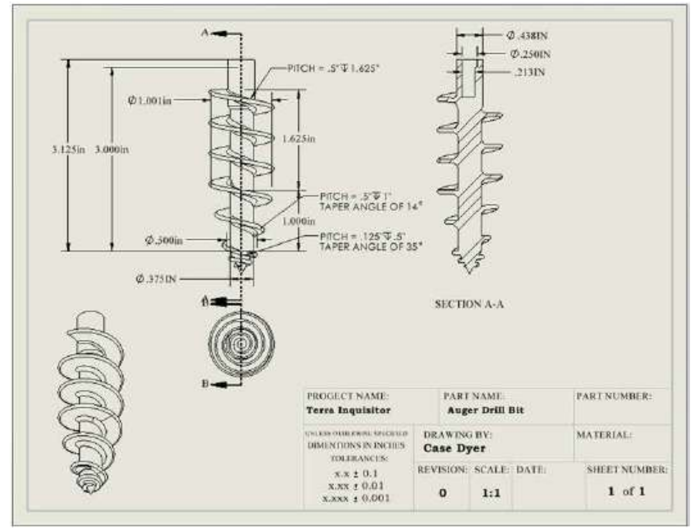
VERTICAL FORCE REQUIRED FOR SAMPLE COLLECTION

$$C = 100psf$$
$$\emptyset = 35°$$
$$\sigma_f = 4000\ psf$$
$$\sigma_f = C + \tan(\emptyset) * \sigma_n$$
$$\sigma_n = \frac{\sigma_f - C}{\tan(\emptyset)}$$
$$\sigma_n = \frac{4000\ psf - 100\ psf}{\tan(45°)}$$
$$\sigma_n = 3900\ psf$$
$$\sigma_n = \frac{F}{A}$$
$$F = 3900psf * \left(\frac{1}{2} * \left(\frac{(0.5in)^2}{144\ in^2}\right)\right) ft^2$$
$$F = 3.38\ lbs\ Required$$

Assumption: Largest cross-sectional area of drill used, worst case scenario according to case studies giving shear strength, cohesion, and angle of internal friction (1).

TORQUE REQUIRED FOR SAMPLE COLLECTION

M_{req} - Rotation moment required to shear the soil
M_{rot} - Rotational moment of drill bit
m_s - Mass of soil inside drill bore
R_{max} - Maximum radius of the flange
g - Gravity
α - Pitch angle of auger blade
ω - Rotational velocity of auger bit
K_i - Soil-against-soil friction ratios
$\tan(\varphi_{ag})$ - Friction coefficient soil-against-steel
$\tan(\varphi_s)$ - Friction coefficient soil-against-soil



Terra Inquisitor Auger Drill Head

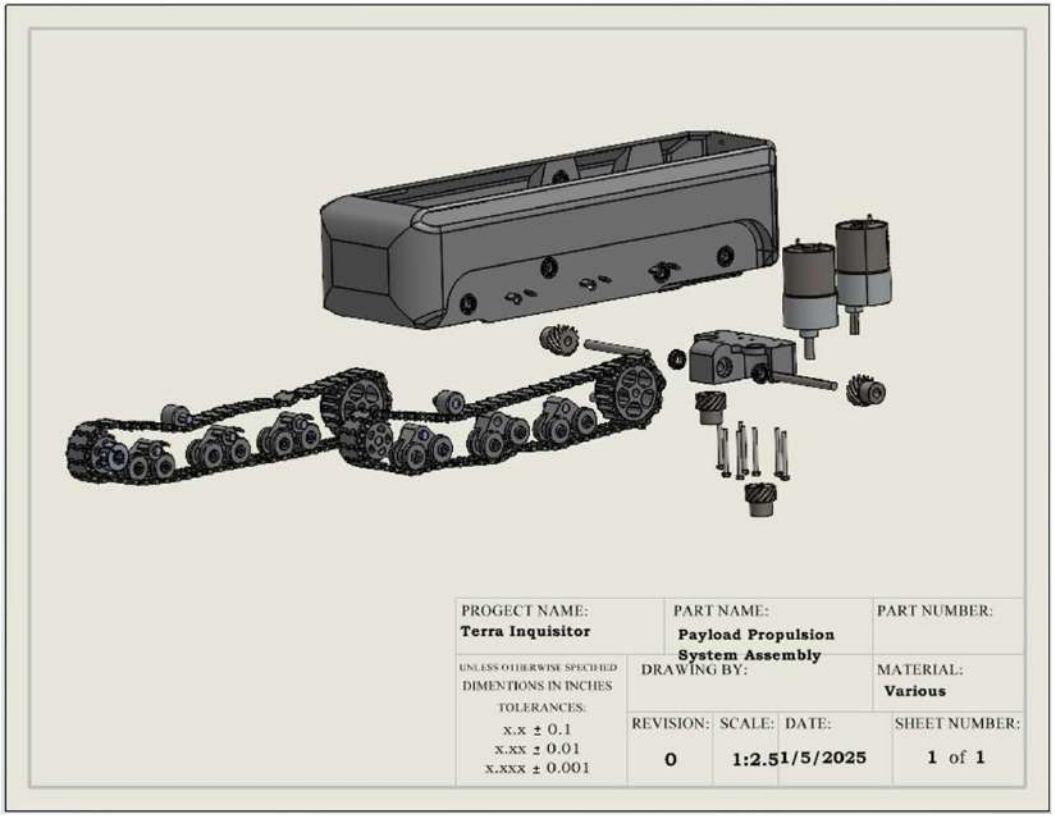
$$M_{req} = M_{rot}$$

$$M_{rot} = \tan(\varphi_{ag})\, m_s * [g\cos(\alpha) + \tan(\varphi_s) R_{max}\omega^2 \sin(\alpha)] * K_i \cos(\alpha) R_{max}$$

$$M_{rot} = \tan(45°)\, 0.0147kg * [9.81\cos(9.03°) + \tan(45°) * 0.014m * (0.796\frac{rad}{sec})^2 * \sin(9.03°)] * 1 * \cos(9.03°) * 0.014m$$

$$M_{rot} = 0.00155\, Nm$$

P R O P U L S I O N   S Y S T E M



Payload Propulsion System Assembly

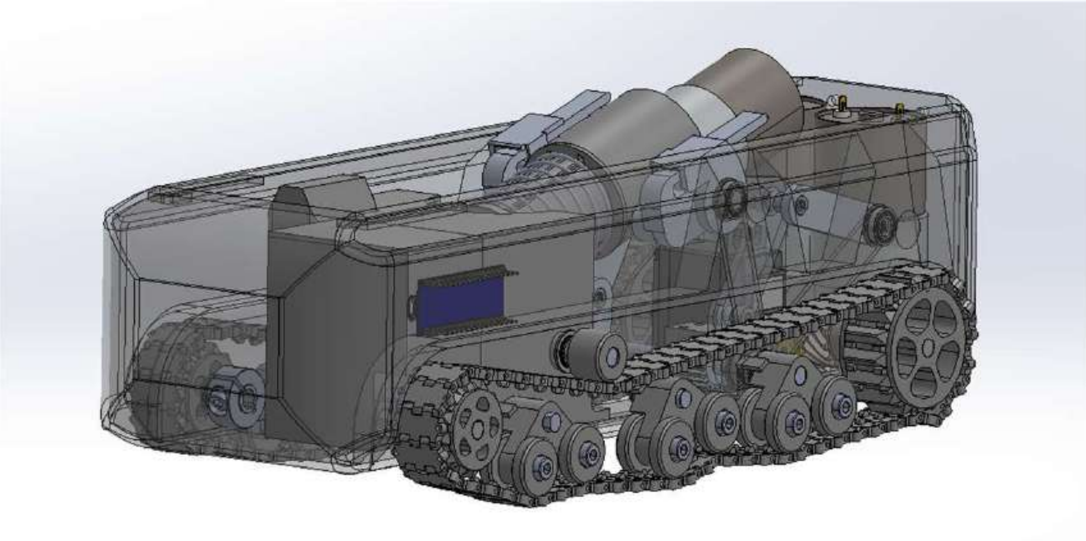
Payload Components List		
Item Number	Component Name	Quantity
1	Terra Inquisitor Chassis	1
2	Rear Sprocket	2
3	Front Sprocket	2
4	Idler Wheel	24
5	Wheel Rotator	6
6	Wheel Rotator Pin	12
7	Pololu 4741 Motor	2
8	3598N291	4
9	Lipo S3 Battery	1
10	Idler Wheel Assembly Guide	12
11	Track Chain	110
12	Track Pin	110
13	6mm ID Flanged Ball Bearing	14
14	6mm D-Shaft (Stainless Steel, 60mm Length)	2
15	2910-0919-0006.STEP	2
16	2800-0004-0010_90128A207.STEP	2
17	6mm D-Shaft (Stainless Steel, 30mm Length)	2
18	Rear Motor Mount	1
19	B18.6.7M - M3 x 0.5 x 30 Indented HHMS --30N	8
20	Tensioner Wheel	2
21	4mm ID Non-Flanged Ball Bearing (10mm OD, 4mm Thickness)	24

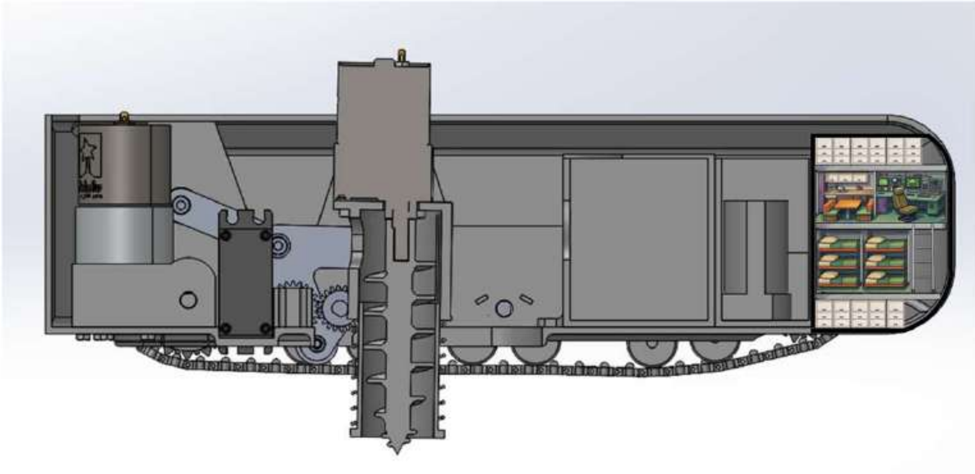
Payload Component List

Motor Selection:

- Required Torque per Motor: 42 oz-in
- Selected Motor: Pololu 37D 4741
- Provided Speed (No Load): 530 RPM
- Provided Stall Torque: 120 in-oz
- Max Efficiency Torque: 13.9 oz-in

