Case Rocket Team - Event Horizon and Singularity
Team 16 Project Technical Report for the 2024 IREC

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The Case Rocket Team (CRT) is an undergraduate rocketry team from Case Western Reserve University in Cleveland, Ohio which plans to participate in the 2024 Intercollegiate Rocket Engineering Competition (IREC) at Spaceport America in New Mexico in the the 30,000 ft Commercial-Off-The-Shelf (COTS) Category. CRT has designed a rocket, Event Horizon, and payload, Singularity, to compete in this year's competition. Event Horizon is notable as CRT's first rocket with completely custom composites, the first integration of our novel dynamics airbrakes structure. The Payload, Singularity, has been engineered to glide to the ground autonomously with a parafoil. Overall, the team's goal is to improve upon last year's performance in the 30K COTS category and demonstrate the team's ability to tackle new and unique challenges in the rocketry world.

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I. Nomenclature

A	=	amps
AGL	=	above ground level
Ah	=	amp hours
CAD	=	computer aided design
cal	=	caliber
CF	=	carbon fiber
CFD	=	computational fluid dynamics
cm	=	centimeter
CNC	=	computer numerical control
$COTS$	=	commercial off-the-shelf
CRT	=	Case Rocket Team
CTI	=	Cesaroni Technologies Incorporated
$ESRA$	=	Experimental Sounding Rocket Association
FEA	=	finite element analysis
FOS	=	factor of safety
ft	=	feet
$GPIO$	=	general purpose input/output
GPS	=	global positioning system
ID	=	Internal Diameter
in	=	inches
IMU	=	inertial measurement unit
$IREC$	=	Intercollegiate Rocket Engineering Competition
JST	=	Japanese Solderless Terminal
lb	=	pounds
lbf	=	pounds-force
$LiPo$	=	lithium-ion polymer (Battery)
mAh	=	milliamp hours
MB	=	megabytes
MHz	=	megahertz
m	=	meters
mm	=	millimeters
NAR	=	National Association of Rocketry
$NFPA$	=	National Fire Protection Association
$NiCr$	=	nichrome
OD	=	Outer Diameter
RF	=	radio frequency
s	=	seconds
$SRAD$	=	student researched and developed
TRA	=	Tripoli Rocketry Association
V	=	volts

II. Introduction

The Case Rocket Team is an undergraduate student design team at Case Western Reserve University. The team consists of members from a variety of disciplines, with a heavy concentration of Aerospace and Mechanical Engineers. The team has designed a rocket (Event Horizon) and a payload (Singularity) for submission in the 2024 IREC Spaceport America Cup. The competition team is overseen by the Competition Lead, Ben Rubinstein and split into seven subteams: CAD, led by Ryan Pappalardo, Airbrakes, led by Garrett Miller, Composites, led by Andrea Silva, Manufacturing, led by Mitchell Milun, Recovery, led by Eabha Abramson, Payload, co-led by McKenzie Roman and Christopher Riviears, and Avionics, led by Serena Lynas.

CAD was responsible for the simulation and design of the rocket architecture. Composites was responsible for the design, testing, and manufacturing of custom composites, including body tubes and couplers, nosecone and boat tail, and the fin layups. Manufacturing was responsible for the machining of non-composite materials and the assembly of the aerostructure, including all manual and CNC operations on bulkheads, electronics bays, and the airbrakes components. Recovery was responsible for the design and sewing of the parachutes used on Event Horizon. The Payload team was responsible for the design, simulation, and manufacturing of the Payload, including the design of recovery and a power distribution printed circuit board (Supernova). Avionics was responsible for electronics integration and software.

Figure 1 shows an organizational chart detailing the teams organizational structure as described previously.

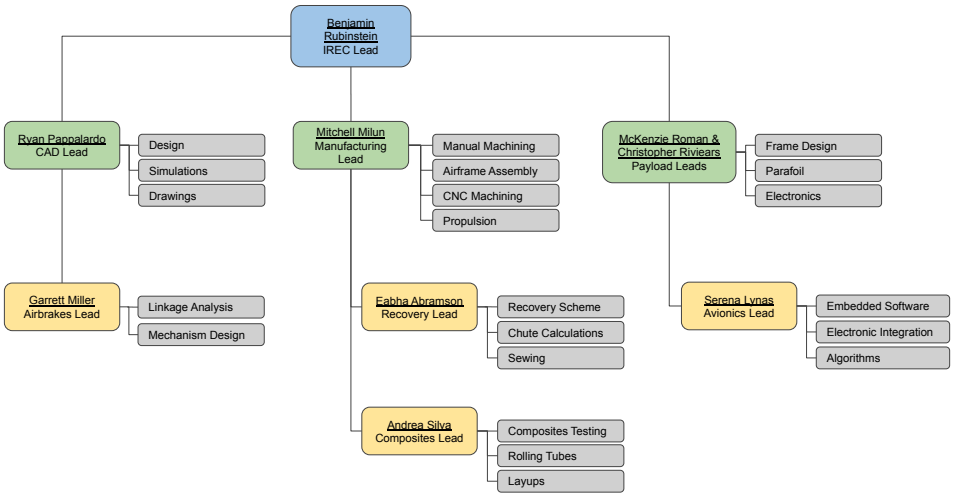


Fig. 1 Case Rocket Team Organizational Chart

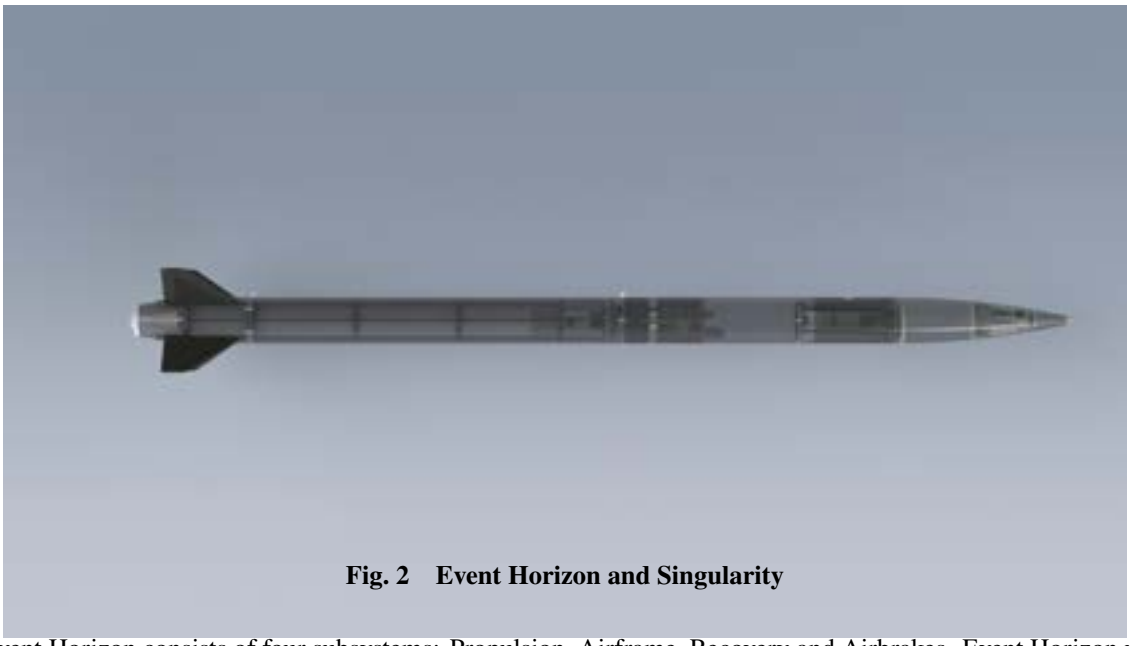


Fig. 2 Event Horizon and Singularity

Event Horizon consists of four subsystems: Propulsion, Airframe, Recovery and Airbrakes. Event Horizon uses a Cesaroni O3400-P motor, reaching an apogee of approximately 31,000 ft AGL at Spaceport America.

Event Horizon's airframe is composed of six sections: fin can, lower body tube, electronics bay, recovery section, payload section and nose cone. The fin can has an integrated boat tail. The lower body tube houses the Airbrakes and Propulsion subsystems. The electronics bay contains all electronic devices responsible for tracking and controlling events. The recovery section houses the recovery for the main aerostructure. The payload section houses the deployable payload. The nose cone section consists of the nose cone aerostructure and electronics for independent nose cone recovery. Event Horizon is designed to separate at apogee, ejecting the nose cone and releasing the payload and then separating the joint between the upper and lower body tubes. The parachute on the nose cone is bundled in until it is released by cord cutters and fully deployed at 1,500 ft AGL. The main airframe falls under drogue while the parachute is held in a deployment bag until it reaches 1,500 ft AGL. The general vehicle and flight characteristics of Event Horizon are shown below in Tables 1 and 2.

Characteristic	Value	Unit
Vehicle Weight	56.9	lbs
Launch Weight	76.3	lbs
Length	118	in
Diameter	5.75	in
Fin Root Chord	9.5	in
Fin Span	17.47	in
CG Location (at ignition, from tip)	75.8	in

Table 1 Launch Vehicle Characteristics

Characteristic	Value	Unit
Apogee	30884	ft
Maximum Velocity	1877	ft/s
Maximum Velocity	1.68	Mach
Maximum Acceleration	466.3	ft/s^2
Maximum Acceleration	14.5	G
Time to Apogee	41.1	s
Flight Time	289.9	s
Velocity Under Drogue	110	ft/s
Ground Hit Velocity	26.5	ft/s
Rail Departure Velocity	100	ft/s^2
CP Location (at ignition, from tip)	90.20	in
Maximum Stability	4.77	cal
Stability at Mach 0.8	3.42	cal
Rail Departure Stability	1.51	cal

Table 2 Flight Characteristics

A. Propulsion

Event Horizon utilizes a CTI O3400-P motor. The motor contains 10,930 g of composite propellant, and has a maximum thrust of 4,750.3 N. The motor burns in 6.2 s. Due to motor availability issues, the O3400-P was chosen as the team already possessed one from a previous year. The O3400-P is a perfect fit for the thrust required to reach the desired altitude of 30,000 ft. The thrust curve for the O3400 is shown below in Figure 3.



Fig. 3 CTI O3400-P Thrust Curve [1]

The motor is retained using a 3/8"-16 threaded rod that screws into the forward closure, shown in Figure 4. This threaded rod is affixed to the motor retention bulkhead in the airbrakes subassembly, with a nylock nut on one side, and 2 jam nuts on the other. This bulkhead is located at the top of the motor tube, which is attached to the rest of the airframe through the airbrakes structure. To ensure proper spacing and for the thrust force of the motor to be transmitted through the boat tail, a 1.25 in COTS G12 fiberglass tube is placed on the motor tube to act as a spacer. With the spacer,

the thrust is transferred from the motor, to the spacer, held in place via compression, to the boat tail, and then to the rest of the airframe.

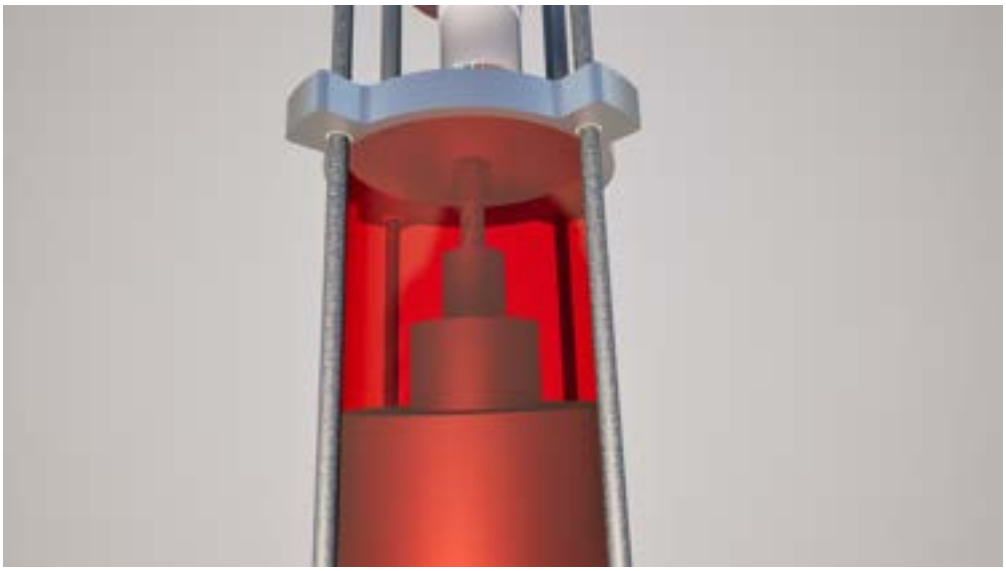


Fig. 4 Motor Retention

The rocket was simulated in OpenRocket and RasAero both before and after manufacturing to ensure that stability always remained between 1.5 and 6 body calibers, as specified in Section 10 of the IREC Design, Test, and Evaluation Guide[2]. Using a 17 ft rail, the departure velocity of Event Horizon is 100 ft/s with a stability of 1.51 cal. According to the simulations, Event Horizon reaches a maximum Mach Number of Mach 1.68 upon ascent. Event Horizon was designed to withstand the aerodynamic stresses of supersonic flight. Figures 5 and 6 demonstrate the Stability of Event Horizon simulated in both OpenRocket and RASAero.

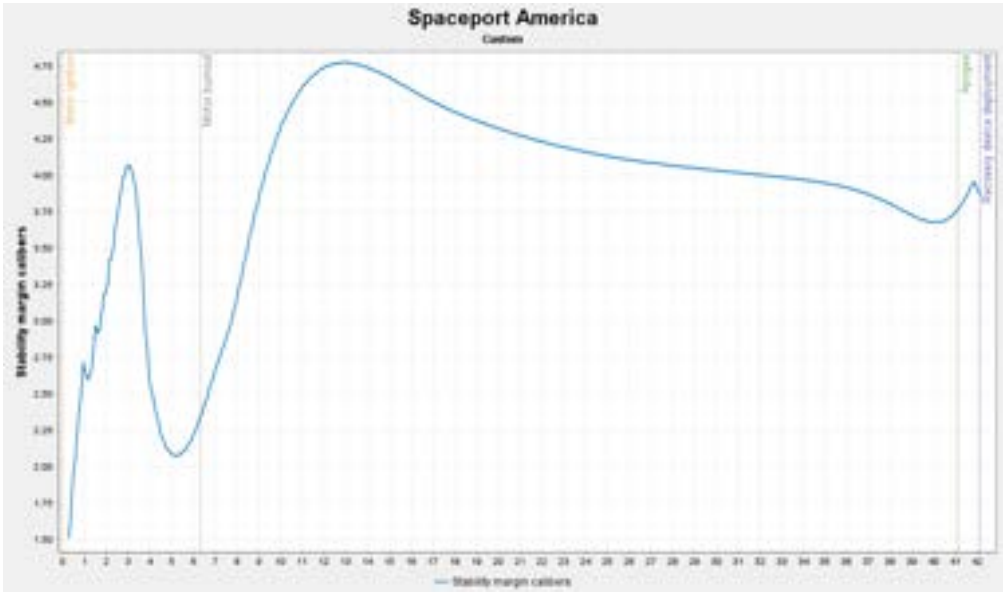


Fig. 5 Event Horizon Stability, OpenRocket

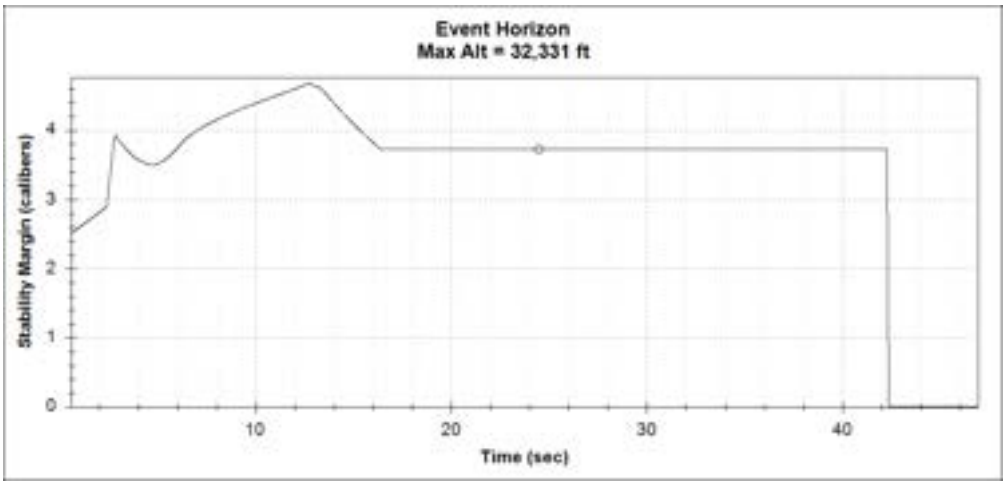


Fig. 6 Event Horizon Stability, RASAero

B. Airframe

The majority of Event Horizon's airframe is constructed of SRAD carbon fiber tubing, made by rolling carbon fiber sheets, with an outer diameter of 5.75". The nose cone is SRAD fiberglass. A COTS G12 fiberglass motor retention spacer was added during manufacturing to ensure the force transfers from the motor to the boat tail. The total length of the airframe is 118". The nose cone separates at apogee, and is affixed to the upper body tube by 4 nylon shear pins. The nose cone contains an independent electronics bay and recovery system. The upper section of the upper body tube houses the payload, while the lower section houses the recovery subsystem for the main airframe. The lower portion of the rocket: the electronics bay, the lower body tube, and the fin can, are all bolted together. The electronics bay is bolted to
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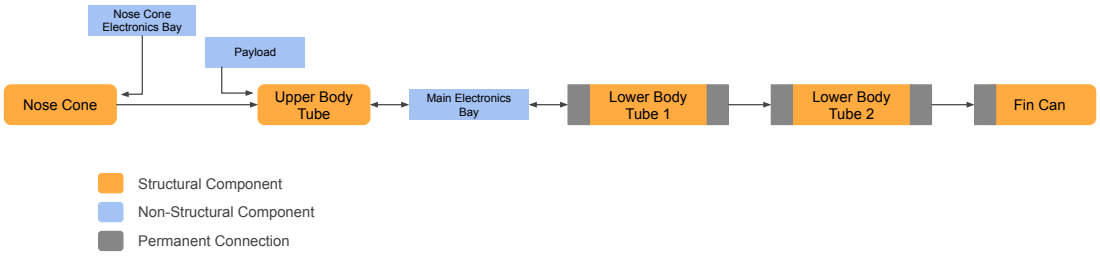


Fig. 7 Event Horizon Block Diagram

Tube Lengths (in)	
Motor Retention Spacer	1.25
Boat Tail	13.5
Lower Body Tube	48.5
Switchband	1.375
Electronics Bay Coupler	9.75
Upper Body Tube	26
Nose Cone	23.25
Total	113.875

Table 3 Airframe Tube Lengths

1. Fin Can

The fin can consists of a straight tubular fin can and an integrated boat tail to reduce after-body drag. The fin can is designed to be 8" long with a constant ID of 5.65", OD of 5.75", and wall thickness of .050". The boat tail tapers linearly with a draft angle of 8.83° to a 3.9" ID and 4.00" OD over its 5.63" length. A 1" fillet on the transition between the straight and tapered sections is added to avoid sharp edges. The fin can is designed to be manufactured using CF sleeves. The fin can is constructed using one 6K CF sleeve and two 3K CF sleeves laminated using Fibreglast System 2000 Epoxy Resin and 2120 Hardener.

Fin flutter calculations were done in AeroFinSim [3] to ensure the fin geometry could withstand the aerodynamic loads causing fin flutter and divergence. To meet these thresholds, a minimum fin thickness of 0.30" was needed for the carbon fiber material. The fins are manufactured out of a 0.25" thick G10 fiberglass core laminated with carbon fiber to a thickness of 0.31". These characteristics result in a minimum divergence velocity of 3,175 ft/s and a minimum flutter velocity of 3,940 ft/s using Pines' Method, and a minimum flutter velocity of 3,101 ft/s using the 2-D Torsion-Flexure Method. The maximum velocity Event Horizon reaches is 1877 ft/s. With the requirement stipulating flutter velocity must be greater than 1.5 times the maximum velocity, found in the DTEG Section 8.2.3 [2], the velocity for flutter must be greater than 2816 ft/s. Both the minimum divergence and flutter velocities are greater than the minimum required velocity. The fins have both a leading and trailing edge bevel of 1.5", with a tip radius of 0.03". These measurements were chosen to reduce the drag of the fins while still being reasonable to manufacture. Further fabrication done to the fin can, mainly tip-to-tip carbon fiber layup, added to the overall thickness of the fin, ensuring the fins will not experience velocities close to the onset of divergence and flutter. Further details on the fins can be found in III.B.7. The results of divergence and flutter analysis can be found in Tables 4 and 5.

Critical (Not to Exceed) Velocity		
Divergence (MACH)	Flutter (MACH)	Lift Slope (CN-a)
2.82	3.5	9.3647

Table 4 Pines Method Flutter and Divergence Analysis Results. Fin Material: CCRP T300 FBRT-934 7-MILL

Flutter Velocity (UF)	2.93 MACH

Table 5 2-D Torsion-Flexure Analysis Results. U-g method used for divergence velocity.

2. Lower Body

The lower body consists of the boat tail, the lower body tube, and the airbrakes subassembly. The lower body tube is made of two tubes, 19.875" and 28.625" in length, connected by a 18" coupler with Fibreglast System 2000 Laminating Epoxy. The lower body tube houses the Airbrakes subsystem, which is built around the motor tube. Aeropoxy PR2032/PH3665 is used to affix centering rings and the motor retainer bulkhead to the motor tube. A 0.75"

thick 6061-T6 bulkhead to attaches both the boat tail and lower body tube to the Airbrakes subsystem and guides the actuation tubes for airbrakes. 7.5" below this connection point lies the actuation mount bulkhead, which serves as the mounting point of the airbrakes flaps and their associated linkages. Four pressure port holes were added to the lower body tube (7/64") and the boat tail (1/16") to ensure pressure was equalized during flight.

3. Electronics Bay

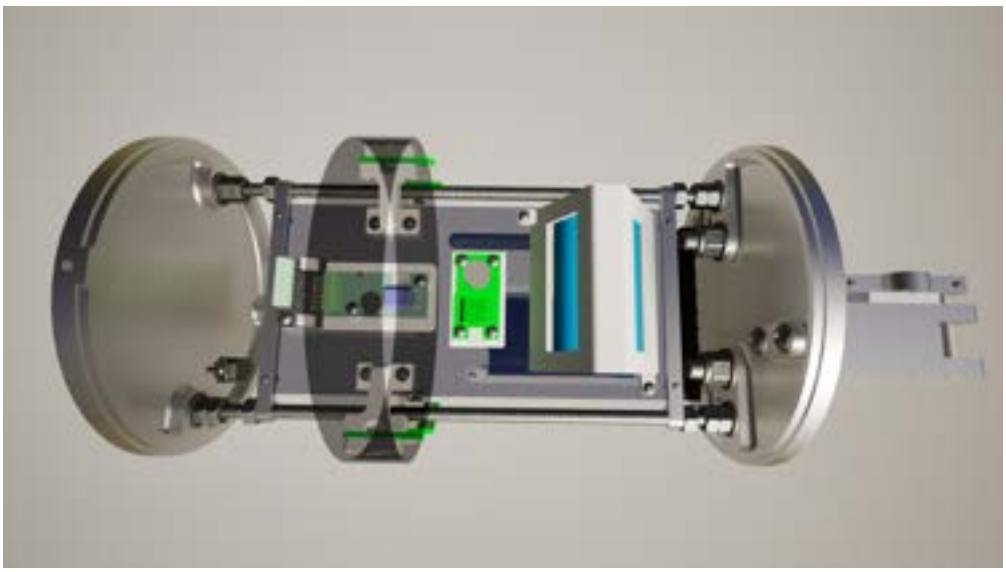


Fig. 8 Electronics Bay (See Through)

The electronics bay sits entirely inside a coupler that is located between the lower body tube and the upper body tube. The coupler is capped by a 0.375" 6061-T6 aluminum lower bulkhead and a 0.425" 7075-T6 aluminum upper bulkhead. There is a small notch in each bulkhead to radially align the screw switches with their access holes in the coupler, shown in Figures 9 and 10. On the upper bulkhead there are two charge wells and a Tendie Descendie Duo for separation and recovery of the lower body, shown in Figure 13.