FINAL PAYLOAD DESIGN OVERVIEW



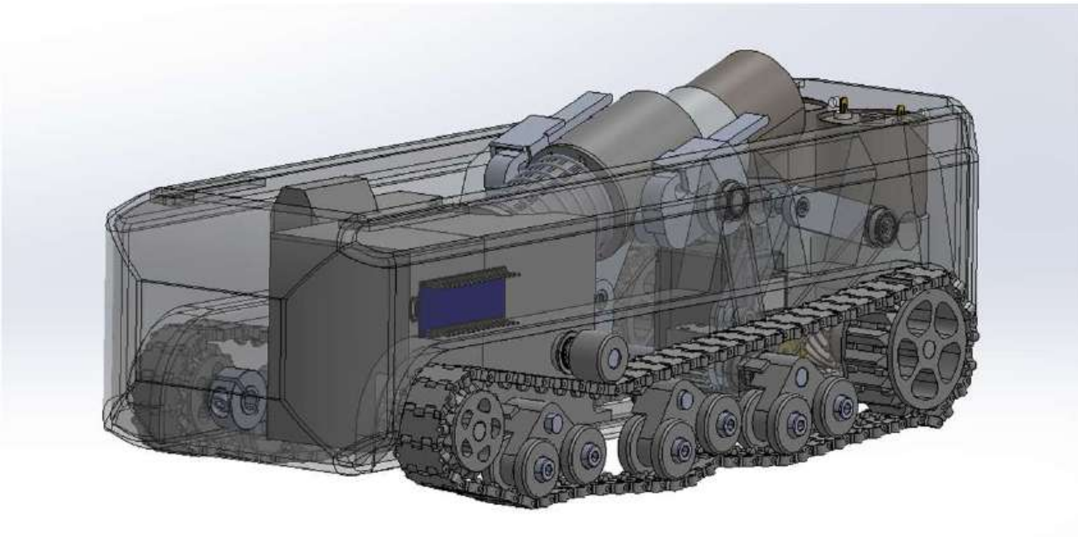


Side Section with Extended Housing

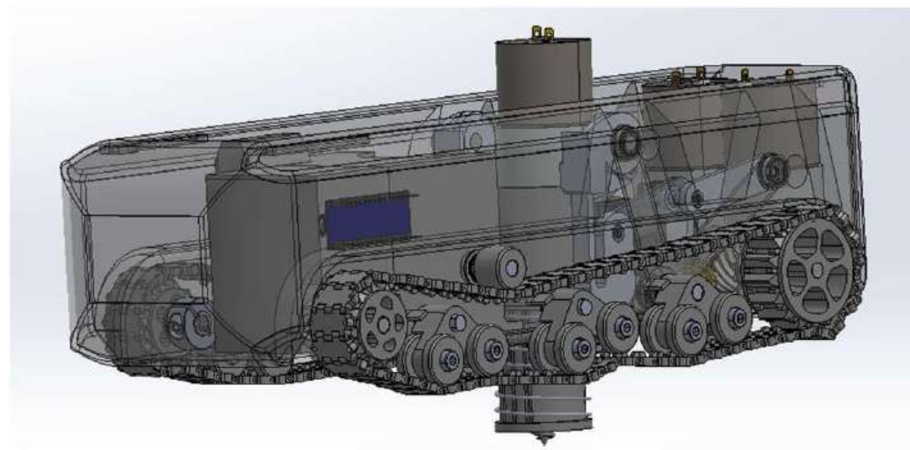
Predicted Payload Weight:

- 5.2 lb.

FINAL PAYLOAD DESIGN OVERVIEW



Payload Full Assembly with Stored Drill



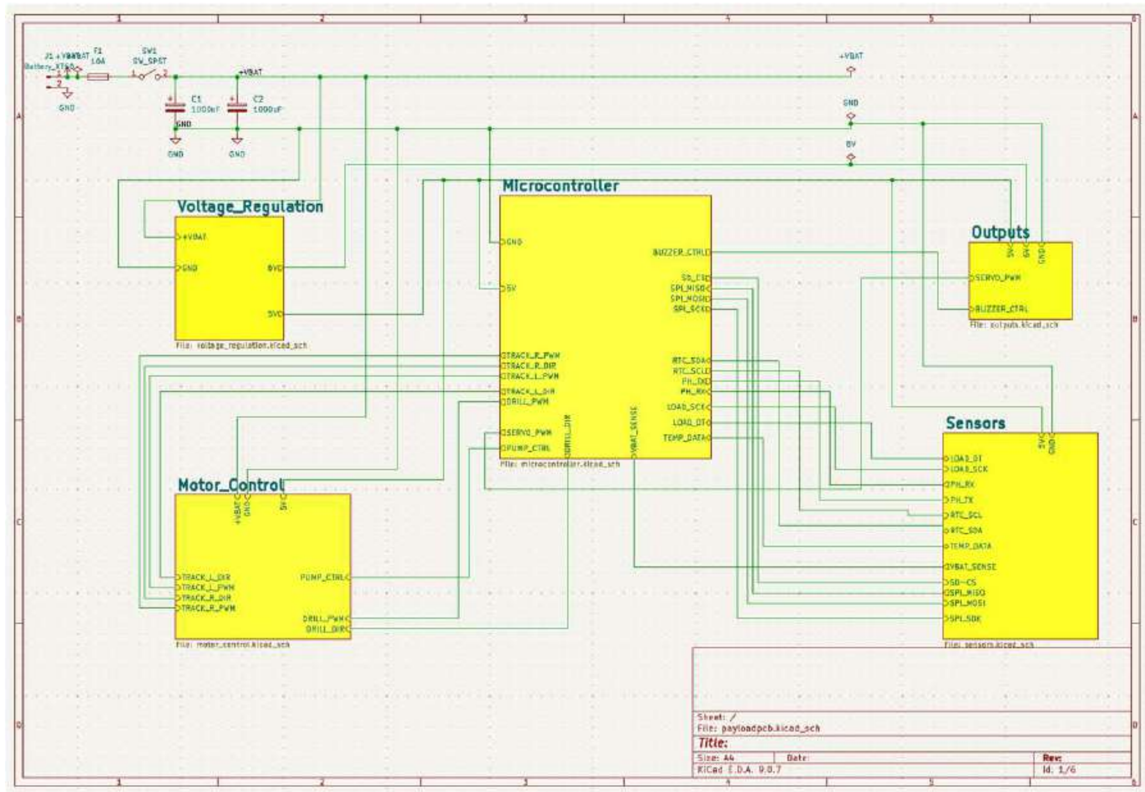
Payload Full Assembly with Actuated Drill

FINAL PAYLOAD DESIGN OVERVIEW

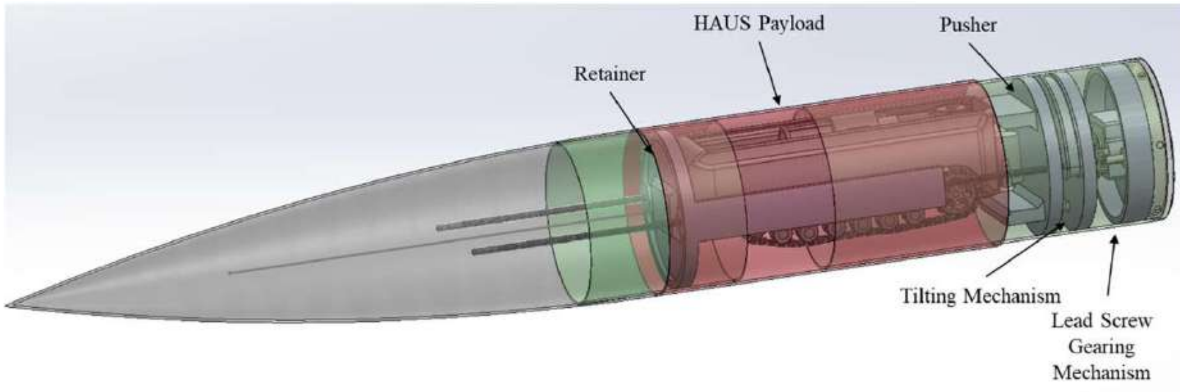
Payload Components List		
Item Number	Component Name	Quantity
1	Terra Inquisitor Chassis	1
2	Rear Sprocket	2
3	Front Sprocket	2
4	Idler Wheel	24
5	Wheel Rotator	6
6	Wheel Rotator Pin	12
7	4mm ID Non-Flanged Ball Bearing (10mm OD, 4mm Thickness)	24
8	Pololu 4741 Motor	3
9	3598N291	4
10	Lipo S3 Battery	1
11	Idler Wheel Assembly Guide	12
12	Track Chain	126
13	Track Pin	126
14	6mm ID Flanged Ball Bearing	15
15	6mm D-Shaft (Stainless Steel, 60mm Length)	2
16	6mm D-Shaft (Stainless Steel, 30mm Length)	2
17	Rear Motor Mount	1
18	B18.6.7M - M3 x 0.5 x 30 Indented HHMS --30N	8
19	Tensioner Wheel	2
20	Soil Container	1
21	Adfruit 4547 Submersible Pump	1
22	ENV-45-pH	1
23	Ground Link	2
24	Crank	2
25	Coupler Link	2
26	Rocker	2
27	Slotted Guide Link Right Side	1
28	Slot Link Right Side	1
29	Slot Guide to Ground Joint	2
30	1501 Series M4 x 0.7mm Standoff (6mm OD, 12mm Length)	2
31	M4 x 0.7mm Zinc-Plated Socket Head Screw (6mm Length)	8
32	2807 Series Stainless Steel Shim (6mm ID x 9mm OD, 0.50mm Thickness)	2
33	1501 Series M4 x 0.7mm Standoff (6mm OD, 8mm Length)	2
34	2807 Series Stainless Steel Shim (4mm ID x 7mm OD, 0.50mm Thickness)	6
35	1501 Series M4 x 0.7mm Standoff (6mm OD, 6mm Length)	4
36	Slotted Guide Link Left Side	1
37	Slot Link Left Side	1
38	Drill Bit Lower Cover	1
39	Auger Drill Bit	1
40	Drill Bit Upper Cover	1
41	B18.3.1M - 3 x 0.5 x 6 Hex SHCS -- 6NHX	4
42	6mm D-Shaft (Stainless Steel, 90mm Length)	1
43	2305 Series Brass, MOD 0.8, Servo Gear (25 Tooth Spline, 20 Tooth)	1
44	Servo Center Gear Block	1
45	Water Tank	1
46	B18.6.7M - M3 x 0.5 x 8 Indented HHMS --8N	4