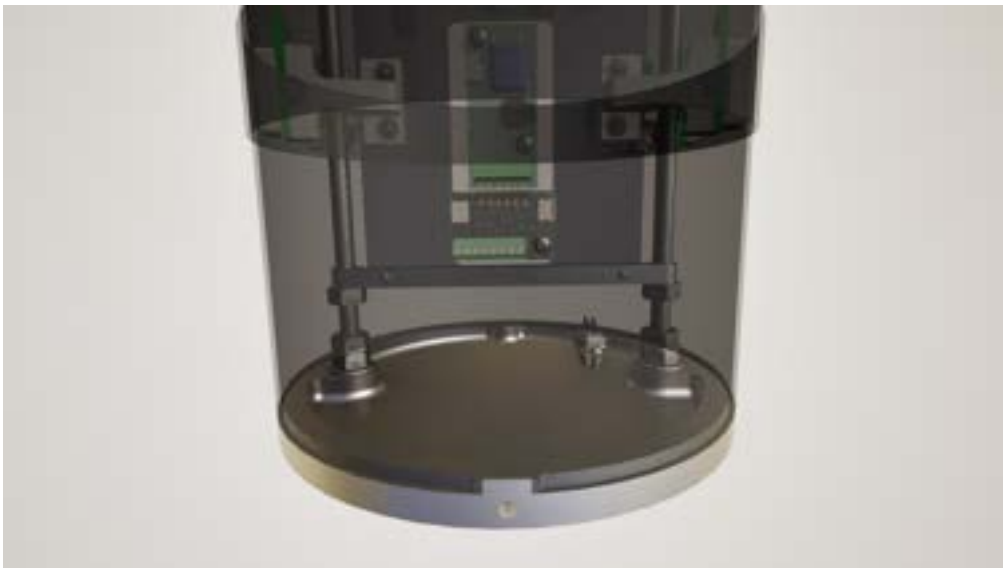


Fig. 9 Lower Electronics Bay Bulkhead Clocking Notch



Fig. 10 Upper Electronics Bay Bulkhead Clocking Notch

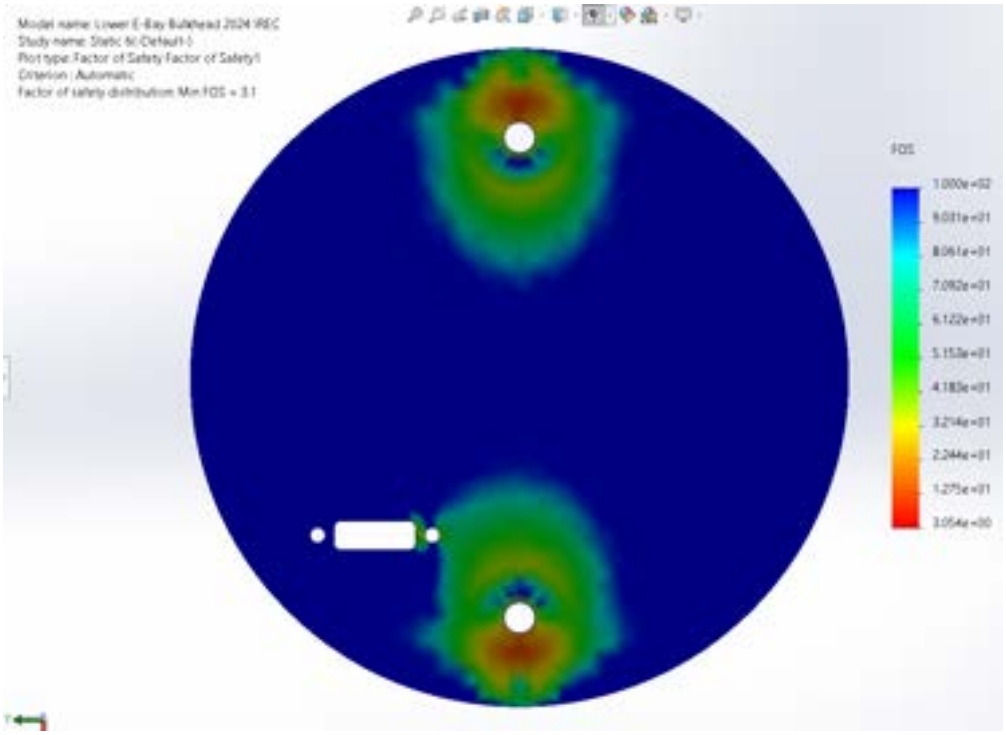


Fig. 11 Lower Electronics Bay FEA, 862 lbf, 3.1 FOS

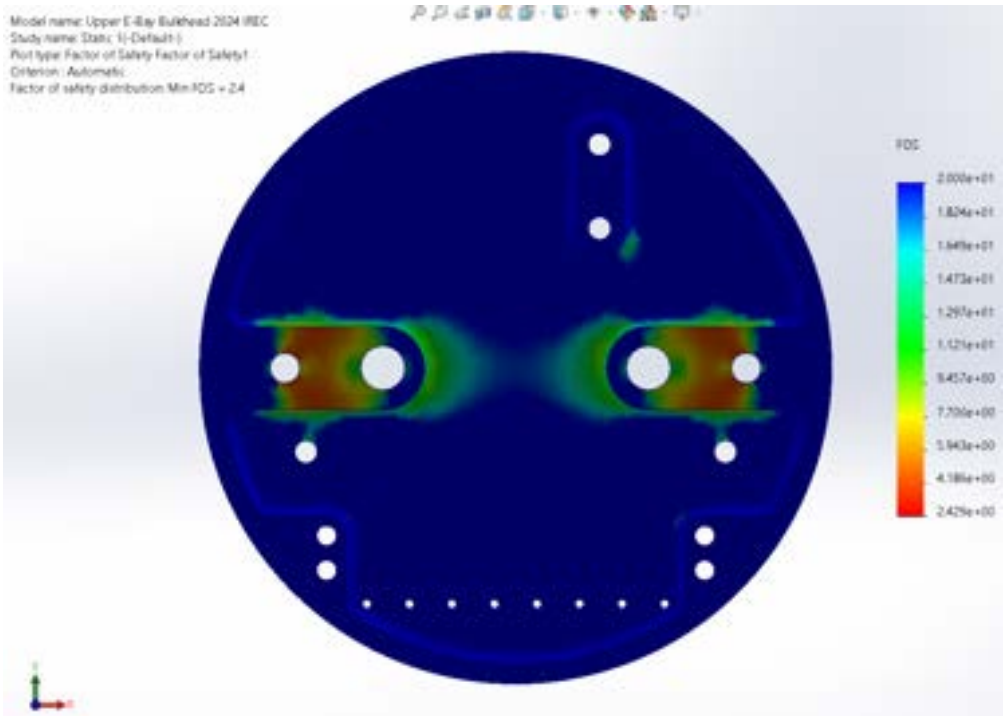


Fig. 12 Upper Electronics Bay FEA, 862 lbf, 2.4 FOS

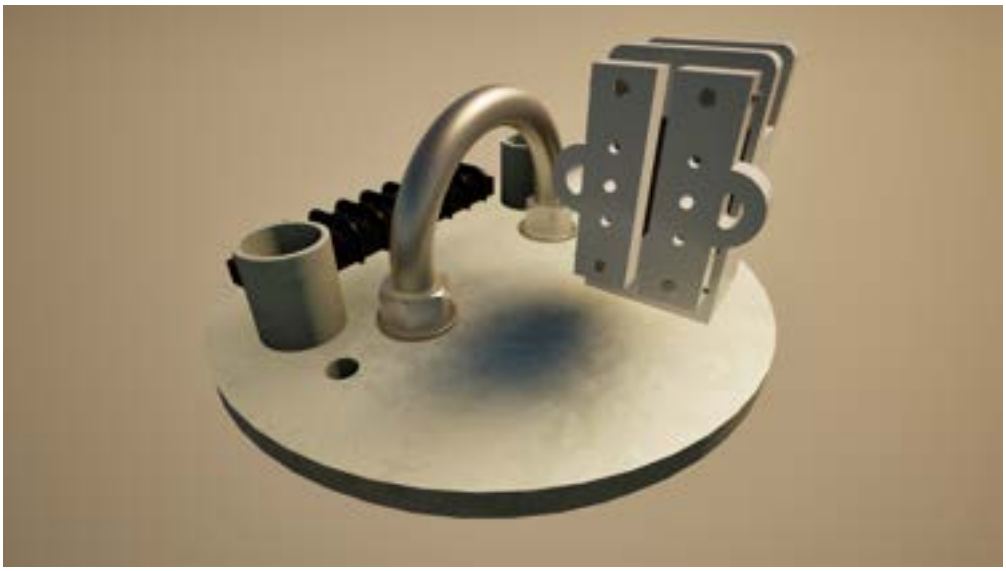


Fig. 13 Tendie Descendie Mounted

The electronics bay sled is fabricated out of 0.25" thick polycarbonate and is bolted onto two 6061-T6 aluminum mounting brackets. The brackets slide on two threaded rods that run the length of the electronics bay coupler and pass through both bulkheads. Jam nuts are used to position the electronics bay sled and to secure the lower electronics bay bulkhead.

2.6 Ah lithium ion batteries give the Raven4 and EasyMini flight computers over 12 hours of flight-ready time on the pad. For ease of assembly, the 2.6 Ah battery is standard throughout the electronics bay. The wiring scheme for the main electronics bay can be seen in Figure 14. Each component and battery is retained using 3D printed PETG

mounts. PETG is used its mix of strength, temperature resistance, and ease of printing. Both flight computers and the Featherweight GPS are turned on and off with COTS screw switches. Screw switches are used because they are relatively simple to operate and their operation is not affected by high speeds. Screw switches also have tactile feedback, meaning it is easier to verify that they are switched on.

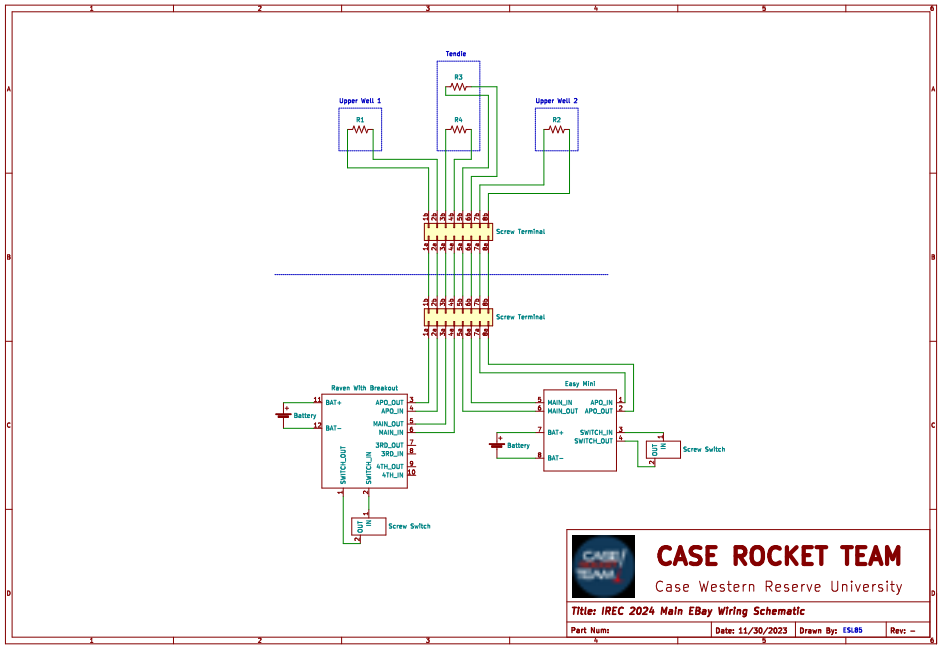


Fig. 14 Main Electronics Bay Wiring Schematic

4. Recovery Section

The recovery section is in the lower portion of the upper body tube. This section holds the drogue parachute, main parachute, deployment bag, shock cord, and all recovery hardware. An SRAD kevlar deployment bag stores the main parachute until deployment and prevents line tangling. The recovery portion of the upper body tube is 26" in length, and is sectioned off from the payload section with a bulkhead discussed in Section III.B.5. The electronics bay coupler takes up 6.5" of this length. Recovery connections and deployments are discussed in greater detail in Section **??**. Four nylon shear pins, each requiring a 23 lb shear force to break, are used to secure the electronics bay to the upper body tube. Four pressure port holes were also added to this section, with a diameter of 0.063", in order to adequately keep the internal pressure equal to the ambient pressure.

5. Payload Section

The Payload Section is the upper section of the upper body tube and the lower portion of the nose cone. The payload retention bulkhead is CNC milled from 0.5" thick 6061-T6 aluminum and is bolted to the upper body tube. This bulkhead features a square recess for the payload to sit in as well as and 8 small rectangular slots which accept Delrin rods for payload alignment. It was later epoxied in to seal the payload and recovery sections from each other. It also has a 1/4"-20 tapped hole in the center which accepts an eye bolt and allows the upper body tube and lower body tube to be connected via shock cord. To prevent upward motion of the payload at motor burnout, a foam and G10 fiberglass ring is epoxied into the nose cone. The fiberglass provides enough structure to prevent motion, and the foam softens any potential impacts, minimizing damage to the payload frame. The payload integration can be seen in Figure 15. Additionally, the upper body tube is affixed to the nose cone coupler with four #2-56 nylon shear pins to prevent drag

separation, and still allow for successful separation shortly after apogee.

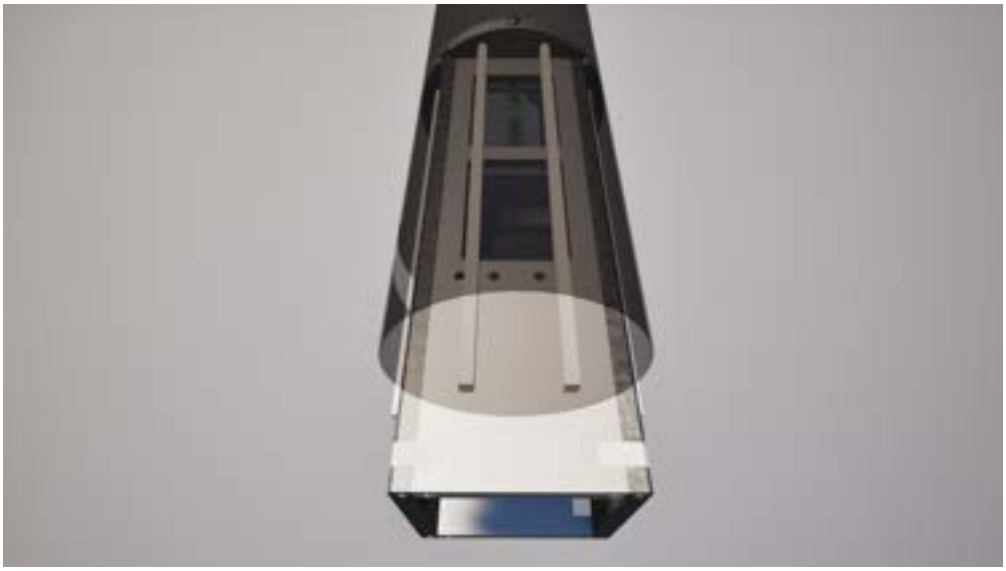


Fig. 15 Payload Retention Render

6. Nose Cone

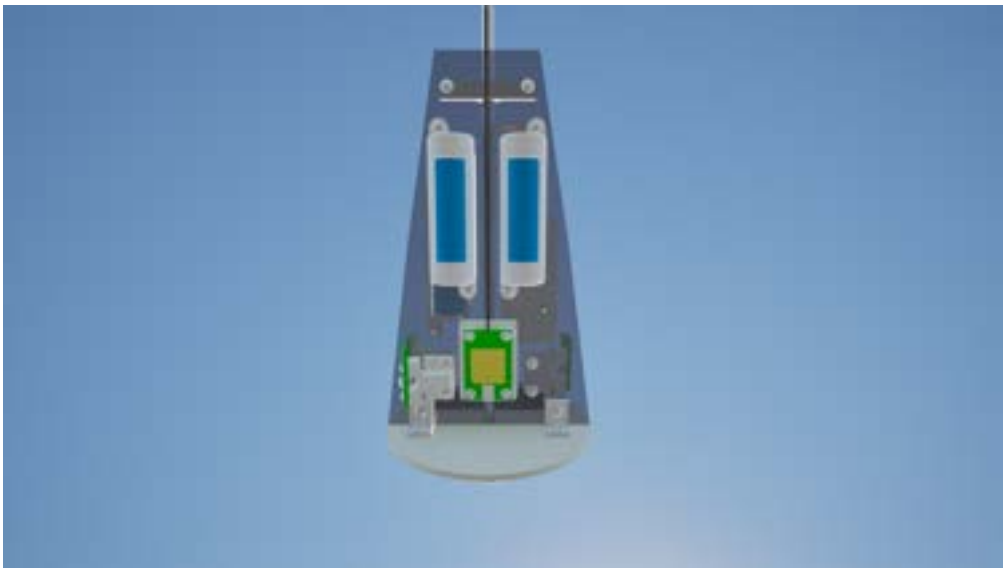


Fig. 16 Nose Cone Electronics Bay

The nose cone is a 33:8 (4.13:1) ogive SRAD fiberglass nose cone. An SRAD carbon fiber coupler is epoxied into the bottom of the nose cone. A rectangular hole is cut through the nose cone and coupler and covered with a bent acrylic sheet, allowing one of the payload cameras to see through the body of the rocket. Three 0.375" pressure port holes are drilled in the coupler. Their location and number aligns with the payload screw switches. The sizing was calculated to ensure adequate pressure venting for the nose cone electronics bay. A 0.125" thick G10 fiberglass bulkhead is secured by a 1/4"-20 13.25" long steel threaded rod which is screwed into the nose cone tip. The 0.25" thick polycarbonate sled which holds the nose cone electronics bay components is also mounted to the threaded rod. Two aluminum brackets are bolted onto the fiberglass bulkhead to fix the sled in place. To radially align the nose cone bulkhead within the nose

cone, a small cutout in the bulkhead is made which aligns with a small 3D-printed clocking notch epoxied onto the inside of the nose cone. The nose cone and nose cone electronics bay can be seen in Figure 17.