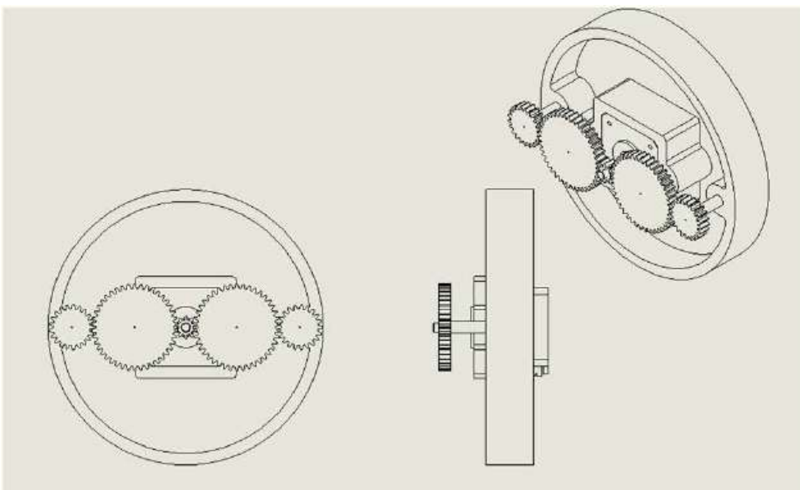
PAYLOAD INTEGRATION PLANS

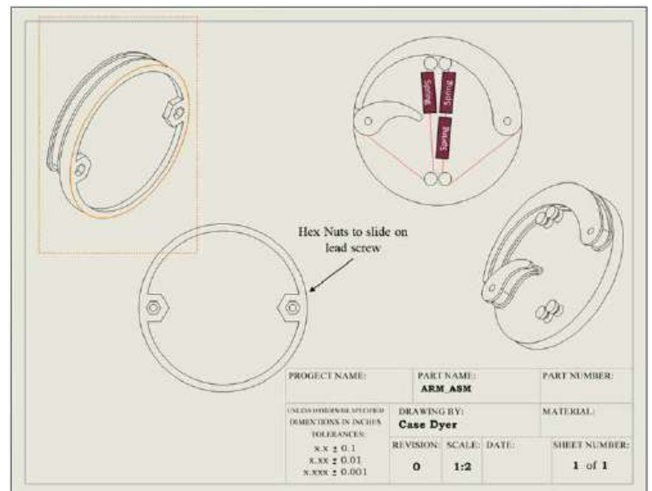
- Power System
- Microcontroller
- Voltage Regulation
- Motor Control
- Outputs
- Sensors



PAYLOAD RETENTION SYSTEM



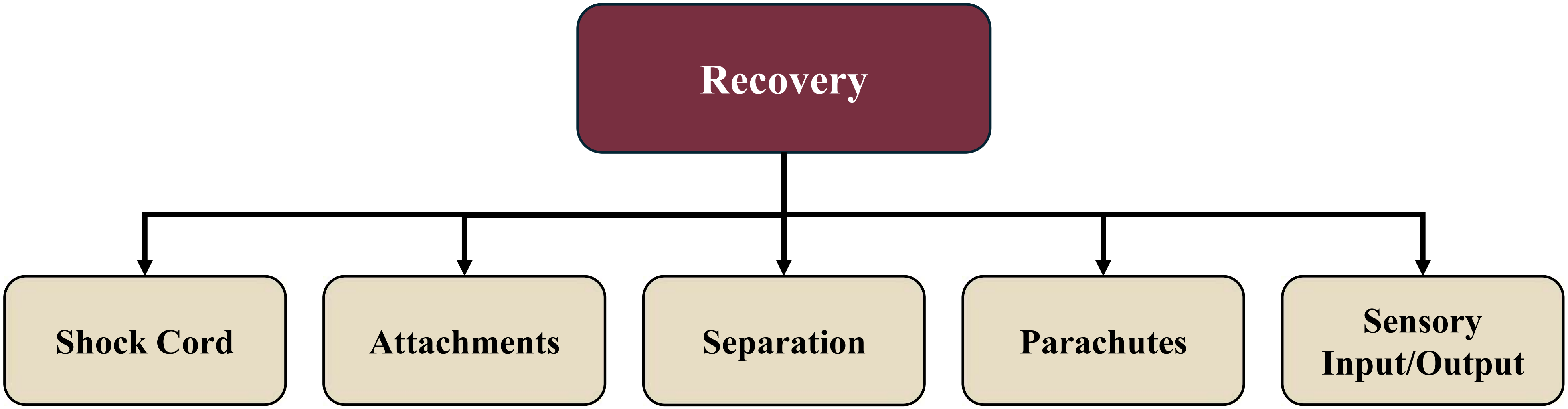




R E C O V E R Y

FUNCTIONAL DECOMPOSITION

RECOVERY SYSTEM



RECOVERY SYSTEM SELECTION

Recovery Selections					
Shock Cord			Separation		
Problem	**Selection**	**Justification**	**Problem**	**Selection**	**Justification**
Shock Cord Material	Paramax Cord	• High TS (1200lb) • Low Weight • Elasticity	Method	CO2 Ejection	• Minimal Pyrotechnics Needed • Safe for Recovery Hardware
Supplementary Cord Material	Paracord 550	• Moderate TS (550lb) • Low Weight • Elasticity	Drogue Separation	Apogee	• Specified Requirement by NASA
Shock Cord Length	4x Rocket Length (40 ft)	• Prevents Collision • Sufficient Length	Main Separation	1000 ft	• Meets Energetic Altitude Requirement • Sufficient Height for Sequencing
			Main Sequence Event	650 ft	• Meets Energetic Altitude Requirement • Achieves Flight Time and Impact Energy Goals

RECOVERY SYSTEM SELECTION

Recovery Selections								
Parachute			Attachments			Sensory Input/Output		
Problem	**Selection**	**Justification**	**Problem**	**Selection**	**Justification**	**Problem**	**Selection**	**Justification**
Main Sequencing	Reefed Main	• Accomplishes Time to Ground and Impact Energy Goals • Simpler than Pilot-Main Design	Cord Attachment Device	Eye Bolt	• Single Load Concentration • Distributes Load Across Bulkhead	Event Control	Barometric Altimeter/ Flight Computer	• Separation 1 at Apogee • Separation 2 at 1000 ft • Reef Cut at 650 ft
Drogue Size	15”	• Accomplishes Time to Ground and Impact Energy Goals	Cord Attachment Device	Quick Link	• Quick Attach/Detach from Eye Bolt	Event Initiation	E-Matches to Black Powder	• CO2 Canisters & Reef Cutters initiated via Energetic Event
Reefed Main Size	36”	• Accomplishes Time to Ground and Impact Energy Goals	Cord Attachment Material	Stainless Steel 316	• Commercially Available Parts • Sufficient Strength	Event Engagement	Eagle CO2 System	• Sharp Pin Releases CO2 • Requires Little Energetic Mass
Full Main Size	120”	• Accomplishes Time to Ground and Impact Energy Goals				Power Device	3.8 V Lithium Battery	• Sufficient Power Capability for All Devices

A V I O N I C S   B A Y

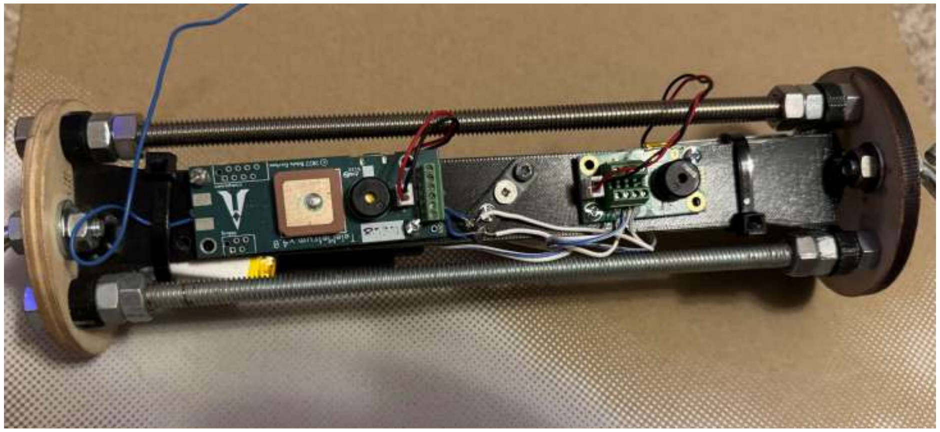
Flight Computer – Telemetrum & EZ Mini Computers

Power Supply – Energizer Ultimate Lithium 3.8V (L522)

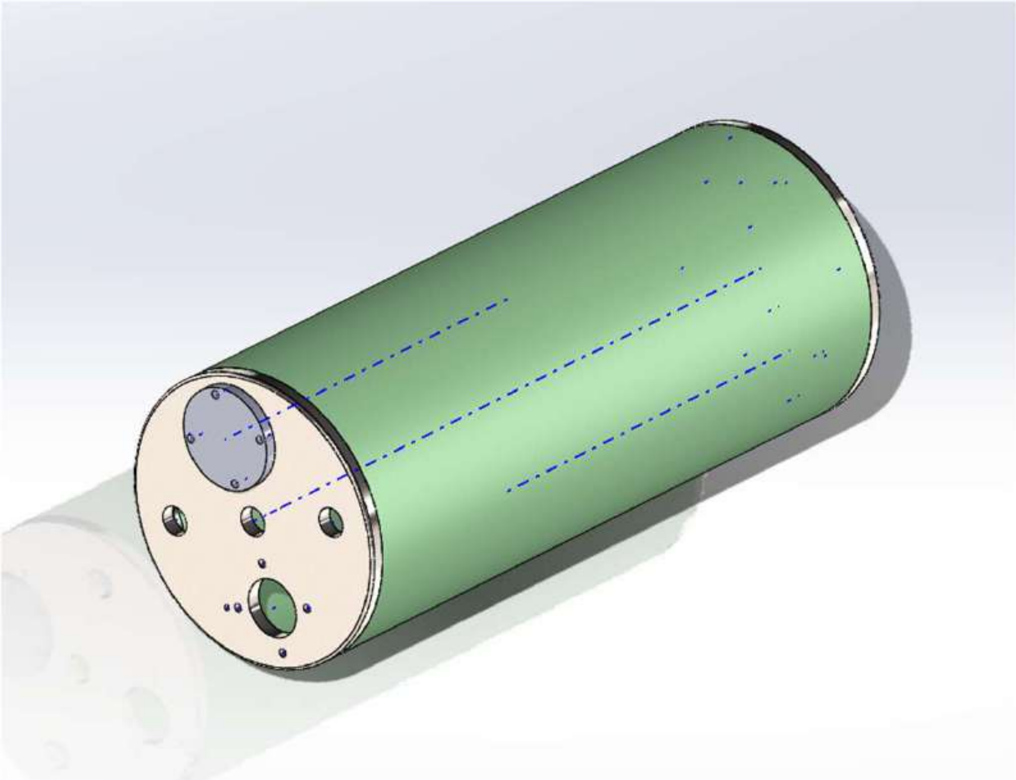
Ejection System – TR Eagle CO_2 Ejection Device

Arming Device – Screw Switch

Material Makeup – 3D Printed Material (PLA/PETG)



Subscale AV Bay



AV Bay SOLIDWORKS Part

E J E C T I O N   S Y S T E M

Two Stage Main Deployment

- Tinder Rocketry's Eagle CO_2 Ejection System
- 38 g CO_2 canisters
- 2 each side, 1 for redundancy
- E-Matches to contained charge

Drogue Release

- Sep Body tube 1 & 2
- Event initiated at apogee

Main Release

- Sep Body tube 2 & 3
- Event initiated at 1000 ft

TR Peregrine

TR Eagle

C O 2 C A R T R I D G E S I Z I N G

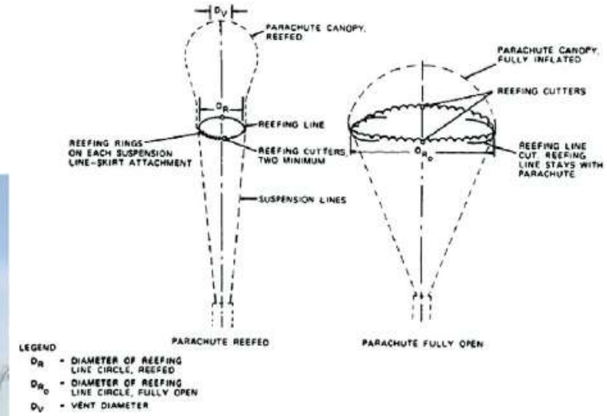
Testing
- Subscale "Terra Parvis V2" tested with TR Peregrine CO2 System
- 7 ejection tests conducted

Results
- 6/7 tests successful
- Failed test had specific cause
- Consistent separation proven

Full Scale Relation
- Sub & full-scale geometries related
- Related CO2 (grams) / volume
- 25g (fwd) 38g (aft) selected
- 38g each for redundancy

Tested 8g CO2 Canisters
Successful (Left); Malfunctioned (Right)

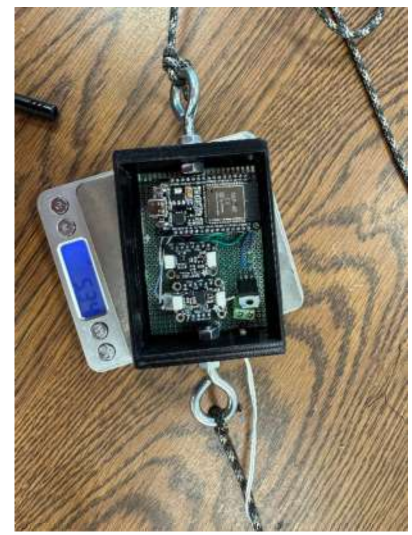
REEFING & CUTTING SYSTEM



Two Stage Main Deployment

120” Parachute
- Deployed at 1000 ft
- Reefed to 36”
- Reef Cut after 4 seconds (~650 ft)

Initiation
- Isolated flight computer/power supply
- E-Matches to contained charge



Testing
- Several tests conducted to prove concept
- Successful demonstration in subscale flight 3

R E E F I N G & C U T T I N G S Y S T E M T E S T I N G

Test Materials

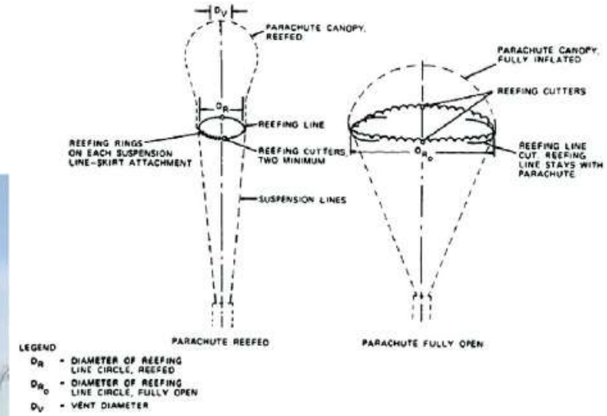
- 72” Parachute from first subscale used for testing
- Moving vehicle used to simulate wind speed

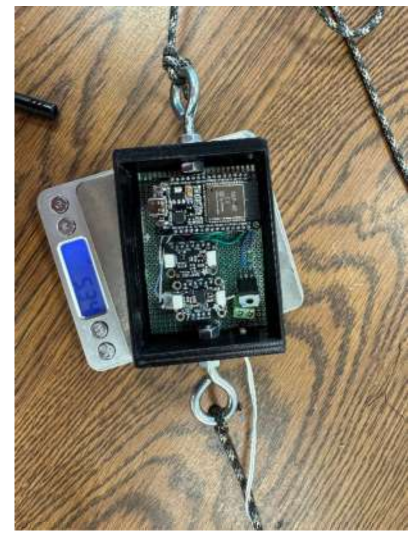
Test Parameters

- Parachute reefed to 24”
- Tested up to 40mph (58.67 ft/s)

Test Results

- Reefing system proved viable
- Difficult to simulate true deployment forces
- Test served to prove chute deploys properly
- Subscale flight 3 proves design can handle recovery





AVIONICS BAY COMPUTER CONFIGURATIONS

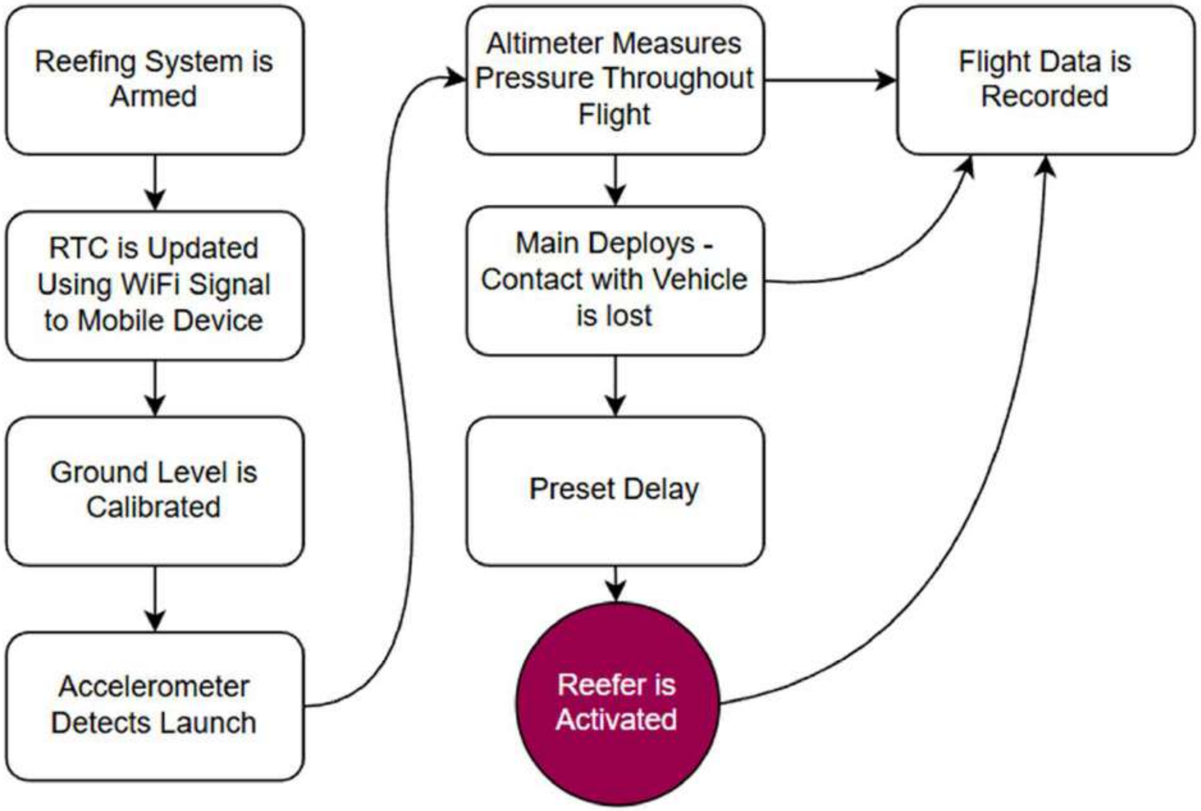
Flight Computer: Altus TeleMetrum

Redundant System: Altus EasyMini

Configuration Software: AltOS

Recovery Electronic Configurations			
Criteria	TeleMetrum	EasyMini	Reefing Computer
Mode	Dual Deployment	Dual Deployment	Single Deployment
Drogue	Apogee	Apogee	N/A
Main	1000 ft	1000 ft	650 ft
Location	AV Bay	AV Bay	Main Parachute
Arming	Screw Switch	Screw Switch	Wireless

REEFING & CUTTING SYSTEM STATE DIAGRAM



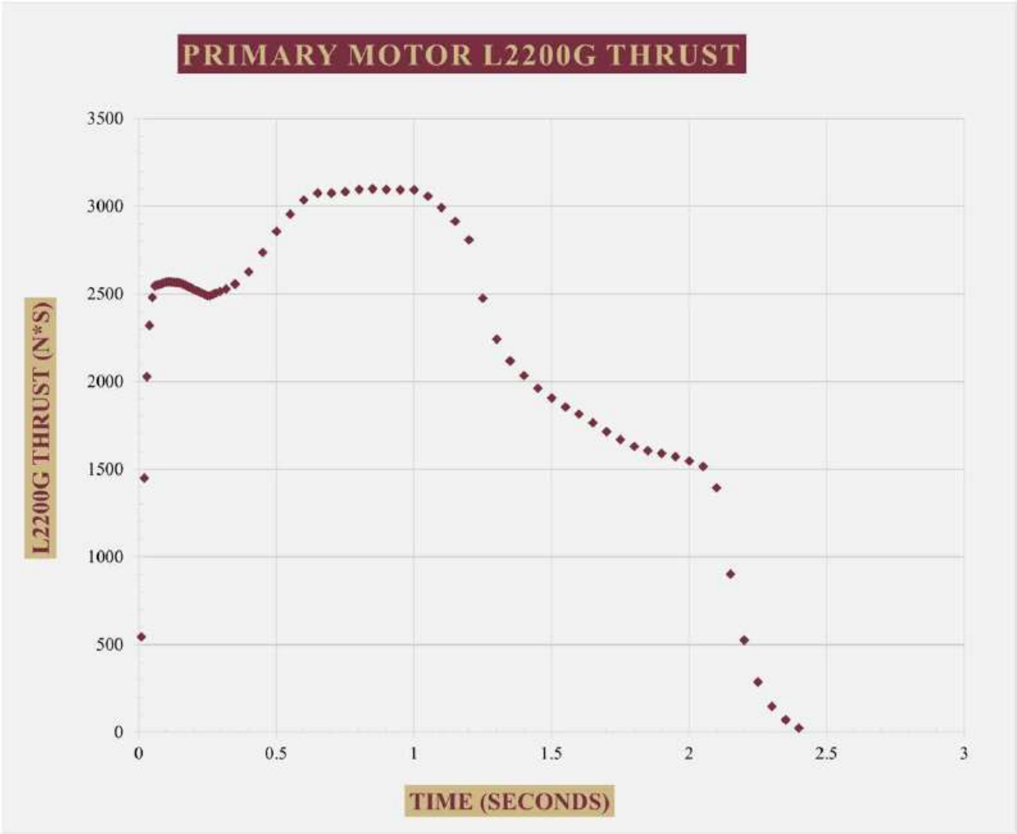
LAUNCH VEHICLE PREDICTED PERFORMANCE

ROCKET PERFORMANCE PREDICATIONS

Motor Selection		
Primary Motor	**Secondary Motor**	**Tertiary Motor**
L2200G-0	**L1420R-P**	**L1395**
Justification		
• Average Apogee of 5141 ft • Total Impulse: 5104Ns	• Average Apogee of 4133 ft • Total Impulse: 4585 Ns	• Average Apogee of 4808 ft • Total Impulse: 4783 Ns