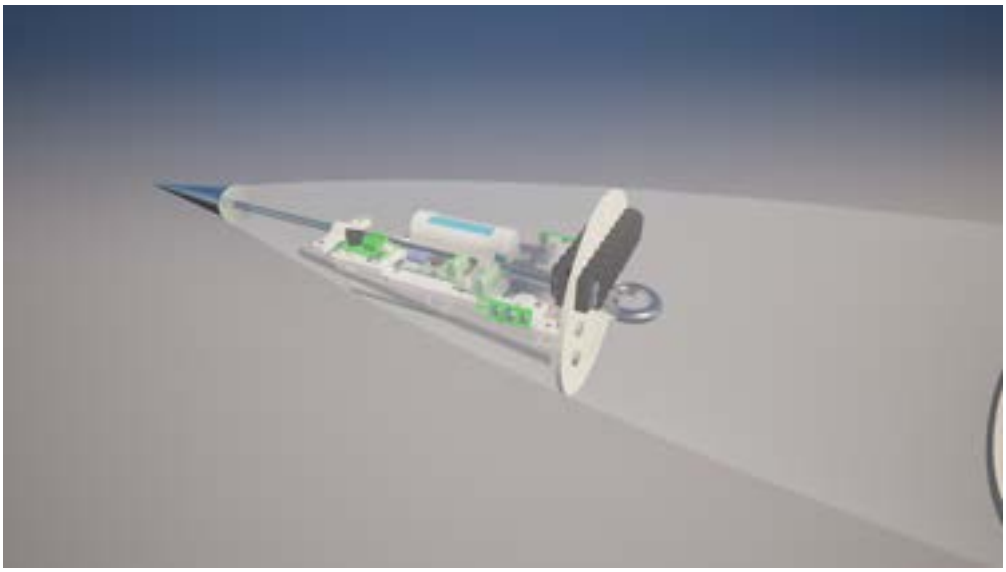


Fig. 17 Nose Cone with Electronics Bay Installed

The electronics bay in the nose cone is configured as depicted in Figure 18. The two flight computers used to control recovery events are an EasyMini and a Raven4. They are each activated by a screw switch. The main deployment event during descent occurs when the altimeters each fire an electric match, igniting the black powder inside the Piranha and deploying the parachute. The electric matches are sized to a length that allows for no tension through the wires, and are secured along the shock cord using zip ties. Two flight computers are used to ensure redundancy in the deployment system. The EasyMini fires 0.5 sec before the Raven4 for at apogee and 1500 ft AGL. A TeleGPS is used during and after flight to track the nose cone. The nose cone electronics bay and its recovery wiring diagram can be seen in Figures 18 and 19.



Fig. 18 Nose Cone Electronics Bay, Raven4 View

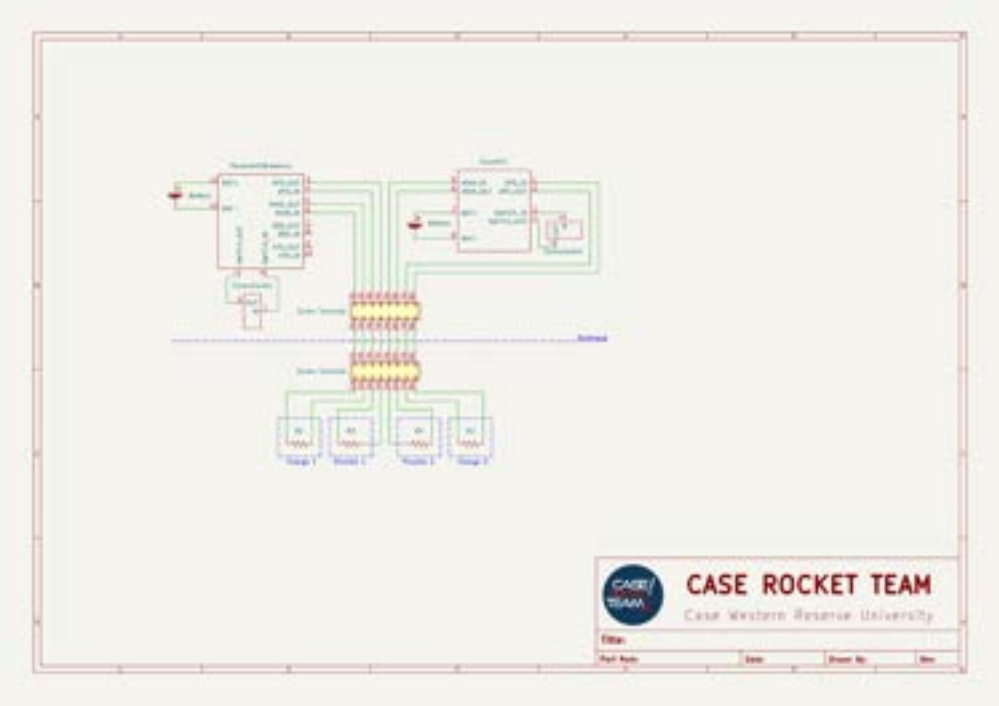


Fig. 19 Nose Cone Electronics Bay Wiring Schematic

7. Manufacturing

Airframe Tubing The airframe is constructed primarily of carbon fiber. For outer tubes, a 30" long mandrel is made from a hollow aluminum tube with an 6" outer diameter and turned to a 5.65" outer diameter. A similar mandrel is made for the couplers using a 20" long mandrel turned to a 5.55" outer diameter.

To prepare the surface of the mandrels, partall paste wax is applied and buffed until the surface is smooth to the touch. Multiple layers of graphite lubricant is sprayed until the surface is opaque, and mylar sheets are then wrapped around the tube using flash tape.



Fig. 20 Aluminum Mandrel Turning



Fig. 21 Surface Preparation for Straight Tubes

To achieve a targeted tube thickness of 0.050", the tube layups consisted of one layer of 6k carbon fiber weave and two sheets of 3k carbon fiber weave. Fibreglast System 2000 Laminating Epoxy with a 2 hour pot life is used for the layup, and the tubes cure on the mandrel for 18 hours. The tubes are removed from the mandrel and left to sit for 3 days to cure completely, then cut to length. Some cut tubes can be seen below in Figure 25

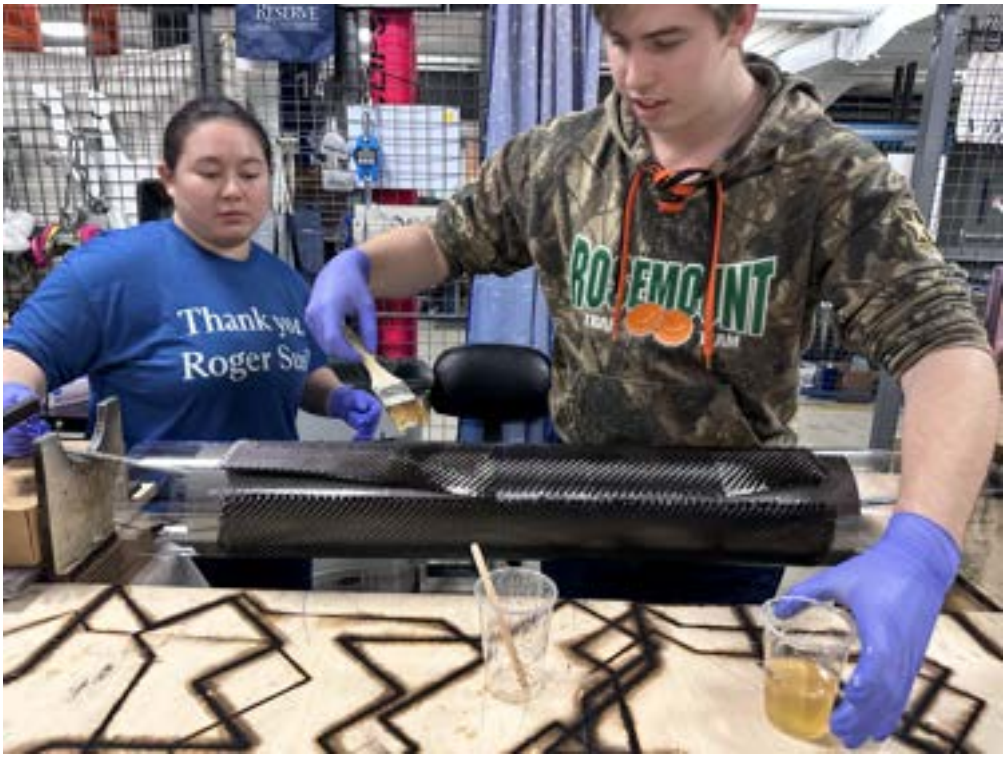


Fig. 22 Outer Tube Layup

Couplers are sanded to fit inside the body tubes. [1] Internal layups are done on the couplers using a reverse vacuum bag method. Four layers of 3k carbon fiber weave are wrapped along the inside of the coupler and applied with Fibreglast System 2000 Laminating Epoxy. After the carbon fiber is laid down a mylar sheet and breather cloth are laid down.

[1] Due to compounding tolerancing issues, the couplers were sanded too thin, and so an internal layup needed to be done for strength.



Fig. 23 Internal Layup Operation

A vacuum tube is then inserted into the coupler and integrated with the external vacuum bag. This allows atmospheric pressure to flow through the tube and provide the necessary compression from the inside out. The vacuum is left for 24 hours.

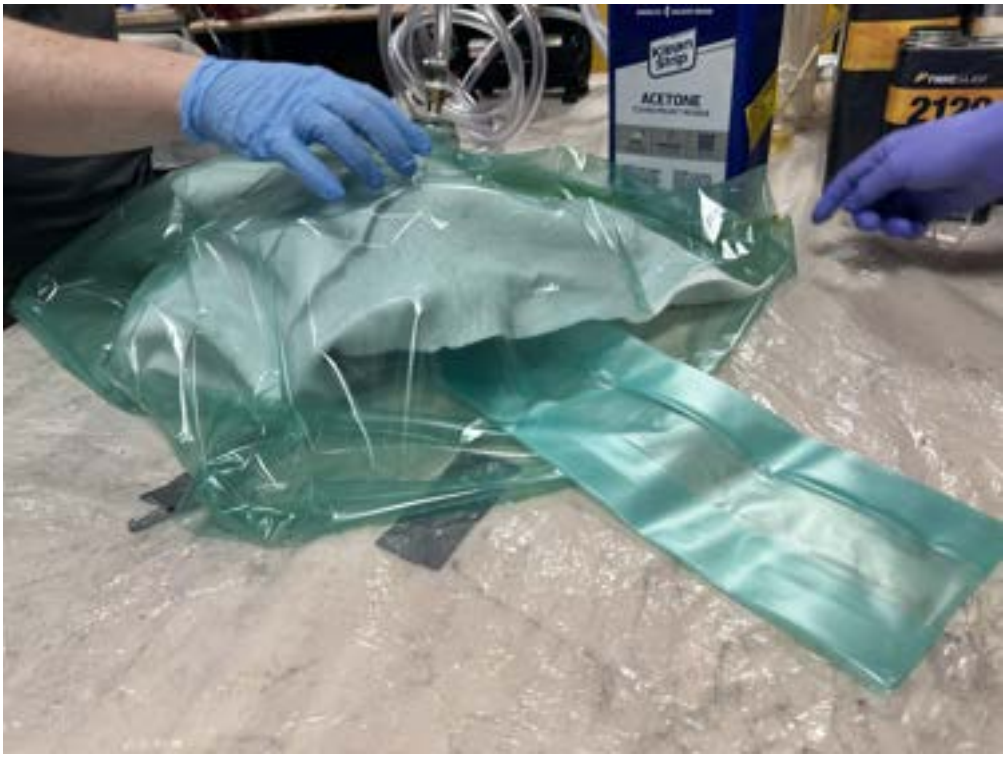


Fig. 24 Vacuum Bag Setup for Internal Tube Layup

Tube Type	Inner Diameter (in)	Length (in)	Reinforced
Upper Body Tube	5.65	26.25	No
Nose Cone Coupler	5.55	10	Yes
Electronics Bay Coupler	5.55	9.75	Yes
Upper-Lower Body Tube	5.65	20	No
Lower Body Tube Coupler	5.55	18	Yes
Lower-Lower Body Tube	5.65	29	No

Table 6 Carbon Fiber Tube Dimensions

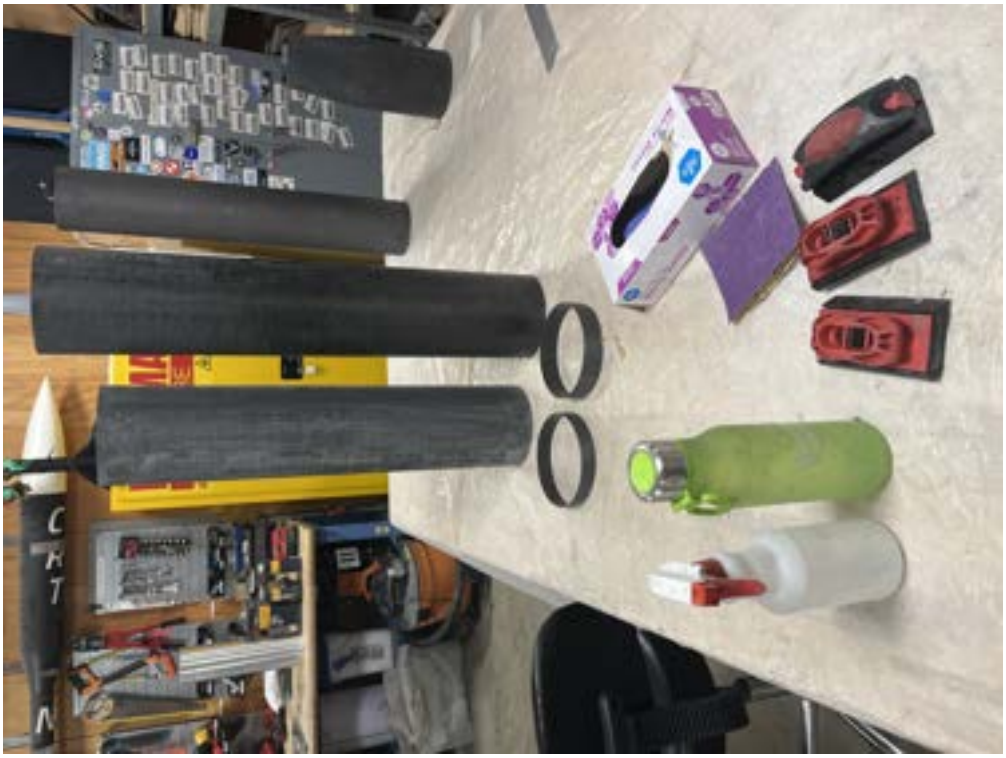


Fig. 25 Cut SRAD Body Tubes

The nose cone and fin can are made by laying up sleeve over a 3D-printed mold. Each mold is made of three pieces which are glued together. Bondo High Bond Filler and Fibreglast Low Emissions White Gel Coat are sprayed on to smooth the surface.