L2200G-0:

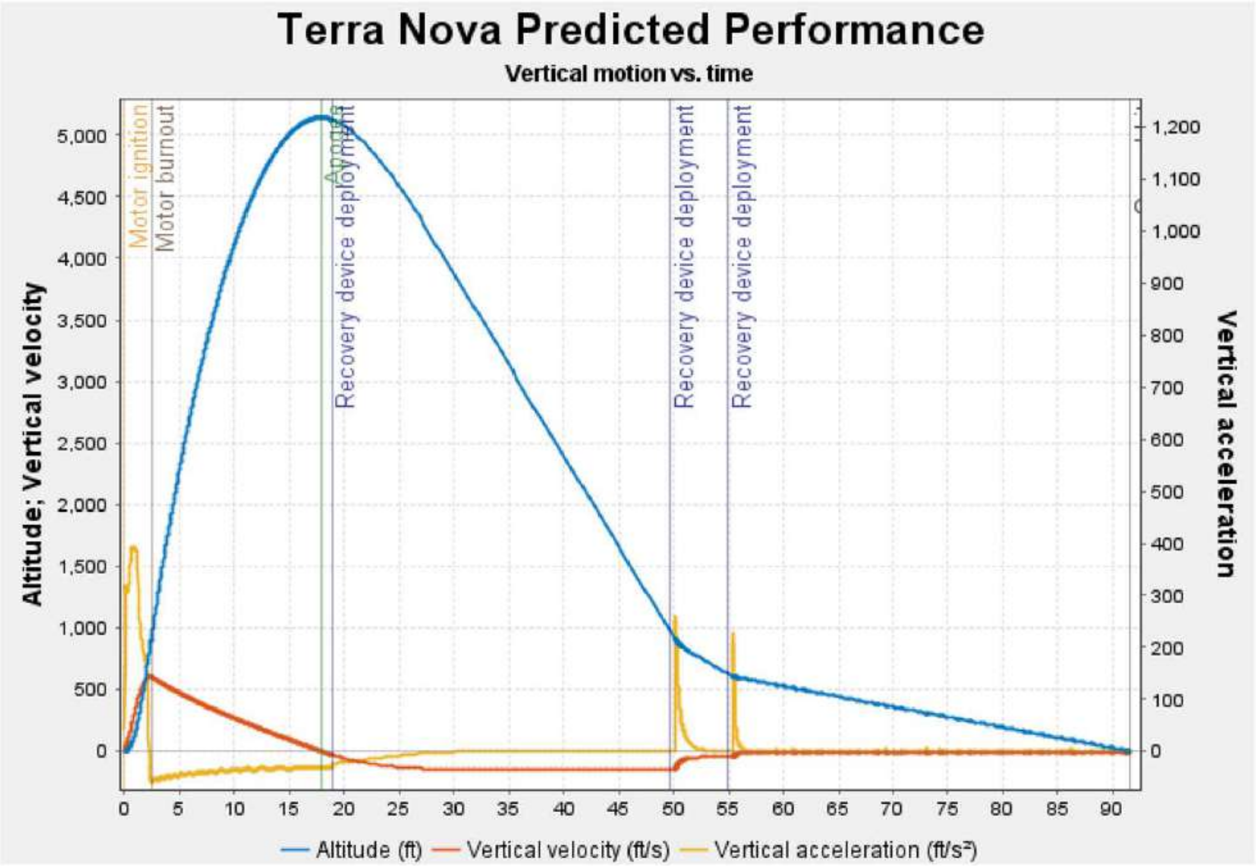
- Thrust to weight ratio: 9.88:1.0
- Maximum Thrust: 3099 N
- Average thrust: 2243 N



ROCKET PERFORMANCE PREDICATIONS

Predicted Performance		
Apogee	**Descent Time**	**MAX Impact Energy**
5141 ft	73.7 s	57.12 ft-lbs
Velocity off Rod	**Landing Vel**	**Heaviest Section**
81.8 ft/s	16.5 ft/s	13.50 lbs
Flight Notes		

- Drogue at Apogee
- Reefed Main at 1000 ft
- Reef cut after 4s (~650 ft)
- Highest Deployment Force: 315 lbs
- Wind speed: 11 ft/s

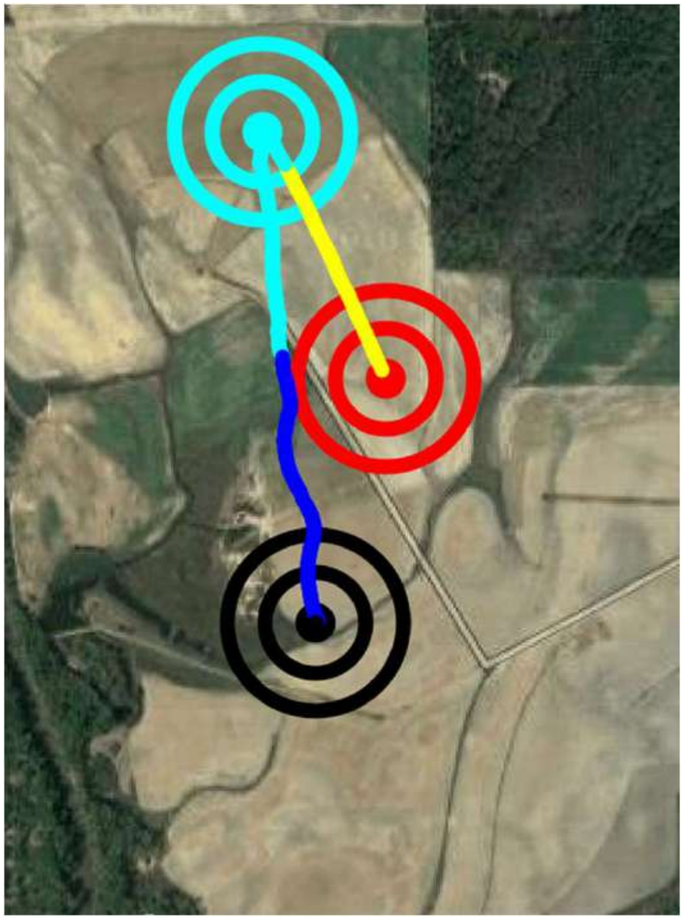


WIND DRIFT CALCULATIONS

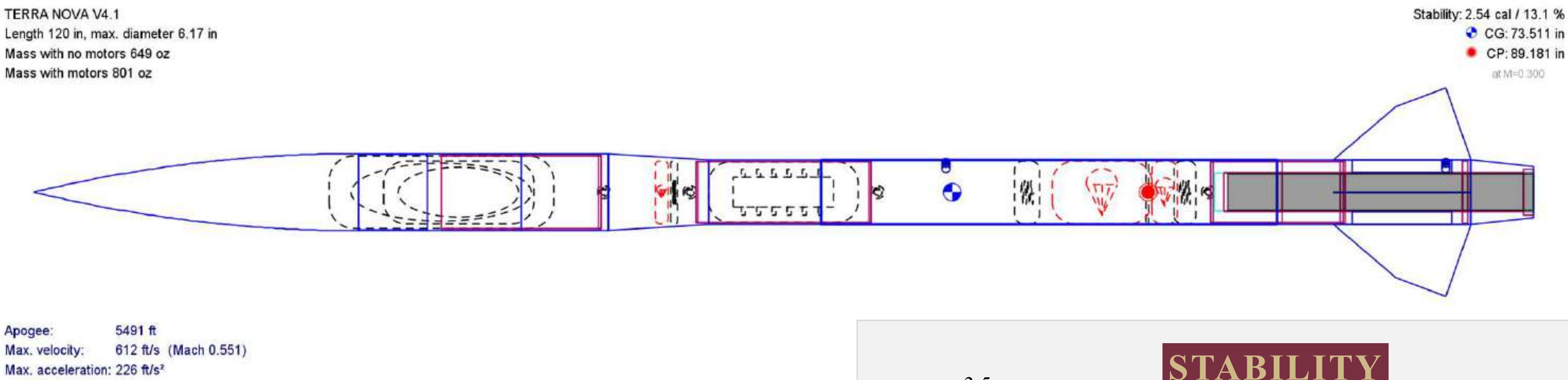
Descent Drift			
5 MPH Wind	10 MPH Wind	15 MPH Wind	20 MPH Wind
540 ft	1081 ft	1621 ft	2162 ft