For the nose cone, four different diameter fiberglass sleeves are used to account for the ogive geometry. Two complete layers of fiberglass are layered, and Fibreglast System 2000 Laminating Epoxy is used for the layup. After curing for three days, the print is broken out to separate the fiberglass nose cone from the mold.

For the boat tail, three layers of 6k and one layer of 3k carbon fiber sleeves are applied to the mandrel in layers using Fibreglast System 2000 Laminating Epoxy.

After curing, the boat tail and nose cone are cut to size using a horizontal bandsaw and sanded.

Type of Fiberglass Sleeve	Length (in)
1.5 Heavy	3.5
3.0 Heavy	4.5
5.0 Heavy	8
8.0 Heavy	12

Table 7 Fiberglass Sleeve Layer Lengths



Fig. 26 Nose Cone Mold Before Gel Coat



Fig. 27 Boat Tail Initial Gel Coat

Clearance holes are drilled through the airframe for bolts. The holes are aligned using 3D printed radial jigs. Holes are drilled through the nose cone and upper body tube to provide access to the screw switches inside the payload. A camera hole is cut into the nose cone and the nose cone coupler. The camera shields are cut on a laser cutter from 0.03" acrylic and attached to the lip on the coupler using cyanoacrylate adhesive.

Bulkheads The lower electronics bay bulkhead is manufactured out of 7075-T6 Aluminum. The other aluminum bulkheads are manufactured out of 6061-T6 Aluminum. Due to the loads the lower electronics bay experiences during flight, a stronger material is necessary to ensure the component doesn't deform or break. The airbrakes actuation actuation mount bulkhead, the motor retainer bulkhead, the lower payload retention bulkhead, and the lower electronics bay bulkhead are manufactured from 0.5 in thick stock, the upper electronic bay bulkhead is manufactured from 0.375 in stock, while the actuation tube stabilizer bulkhead is manufactured from 0.75 in thick stock. The blanks were waterjet cut, and the actual bulkheads were CNC milled from the blanks. Jigs were used to manually mill the radial holes in the actuation tube stabilizer bulkhead, the lower payload retention bulkhead and the lower electronics bay bulkhead. These jigs ensured the radial hole locations were correct.

The fiberglass bulkheads are manufactured out of a G10 fiberglass sheet. The upper payload retention bulkhead and the nose cone bulkhead are waterjet cut from 0.125" thick. All fiberglass bulkheads and components are waterjet cut. The components were surface prepped by sanding with 220 grit sandpaper, and then epoxied using Aeropoxy Structural Adhesive.

Electronics Bays Both electronics bay sleds are made from polycarbonate sheets cut on a CNC router. All of the electronics housed within the two electronic bays are secured to the sled using 3D-printed PETG mounts. The main rocket's sled is suspended on two threaded rods using 6061-T6 mounting brackets. The threaded rods are positioned in the bay using jam nuts. The nose cone electronics bay sled is attached to the fiberglass bulkhead through the central threaded rod in the nose cone. The nose cone electronics bay sled is bolted onto two 6061-T6 mounting brackets cut using the waterjet that are bolted onto the nose cone bulkhead.

The switch band is epoxied to the coupler using Fibreglast System 2000 Laminating Epoxy. Holes are drilled through in subassembly to give access to the screw switches in the main electronics bay. The charge wells are made on the lathe out of 6061-T6 Aluminum. The base of the Tendie Descendie Duo is milled and the plates waterjet cut, with an additional drilling operation performed on the mill. The milled holes allowed set screws to attach the dowel pins to the plate. The Tendie Descendie Duo's charge wells are machined on a CNC mill out of Delrin.

Fin Can T rface is wet sanded with abric sheets are laminate ial strength, weaves were the surface for layup, a to allow air to escape. T e fiberglass sheet in the sheet using a waterjet c

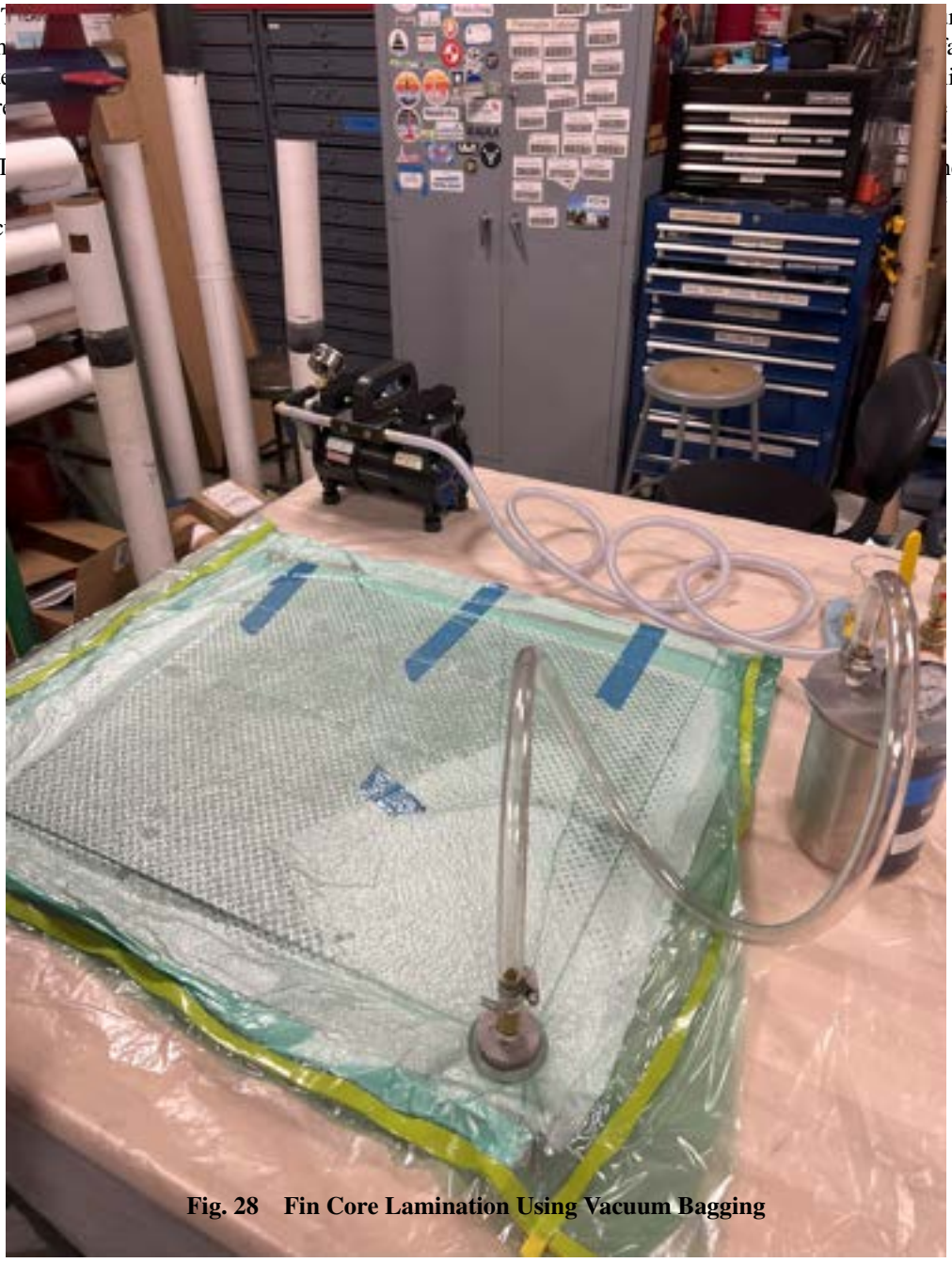


Fig. 28 Fin Core Lamination Using Vacuum Bagging

To manufacture the desired bevel, the fins are CNC milled and finished with hand sanding. The size of the bevel is determined by simulation, with consideration for ease of manufacture. The fins have a hexagonal profile, with symmetric bevels of 1.5" length.



Fig. 29 Fin During CNC Beveling Operation

In order to ensure that each fin is as straight as possible and all four fins are equally spaced, lines are drawn on the boat tail where each fin should sit utlizing a two-part MDF wooden jig cut using a CNC router, and checked for straightness and squareness with a combination square. The fins were surface mounted using five-minute epoxy one at a time and supported using the fin jig while drying.

Once the fins are tacked onto the body tube, Aeropoxy ES6209 is used to form the fillets. These fillets strengthen the fins, and provide a smooth transition from the body tube to the fins for the carbon fiber layup. The resin, hardener, and colloidal silica are combined in a 1:1:1 mass ratio and mixed thoroughly. The outline of the fillets is created with painter's tape. The epoxy is poured on the general area of the fillet and formed by dragging a 3D-printed rounded tool with a 1" radius at an angle along the root chord of the fin. The epoxy sets for about five minutes, at which point the painter's tape is removed. The fillets are formed two at a time and left to cure for twelve hours before more fillets are applied. The ends of the fillets are smoothed using isopropyl alcohol to ensure a smooth transition.

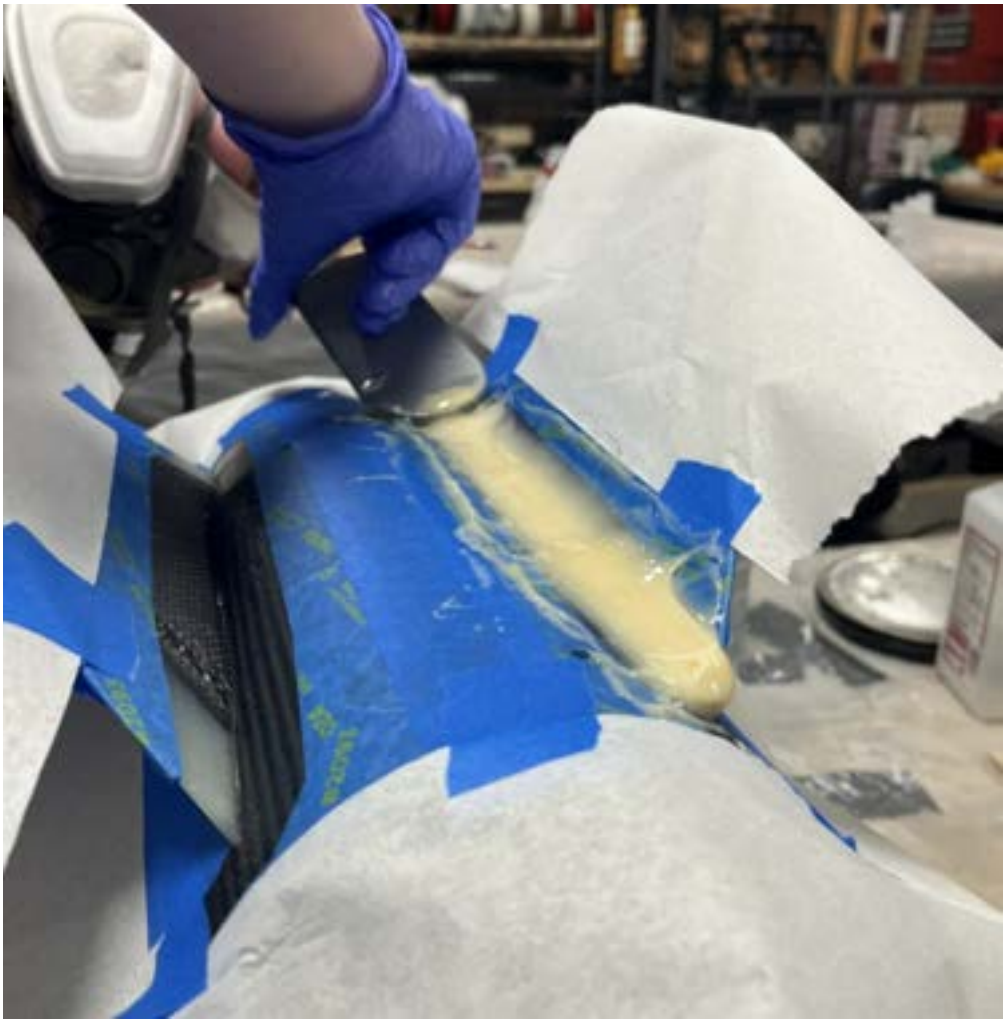


Fig. 30 Fin Fillet Application



Fig. 31 Fins Fillets

A laser cutter is used to cut out the layers of carbon fiber fabric needed for the tip-to-tip layup. For each section, two layers of 6k carbon fiber fabric were cut to cover everything but the fin bevels, as well as a rectangular sheet to cover each bevel. The lower sheet was cut with fibers at a 45° angle, and the second sheet cut at a 90° angle to provide multi-axial strength. The third sheet was cut with fibers at a 45° angle completely covering the fins. To prepare the body of the rocket for layup, the fin can and transition to the fillets are sanded with 400 grit sandpaper and wiped with acetone. A batch of US Composites 3:1 laminating epoxy is applied onto the fillets to apply the rectangular sheet. Another coat of epoxy was applied, ensuring that a large enough surface area was covered so that the carbon fiber was only resting on epoxy. This process was repeated for all carbon fiber layers. Once all sheets of carbon fiber were epoxied in the correct position, the boat tail was placed in a vacuum bag to extract excess epoxy and ensure there were no bubbles in the carbon fiber layup. To ensure the vacuum worked properly, a layer of peel ply and 2 layers of polyester breather cloth were added on top of the carbon fiber. The boat tail was then placed into a vacuum bag, which was then sealed with rubber sealant tape.