Descent Rates		
15” Drogue	36” Reef	120” Main
146 ft/s	51 ft/s	16.5 ft/s

APOGEE: 5141 ft
DESCENT TIME: 73.7 s

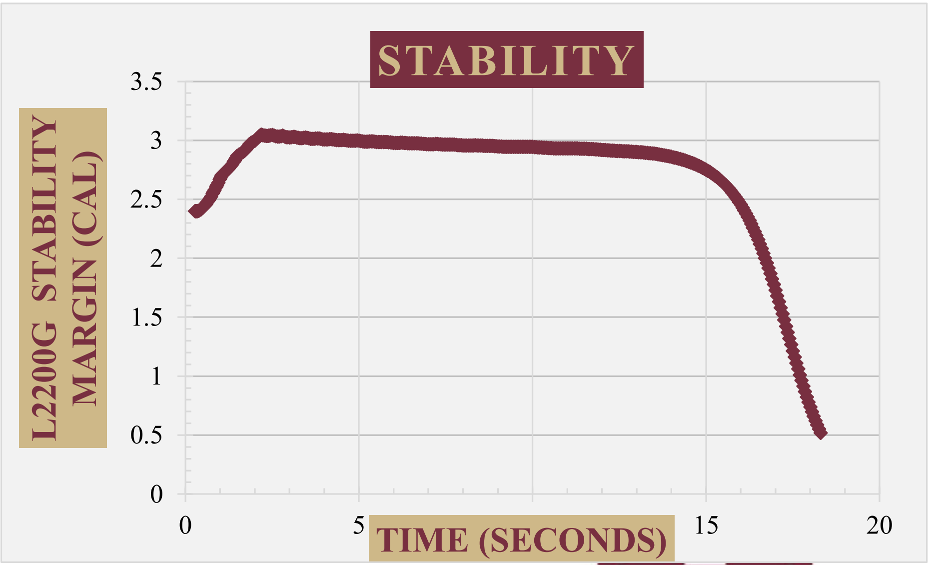


ROCKET STABILITY



Stability (Cal)		
Minimum	Maximum	Static Stability
0.5	3.05	2.4

CG: 73.51” AFT
CP: 89.18” AFT



S A F E T Y

Pre-Launch

- Oversee final vehicle integration and readiness
- Verify safety, arming states, and configuration compliance
- Support launch readiness and resolve discrepancies

Launch

- Support pad operations and final safety checks
- Coordinate with mentor, RSO, and range personnel
- Assist with troubleshooting and launch execution

Post-Launch

- Assist with post-flight inspection and data retrieval
- Support cleaning and disassembly

THANK YOU!

ANY QUESTIONS?

S O U R C E S

1. Xuan, M., Montgomery, J., Anderson, J. B., & Kiernan, M. (2023). *Characterizing strength loss in high plasticity clays along Alabama highways* (Final Report No. 930-988). Highway Research Center, Department of Civil Engineering, Auburn University. Submitted to the Alabama Department of Transportation. https://www.eng.auburn.edu/files/centers/hrc/930-988-final-report.pdf

A P P E N D I X

LAUNCH VEHICLE DIMENSIONS

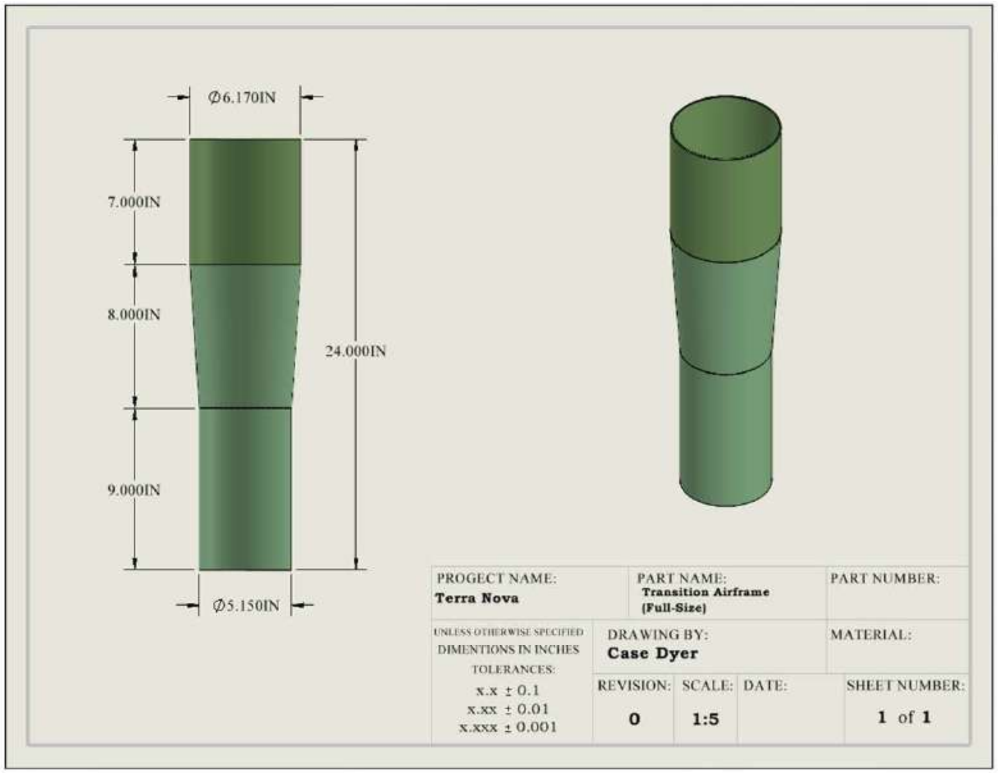
General Dimensions		
Airframe Component	Measurement	Weight (oz)
HAUS Section	Primary ID: 6” Primary OD:6.17”	
Nose Cone	·Shape: 4:1 Ogive ·Base OD: 6.17” ·Length: 24”	26
Nose Cone Shoulder Length	Length: 5.5”	0
Body Tube 1	Length: 13”	25.6
Terra Inquisitor	Length: 13.5"	96
Mechanical Separation	Full Section	40
HAUS Section Coupler	Length: 12.75”	25.5
HAUS Bulkhead	Thickness: 3/16”	23.4
HAUS Recovery Hardware	I-bolt Assembly	3

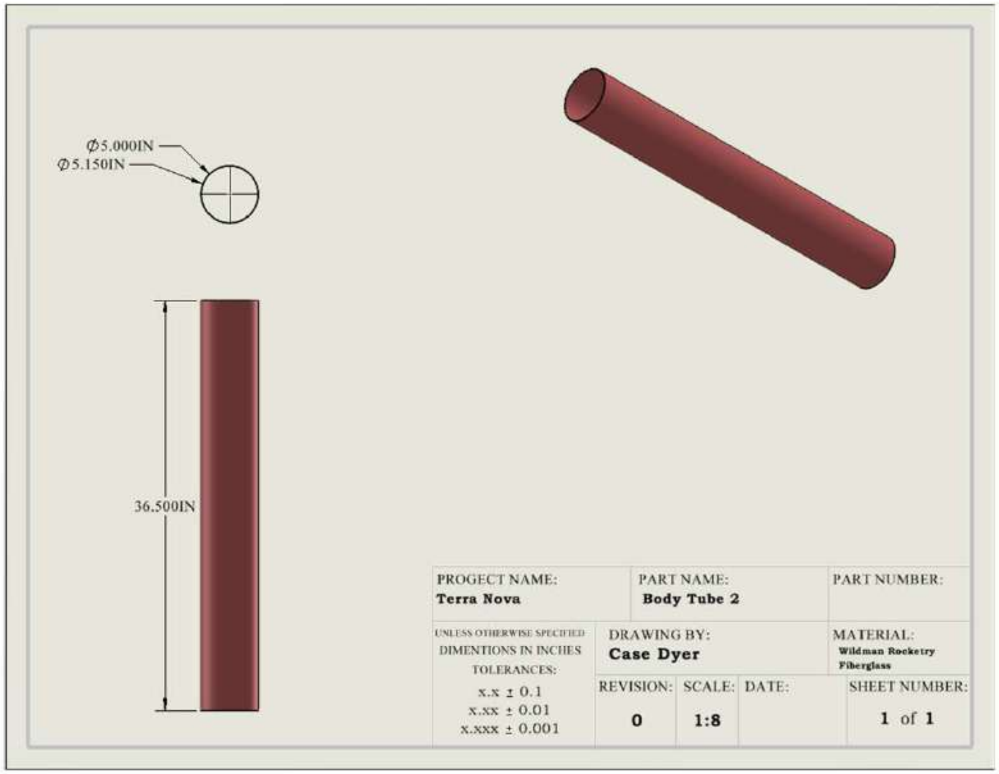
Avionics Section		Primary ID: 5” Primary OD:5.15”
Apogee Drogue Parachute	Diameter: 15”	1
Paramax Drogue Shock Cord	Cord Length: 20ft	12.5
Custom Transition Airframe	·Overall length: 24” ·Transitions OD from 6.17” to 5.15” OD ·Transitions from 6” ID to 5” ID Upper Length: 7"; Weight: 18.8 ·Transitioning length: 8” Weight: 24 Lower Length: 9"; Weight: 17.8 ·Transition angle: 3.68°	60.6
Avionics Recovery Hardware x 2	I-bolt Assembly	3
Avionics Bay Coupler	Length: 14”	15.5
Avionics Bay Bulkhead x2	Thickness: .25”	16
Avionics Bay Electronics Assembly	Length: 13”	50
Body Tube 2	Length: 36.5”	52.8
Main Shock Cord	Length: 24 ft	19.3
Main Parachute	Diameter: 120”	22
Reef Mechanism	Diameter: 30”	8

LAUNCH VEHICLE DIMENSIONS

Propulsion Section		Primary ID: 5" Primary OD:5.15"
RMS Bulkhead	Thickness: .25"	15.8
RMS Recovery Hardware	Already Attached I-bolt	0
Propulsion Coupler	Length: 10.625"	11.8
Motor Tube	24	6.23
Aerotech RMS	RMS size: 75/5120	65.1
Body Tube 3	Length: 16.5"	22.4
Clipped Trapezoidal Fin Set	As detailed	51.4
Coupler Centering Ring	Thickness: 7/16"	3.53
Centering Rings x2	Thickness: 7/16"	3.78
Rail Buttons	Standoff Length 3/8	0.265
Motor Retainer	RMS Diameter: 75mm	3.35
Boat-Tail	·Length: 5" ·Transitions: 5.15" OD to 4.5" OD	15.52
Overall Vehicle Length		120"
Motor Weight		10.5 lb
Vehicle Weight (Excluding Primary Motor)		45.13 lb
Total Vehicle Weight		55.63 lb