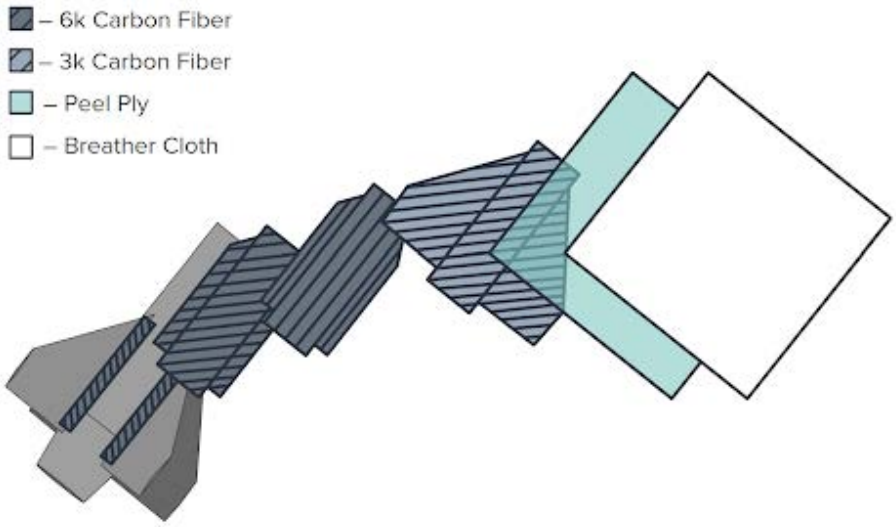


Fig. 32 Fin Can Layup Process Diagram

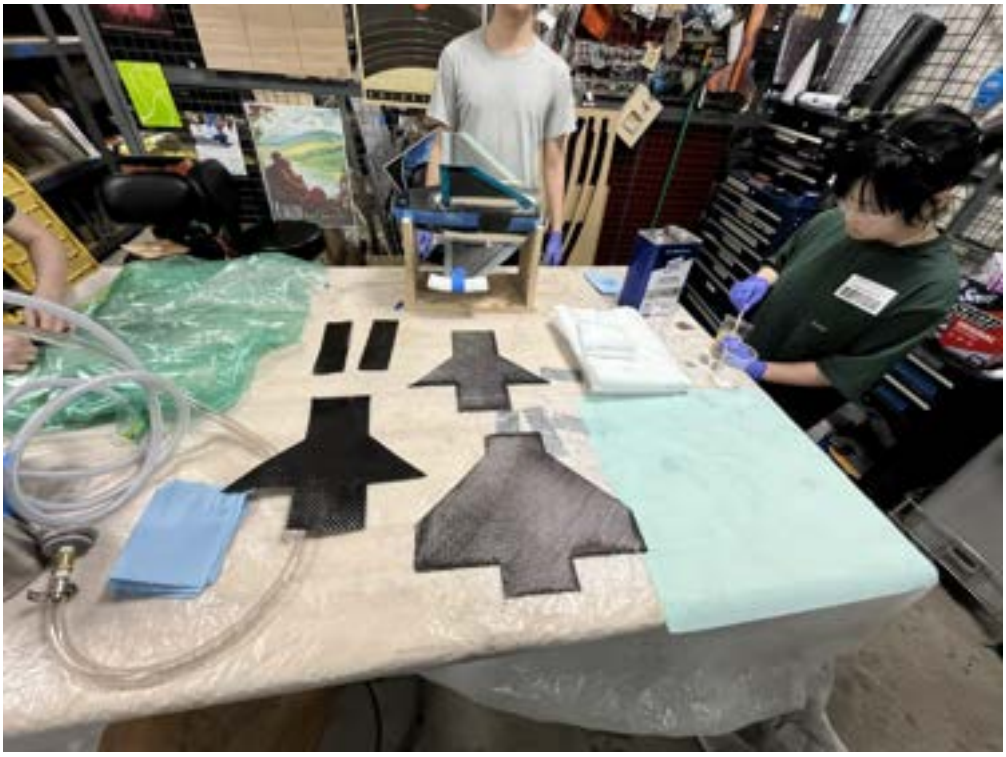


Fig. 33 Fin Can Layup Setup



Fig. 34 Fin Can Layup Setup

For painting, Event Horizon is stripped of epoxy residue and prep sanded using 220 grit sandpaper. The carbon fiber and other external features are covered, and automotive primer is sprayed on. A Cricut is used to cut vinyl stencils. The temporary stencils are painted over, removed and then 2K clear coat covers the entire rocket.

C. Recovery

Event Horizon is recovered in two independent sections, the main body and the nose cone. Previous experience has shown that independent separation reduces the risk of the payload tangling in the recovery line. The parachutes are sized in OpenRocket to fit within the descent rates outlined in Section 6.3 of the DETG [2]. The parachutes selected and relevant information are summarized in Table 8.

Launch Vehicle			
Parachute	**Size (in)**	**Type**	**Descent Rate (ft/s)**
Drogue	22	Elliptical	110
Main	70	Toroidal	26.5
Nose Cone			
Parachute	**Size (in)**	**Type**	**Descent Rate (ft/s)**
Bundled	N/A	N/A	78.4
Nose Cone	24	Elliptical	25.8

Table 8 Recovery Parachute Sizing and Descent Rates

1. Main Body

The main body utilizes a dual event recovery scheme. The drogue parachute is a 22" elliptical parachute which deploys at apogee. The main parachute is an 70" toroidal parachute wrapped in a deployment bag, secured by a small

loop of 3/8" kevlar shock cord. The main parachute deploys at 1500 ft AGL. A Brunnian link [4] is used to tie the loop of shock cord at the Tendie Descendie Duo. This is redundancy ensure that if either pin fails to eject, the line will still be released. The Raven4 and EasyMini in the electronics bay fire redundant ejection charges that deploy the Tendie Descendie Duo, allowing the parachute to come out of the bag. The parachute is attached to the top of the electronics bay with 3/8" kevlar shock cord, sized so that the parachute is able to fully exit the bag and unfurl safely. The total length of the recovery line is 403.5". More detailed recovery diagrams can be found in Figures 35, 36, and 37.

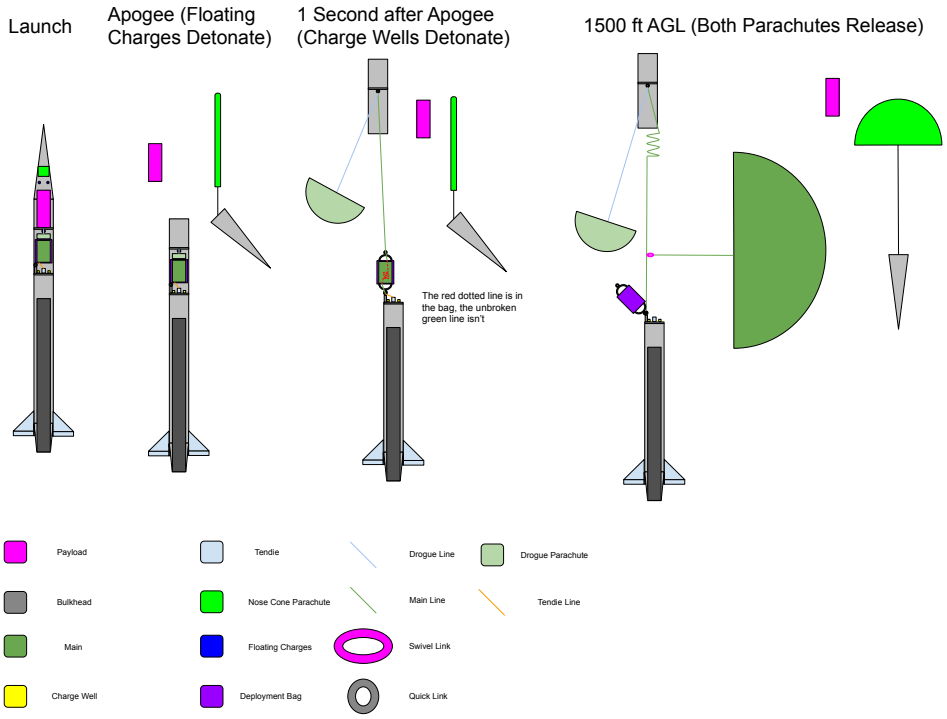


Fig. 35 Main Airframe Recovery Diagram

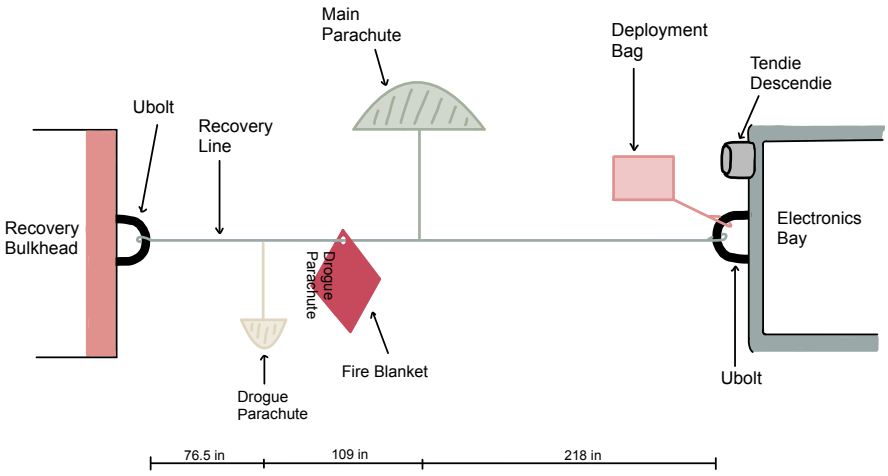


Fig. 36 Main Airframe Recovery Line Diagram

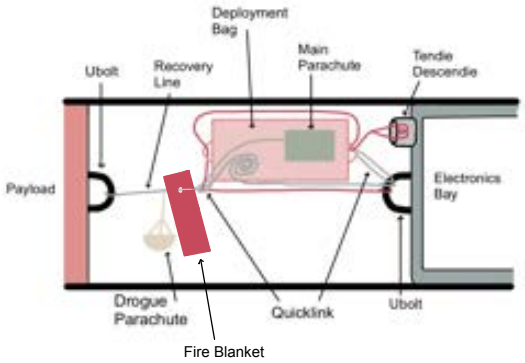


Fig. 37 Main Airframe Recovery Packing Diagram

1 second after apogee, the electronics bay fires two redundant black powder charge wells to separate the upper body tube from the lower body tube. The EasyMini altimeter fires the primary charge, sized at 2 g of black powder. After 0.5 seconds (1.5 seconds after apogee) the backup charge of 2.5 g of black powder, fired by the Raven4, is triggered to ensure tube separation. Although the nose cone and payload should have already deployed at this point, the main recovery charges and other recovery elements are sized so that they will still function nominally if nose cone and payload separation fails to occur. After apogee, the upper body tube and lower body section descend at 110 ft/s with the main parachute retained in its deployment bag. Once Event Horizon reaches 1500 ft AGL, both altimeters fire the Tendie Descendie Duo, thus allowing the main parachute to exit the deployment bag and fully deploy. Once this occurs, the rocket descends at 26.5 ft/s to a safe landing.



Fig. 38 Tendie Descendie Duo with Exposed Plate Assembly

Tendie Descendie Duo The Tendie Descendie Duo is an SRAD device that has the same function as a COTS Tender Descender, but is able to mount to a bulkhead instead of in-line with the parachutes. This is the team's second year using the device, and after its effective utilization at the 2023 Spaceport America Cup, it has not been changed. The Tendie Descendie Duo utilizes two independent charges to ensure redundancy. The Tendie Descendie Duo holds a short length of kevlar line that prevents the main parachute from deploying until it is released. It has two black powder charge wells, each with a plate holding the dowel pins to secure the line. The line is wrapped around the two dowel pins using a Brunnian link, so that when either charge well is fired, the main parachute is released. For the launch at Spaceport America, the pins are set to release at 1,500 ft AGL. The Tendie Descendie Duo was designed to withstand all expected deployment loads. At a force of 1,000 lbf, which is well above any expected load, the Tendie Descendie has a factor of Safety of 7.4, as seen in Figure 39.

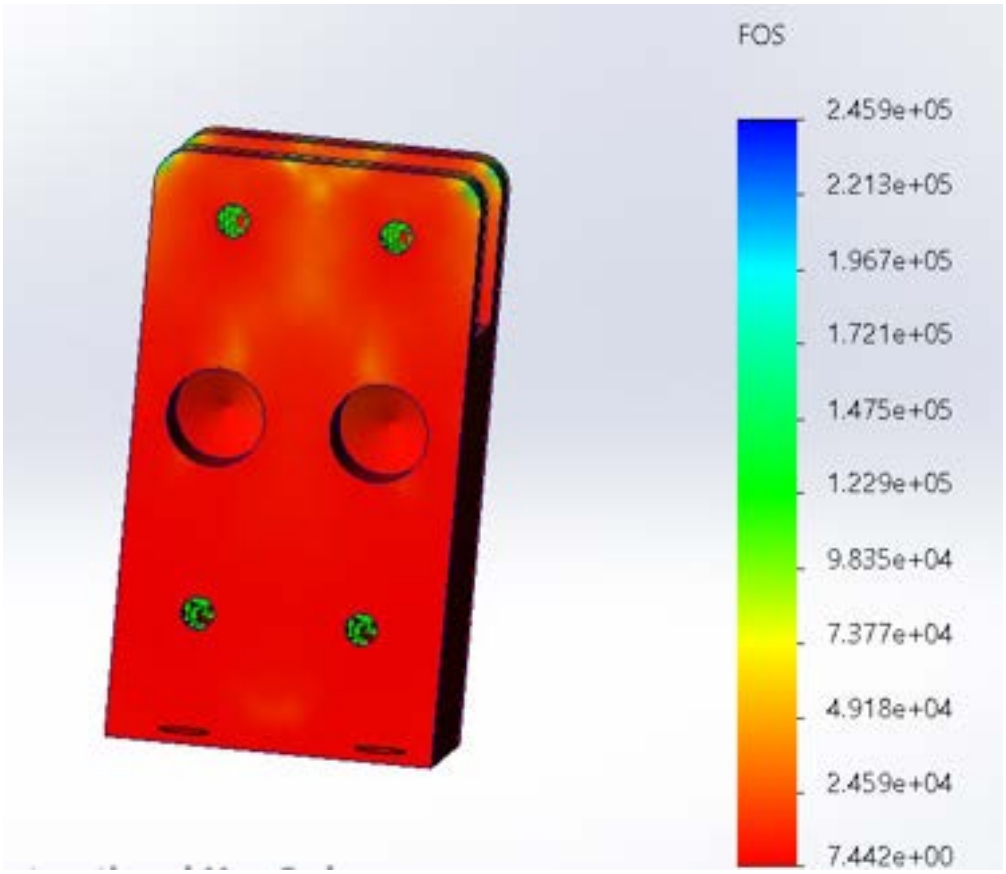


Fig. 39 Tendie Descendie Duo FEA, 1000 lbf, FOS 7.4



Fig. 40 Tendie Ejection Sequence, Section View

2. Nose Cone

The nose cone utilizes a dual event recovery scheme. Its main parachute is wrapped in a nomex fire blanket that is secured using a zip tie threaded through two COTS Piranha cord cutters. The EasyMini and Raven4 located inside the nose cone each fire an electric match that activates one of the cord cutters. The parachute is attached to the nose cone using a 3/8" kevlar shock cord which is 66" long. The length of the shock cord is chosen such that the wrapped parachute could completely exit the nose cone. The electric matches connecting to the cord cutters are longer than the kevlar so that they are not under any tension. As an added precaution to ensure the electric matches are under no tension, loops are created in the electric matches which are zip tied to the shock cord. The recovery diagrams are in Figures 41, 42, and 43.