LAUNCH VEHICLE DIMENSIONS





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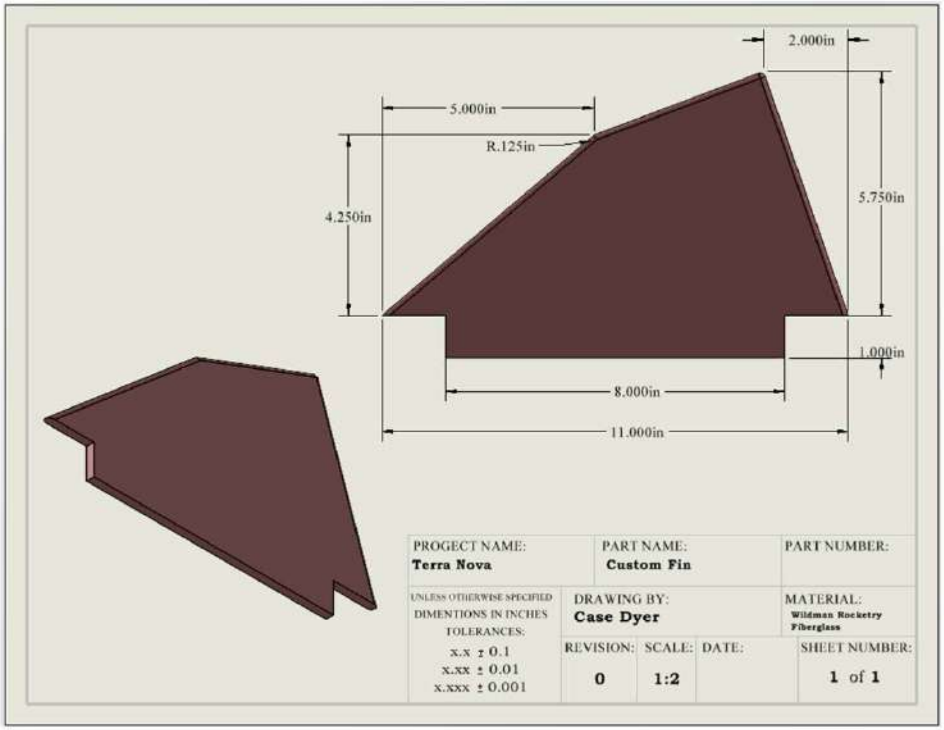

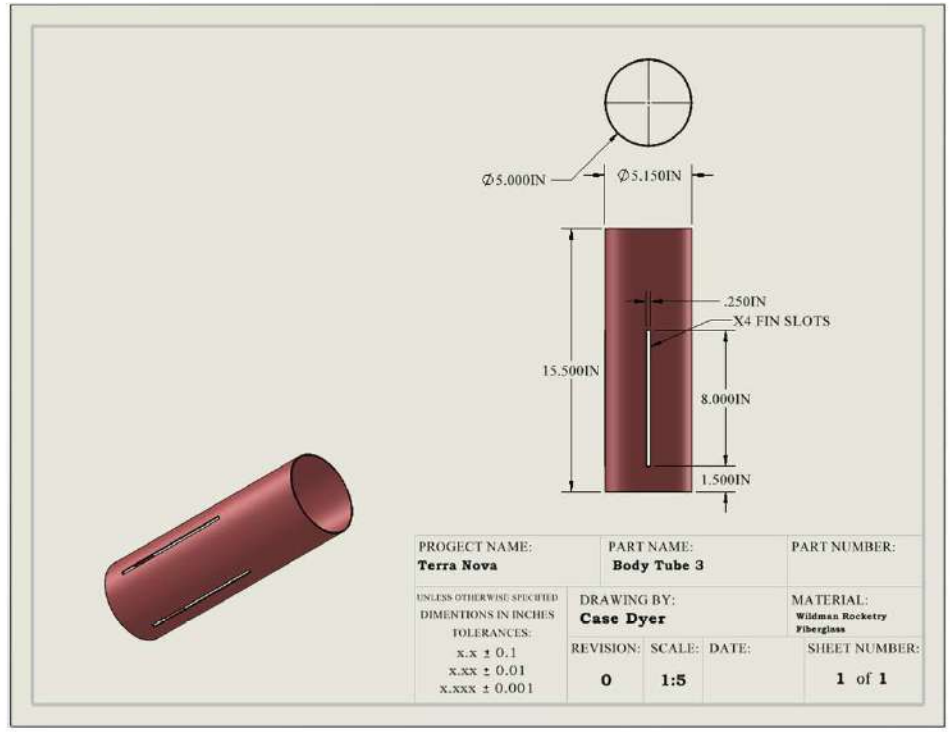

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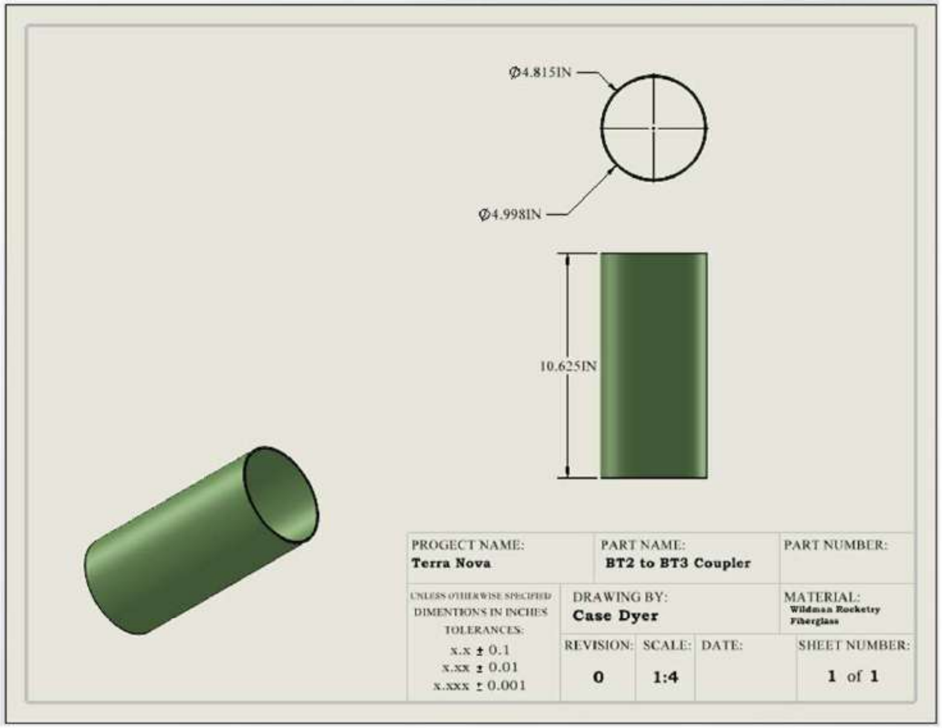

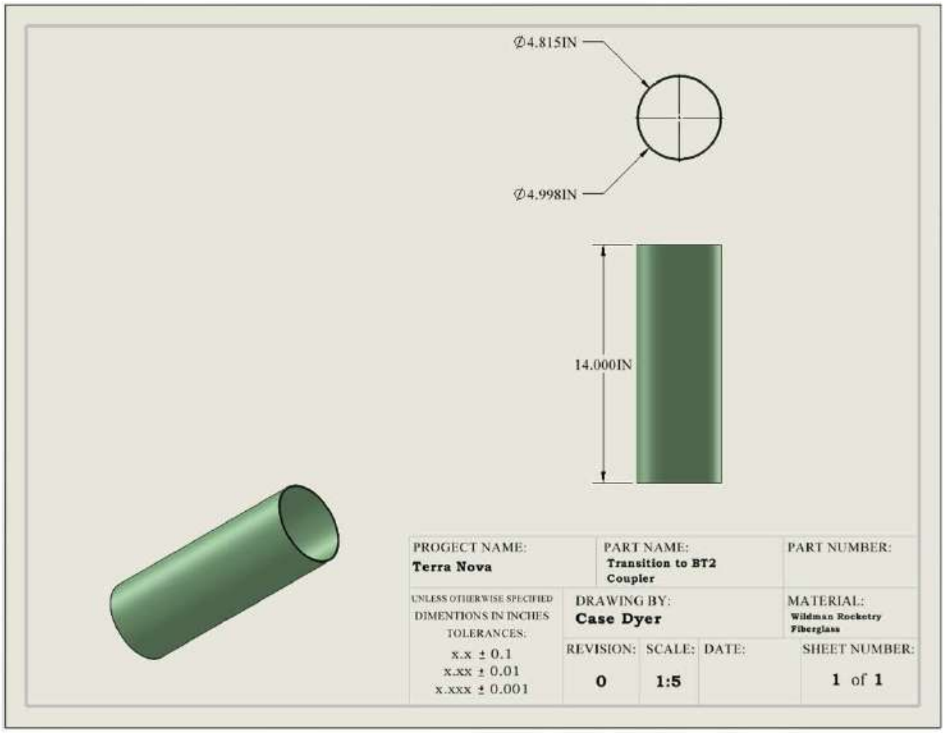

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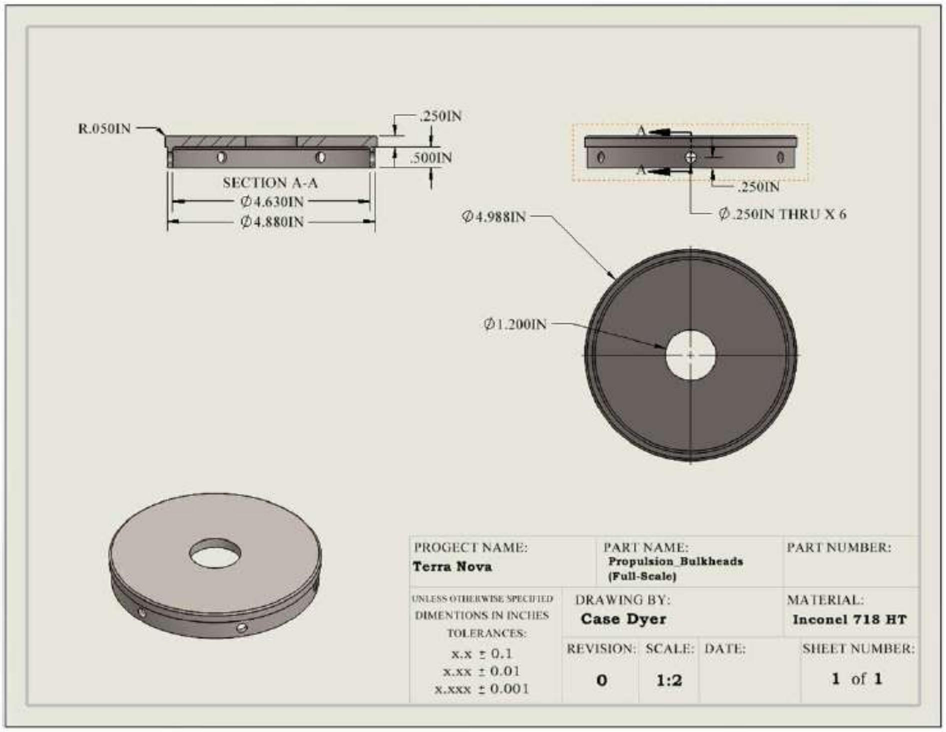

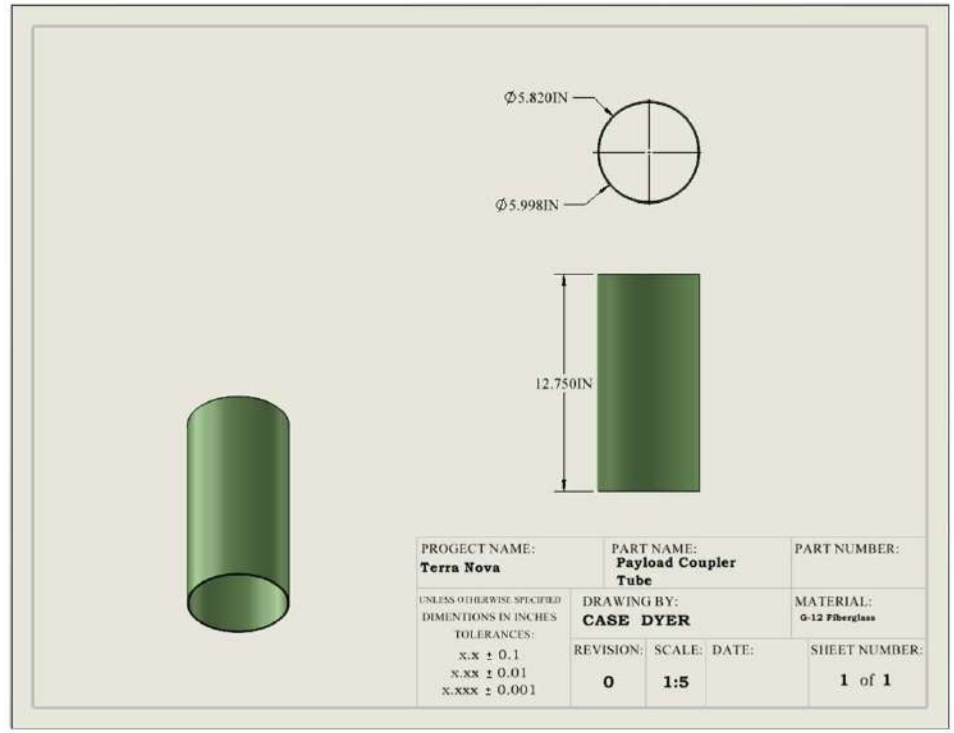

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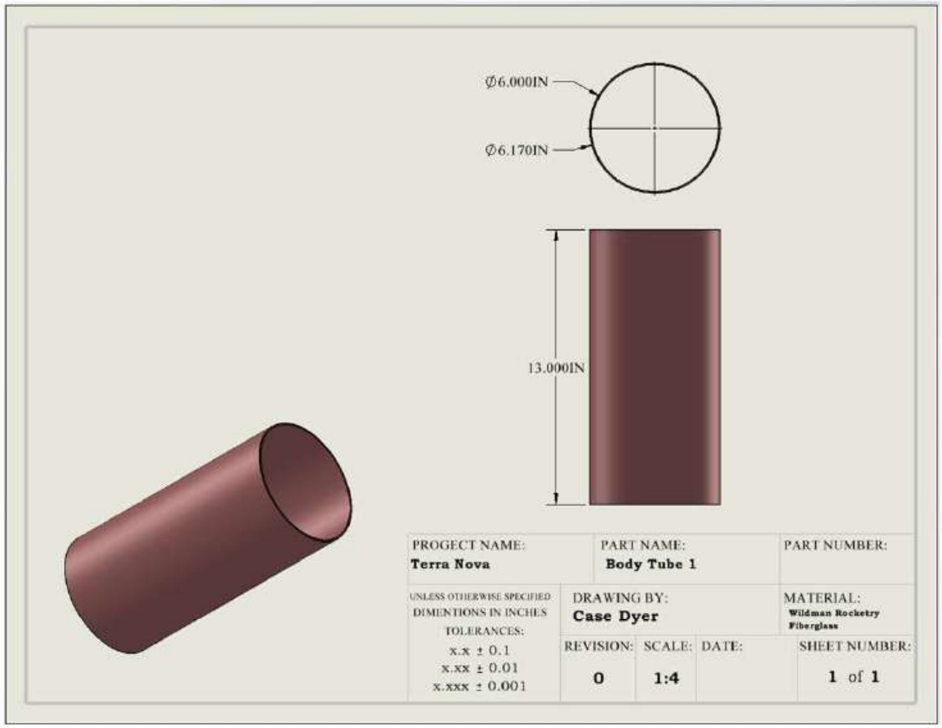

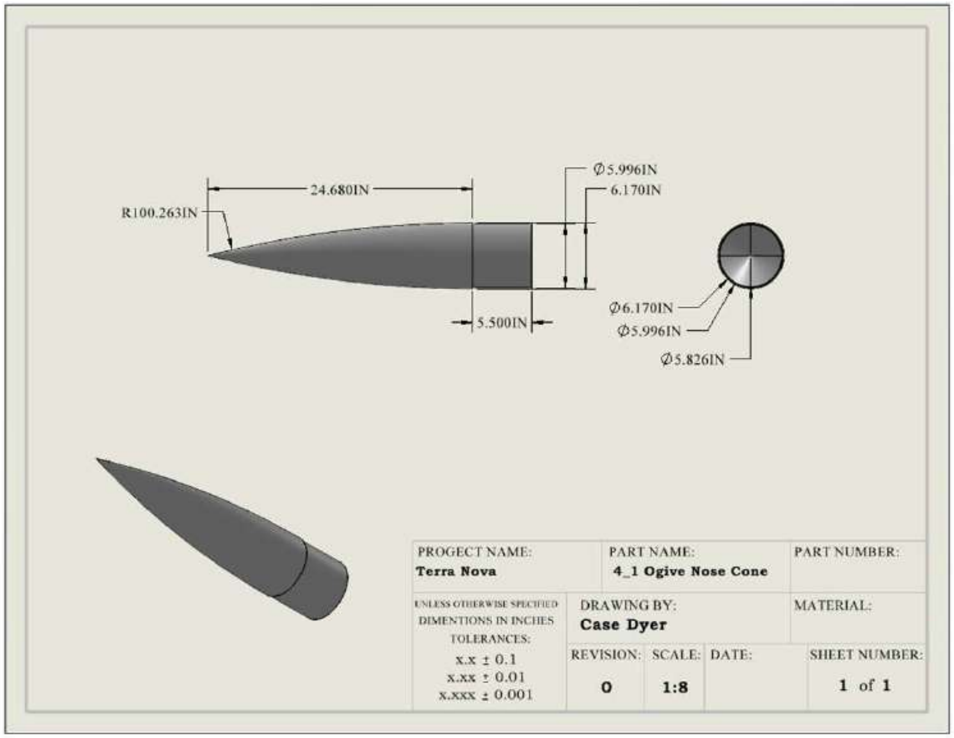

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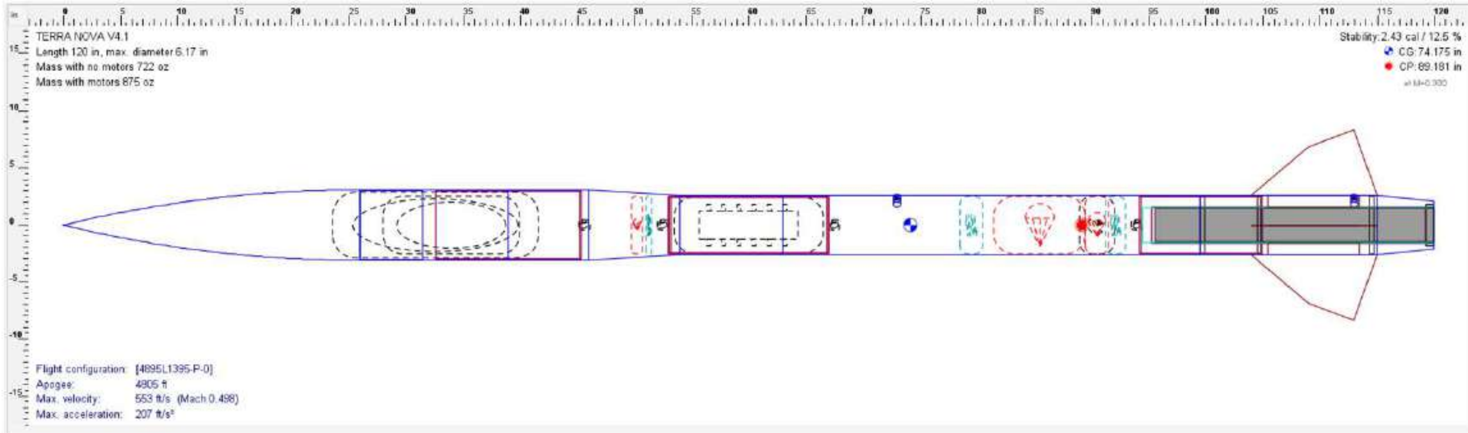


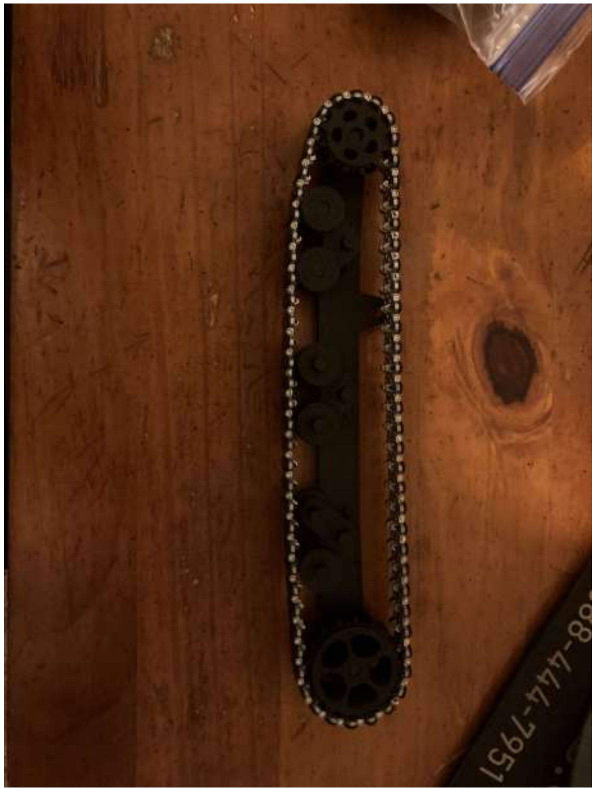
Internal Length for Apogee Separation
- 7.625”

Internal Length for Main Separation
- 51.19”

Internal Volume for Apogee Separation
- 191.7 in^3

Internal Volume for Main Separation
- 1005 in^3

Track System Testing



SUBSCALE LANDING IMAGES V2 FLIGHT 1

SUBSCALE LANDING IMAGES V2 FLIGHT 2

SUBSCALE LANDING IMAGES V2 FLIGHT 2

SUBSCALE SEPARATION TESTS