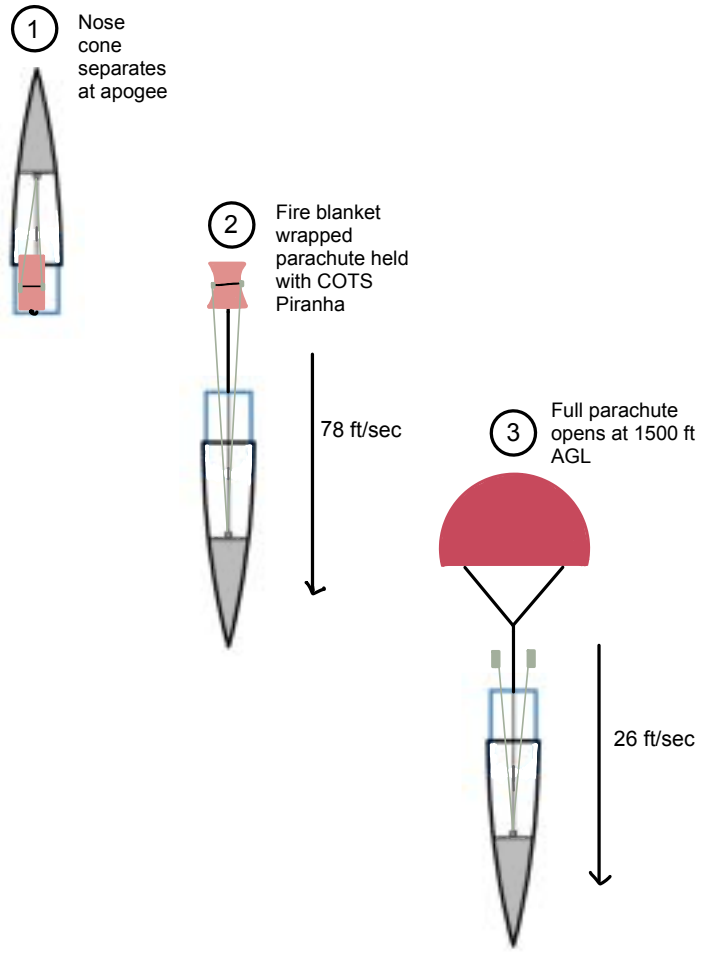


Fig. 41 Nose Cone Recovery Diagram

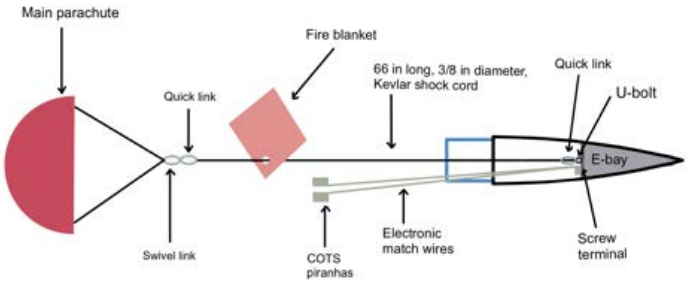


Fig. 42 Nose Cone Recovery Line Diagram

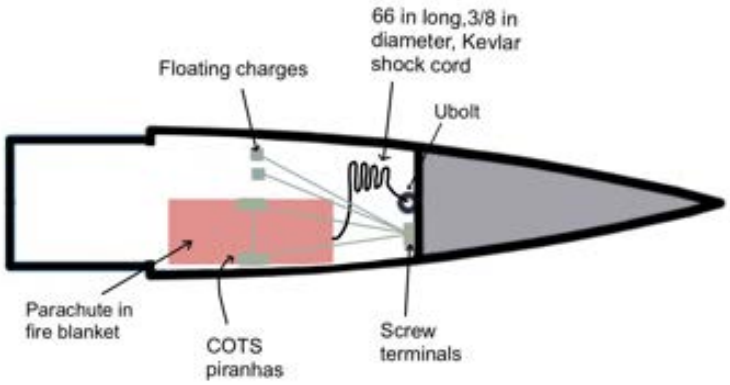


Fig. 43 Nose Cone Recovery Packing Diagram

At apogee, the nose cone separates from the rest of the rocket and the wrapped parachute deploys. The separation occurs through the ignition of the floating charges. The floating charges are nitrile glove tips filled with black powder that are secured using electrical tape. The floating charges are 3 and 3.5 g for the primary and backup charges, respectively. After apogee, the nose cone descends at at 78 ft/s until 1500 ft AGL, at which point the main parachute deploys by the firing of the COTS Piranhas. The nose cone coasts the rest of the way to the ground under the main parachute at 26 ft/s.

3. Black Powder Sizing

The amount of black powder needed for each charge well is calculated using the density of 4F black powder, shear pin strength, and tube characteristics. Event Horizon uses four nylon shear pins to hold separation joints together during ascent. The calculated values are verified in ground ejection tests. The calculated amounts can be seen in Tables 9 and 10. The amounts are adjusted as needed as a result of ground testing. The charges and vehicle sections are packed the same as they would be during flight, and ignited by a flight computer running a flight simulation. A black powder amount is deemed sufficient if the tube sections separated without causing the shock cord to become taut when the charge fired. Around 0.5 g of extra black powder is added to the backup charge wells to ensure that the sections would separate in the air. The final amounts can be found in Table 11.

Inputs			
Rocket	Tube Length	11.19	in
	Internal Diameter	5.65	in
Shear Pins	Shear Pin #	4	
	Minor Diameter	0.0641	in
	Factor of Safety	3	
Constants			
Nylon	Tensile Strength	12000	psi
	Shear Strength	7200	psi
Black Powder	Combustion Temperature	3307	°R
	Gas Constant	265.92	in-lb/lbm-°R
	Density	0.0336	lbm/in^3
Calculated Values			
Rocket	Reference Area	25.07	in^2
	Internal Volume	280.55	in^3
Shear Pins	Desired Pressure	11.12	psi
Black Powder	Desired Amount	1.53	g

Table 9 Recovery Section Black Powder Calculations

Inputs			
Rocket	Tube Length	18.477	in
	Internal Diameter	5.65	in
Shear Pins	Shear Pin #	4	
	Minor Diameter	0.0641	in
	Factor of Safety	3	
Constants			
Nylon	Tensile Strength	12000	psi
	Shear Strength	7200	psi
Black Powder	Combustion Temperature	3307	°R
	Gas Constant	265.92	in-lb/lbm-°R
	Density	0.0336	lbm/in^3
Calculated Values			
Rocket	Reference Area	25.07	in^2
	Internal Volume	463.25	in^3
Shear Pins	Desired Pressure	11.12	psi
Black Powder	Desired Amount	2.52	g

Table 10 Payload Section Black Powder Calculations

Charge	Amounts (g)
Nose Cone Section Primary	3
Nose Cone Section Secondary	3.5
Main Section Primary	2
Main Section Secondary	2.5
Tendie Descendie Duo Primary	0.1
Tendie Descendie Duo Secondary	0.1

Table 11 Black powder Charges, Final Amount

D. Payload

Singularity is a technical payload designed to be deployed from the launch vehicle at apogee, then release a parafoil and guide itself to land on the ground. Singularity is designed to fly with either an SRAD flight computer or an Arduino Nano and a Raven4 flight computer. Success in this technical objective will help develop precision landing capabilities. To control the parafoil, control lines are wrapped around drums of servo motors inside the payload. The servos tension the parafoil's control line and deflect the trailing edge of the parafoil.

Singularity is designed to accommodate all necessary components and systems to complete its mission while conforming to the 3U CubeSat standard, as stated in Section 2.3.5.2 of the IREC Rules and Requirements[5]. Singularity is composed of a single 3U unit, with the majority of the upper third being occupied by the parafoil. The overall size of Singularity is 10 by 10 by 30 cm, or approximately 3.9 by 3.9 by 11.8 in.

The payload is divided into two volumes: the parafoil bay and the electronics bay. They are separated by the recovery bulkhead, which transmits recovery loads from the parafoil to the rest of the payload. The structure is illustrated in Figure 45. The parafoil bay stores the parafoil prior to deployment. The two servos and nichrome line cutters are attached to the underside of the recovery bulkhead. The electronic components are mounted to a removable module that contains: batteries, two COTS flight computers, a COTS GPS, an Arduino Nano, an SRAD power distribution board called Supernova (described in III.D.3), and two cameras. The module is secured to the lower bulkhead and in contact with all four internal walls of the payload.



Fig. 44 Singularity Render

1. Frame

The frame of Singularity is a 3U cubesat form factor that encloses and secures all of the internal components and systems of the payload. The frame consists of two steel frame plates and two aluminum frame plates, a recovery bulkhead, a lower bulkhead, and corner connectors. The frame plates attach to the outside of the lower and recovery bulkheads. The frame connector pieces are placed into the cutout near the top of the frame plates. The frame plates are made of 0.375" thick 6061-T6 aluminum and 0.375" thick 1018 steel. The bulkheads are 0.375" thick 6061-T6 aluminum. To allow for communication and camera views, 0.125" thick polycarbonate frame shields are placed in the cutouts of the frame plates.

The upper recovery bulkhead has several holes to allow recovery control lines to pass through, a center window for the camera, and mounting locations for the parafoil, nichrome cutters, and servo motors. The lower bulkhead contains three 0.22" counterbores that allow the electronics sled to be secured to the payload. The connector pieces are small 3D printed rectangles to secure the top of the frameplates together. All parts of Singularity's frame are fastened with 4-40 alloy steel screws.

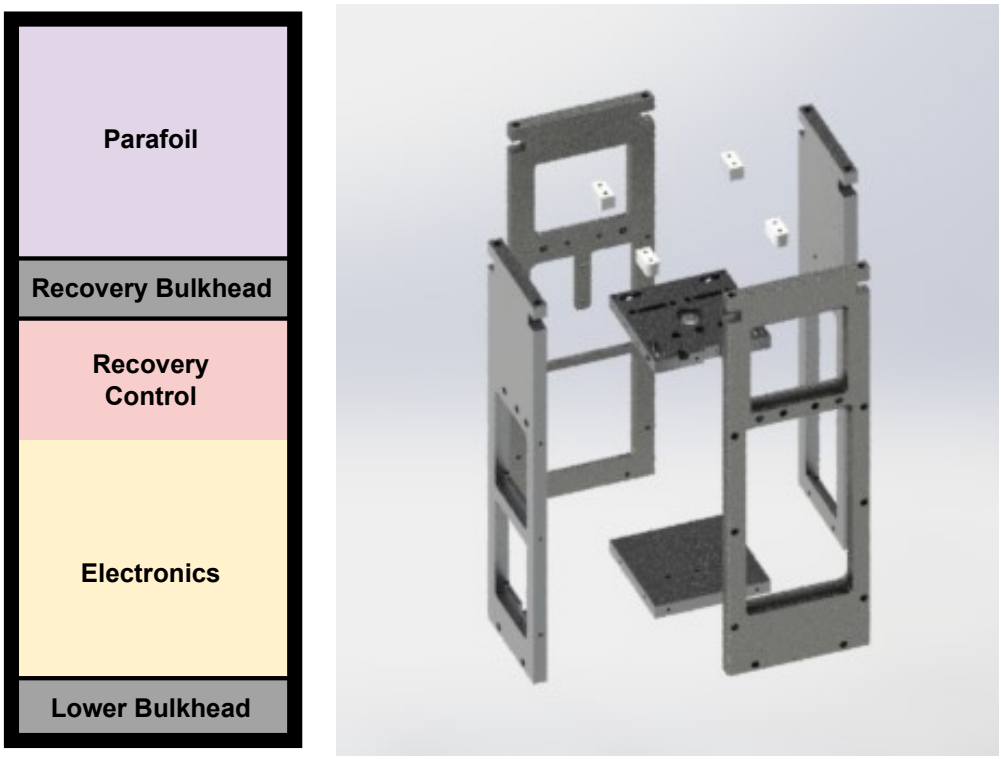


Fig. 45 Singularity Frame

Design Singularity is designed so that all internal components are mounted modularly. None of the recovery components or electronics are mounted on the frame plates, allowing for easy removal and access to the payload's internal components. The frame is structurally stable with up to two frame plates removed, allowing access to all internal components. The recovery bulkhead separates the parafoil from the control electronics, while still allowing parafoil control lines to pass through. The payload outer frame is mostly metal to protect the internal components. Polycarbonate shields are placed in specific cutouts in the frame to aid camera views, GPS connectivity, and radio transmission.

Singularity consolidates the electronics into one removable sled. The team's design fully embraces this character by allowing the entire electronics sled to be removed from the payload, so that the electronics can be worked on separately and integrated just prior to launch. Additionally, this improves the structural stability of the payload, and increases the available internal volume, which is needed to accommodate the new LiFe batteries, which are bigger than LiPo batteries for the same charge capacity.

Aluminum is used for two frame plates, bulkheads and ribs due to its light weight, and machinability. The two other frame plates are made of steel for extra strength and rigidity, as well as its high density. The added weight of the steel plates allows Singularity to meet the weight requirement in Section 2.3.1 of the IREC Rules & Requirements Document [5]. Polycarbonate is used for the clear shields for its heat resistance and durability.

Manufacturing Singularity's frame is manufactured using CNC machining, manual milling, and waterjet. The frame consists of four frame plates, two bulkheads, four clear face shields, and four plate connectors. The 0.375" thick bulkheads are manufactured from 6061-T6 aluminum. Two frame plates are machined from 0.375" thick 6061-T6 aluminum, and the other two frame plates are machined from 0.375" thick 1018 steel. The four plate connectors are 3D printed using PETG because they are non-structural. Aluminum and steel parts are first cut from plate stock using a waterjet. The parts are processed to prepare frame plates and the recovery bulkhead for CNC operations. All features on the largest face of these parts are cut on the CNC mill to ensure proper alignment of features and to speed up machining operations that are time consuming to perform manually. Additional feature on the side faces are added to the parts using a manual mill. The clear face shields are cut from 0.125" polycarbonate plastic using a waterjet and then epoxied to the frame plates.

2. Internal Components

The internal structure consists of the electronic and recovery systems. Above the recovery bulkhead, the parafoil and drogue chute are packed into the recovery section. The NiCr cutters and servo motors are attached to the recovery bulkhead in the electronics section. The electronic sled is attached to the lower bulkhead in the electronic section. The electronic sled houses six batteries, Featherweight GPS, two Raven4s, Arduino Nano, 2 RunCams, and Supernova.

The electronic systems are contained within a 3D printed sled that is attached to the bottom bulkhead of the payload. The sled is composed of two main sections, with a large mount in the center, and a vertical plate that attaches to the bottom of the sled. The vertical plate holds two RunCam Split HD cameras and their camera boards, the Arduino Nano, a Raven altimeter, and the power distribution board. The large mount houses five batteries, three screw switches, the other Raven4 and antenna, the Featherweight GPS and antenna. The batteries are specified to maximize the power lifetime of each electronic component. The electronic sled holds 4 2500 mAH 18650 lithium ion batteries, and 2 900 mAh lithium iron phosphate batteries. Details about the electronic components on the sled are shown in Table 12.

Component	Battery	Operational Time	Regulation	Power Switching
Raven4	2S 900 mAh LiFe	8.0 hrs	Built-in	COTS Screw Switch
Raven4	1S 2500 mAh Li-ion	8.0 hrs	Built-in	COTS Screw Switch
Arduino Nano	2S 900 mAh LiFe	8.0 hrs	Built-in	COTS Screw Switch
RunCam	2S 2500 mAh Li-ion	8 hrs	5V 1.5A	Shutdown pin on regulator by Arduino Nano
Servo	2S 900 mAh LiFe	0.5 hrs	6V 1A	Shutdown pin on regulator by Arduino Nano
NiCr Cutter	2S 900 mAh LiFe	140 s	N/A	MOSFET controlled by Arduino Nano

Table 12 Singularity Electronics Summary

Design The electronics mounting design in the payload requires many components of different forms to be secured in as little volume as possible. It needs to be removable from the rest of the payload frame for assembly and testing purposes. 3D printing the electronics sled allows the most flexibility in design to meet these requirements. The sled is designed in two pieces to maximize surface area to mount electronics on while enabling the sled to be taken apart to access the central components. Features are modeled to the form of each component exactly. PETG is selected over other plastics for its heat resistance and ease of printing. Both flight computers and the GPS are turned on and off with COTS screw switches. Screw switches are used because they are relatively simple to operate and their operation is not affected by high acceleration. Screw switches also have tactile feedback, meaning it is easier to verify that they are switched on.

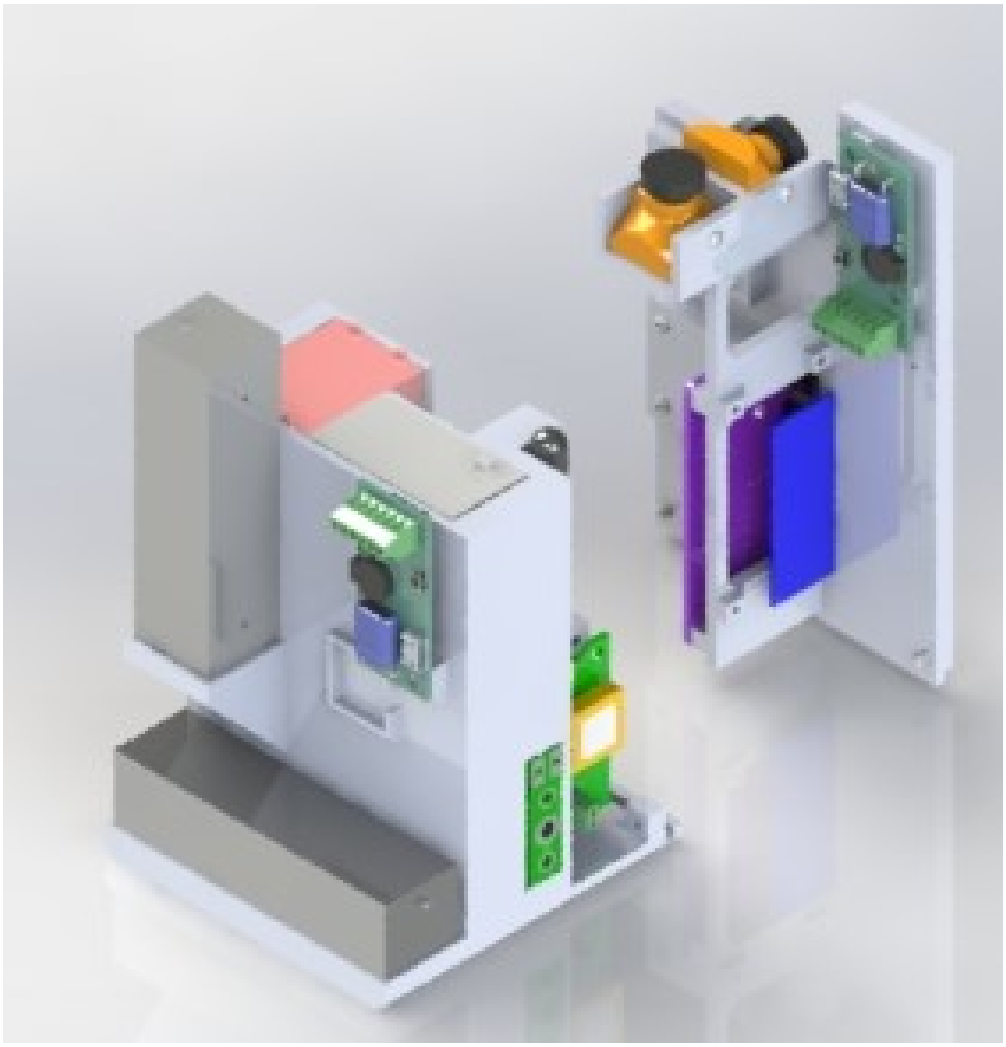


Fig. 46 Singularity Electronics Sled, Exploded View

Manufacturing The speed and flexibility of 3D printing allowed multiple versions of the electronics mount to be printed and tested. The mount is split into 2 separate parts that can be printed more easily, then assembled together. The entire sled is 3D printed with PETG. The servo drums and their cover are similarly printed.

Wiring The payload electronics are separated into two systems, one for each flight computer. For redundancy, each system has an independent power source and independent control of the recovery event. The Raven4 connections contain only the battery and NiCr cutter. The other system involves Supernova, an Arduino Nano, a separate Raven4, cameras, NiCr cutter, servo motors, and batteries. All the components above are connected to Supernova via JST connectors. The Raven4's deployment charges are being used to communicate with the arduino when certain flight events occur. When the Raven4 fires a channel, the corresponding pin on the arduino reads low, which prompts an output pin to send a signal to Supernova. Supernova allows the Arduino Nano to control power to the RunCams, servos, and the NiCr cutter firing circuit. The board includes a 5V 1.5A voltage regulator for the cameras and a 6V 1A voltage regulator for the servos. Power switching is achieved with a MOSFET for the NiCr cutter, and with a built-in shutdown pin on the servo voltage regulator and the RunCams voltage regulator. The wiring diagrams for the various circuits on Supernova are shown in Figure 47. The wiring diagram for the Arduino Nano and Raven4 is shown in Figure 48.

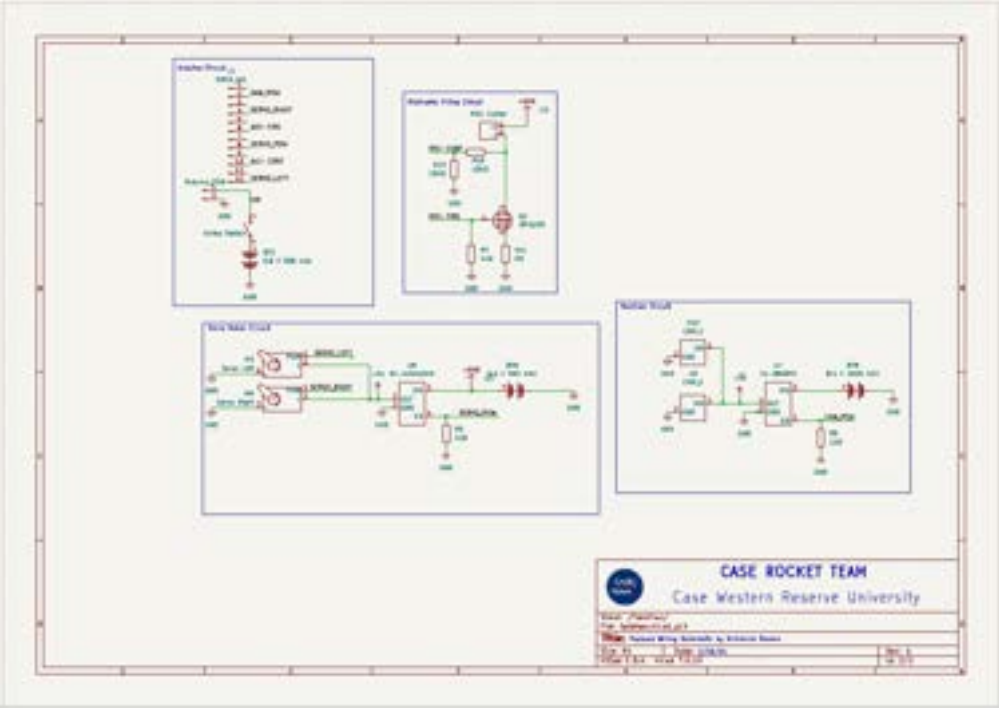


Fig. 47 Supernova Wiring Schematic

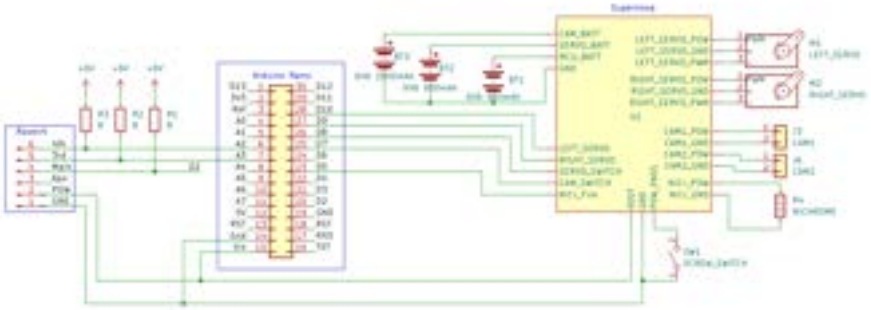


Fig. 48 Ardiuno Nano, Raven4, and Supernova Schematic

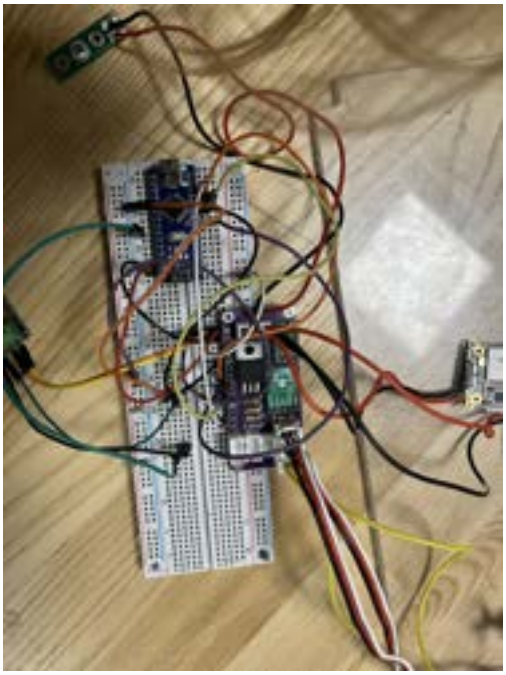


Fig. 49 Testing the concept of using an Arduino and Raven4 with Supernova on a breadboard

3. Supernova

Supernova is a custom PCB designed to be the power distribution board for the payload. A PCB reduces the amount of wires and challenges of routing on the electronics sled. Supernova houses four separate circuits, attached with a common ground. The first circuit connects the battery to the Arduino Nano and Raven4 in parallel. This also ensures that all components have the same ground. The second circuit is used to turn on the cameras. It consists of two RunCams, a 5V regulator, two 18650 batteries, and a pull down resistor. Pin 2 on Supernova outputs a voltage to the shutdown pin on the 5V regulator to turn the cameras on. The third circuit turns on the servo motors. Pins 4 and 12 on Supernova output to the right servo PWM and the left servo PWM respectively. Pin 8 on Supernova outputs a voltage to the shutdown pin on the 6V regulator to turn the servo motors on. The last circuit is to fire the NiCr cutter for deployment. It consists of a MOSFET, battery, the NiCr cutters, and four resistors. Pin 6 on the Supernova outputs a threshold voltage to the MOSFET to complete the NiCr circuit. Pin 10 is related to NiCr continuity. It will not be used for competition. Supernova is shown below in the figure.

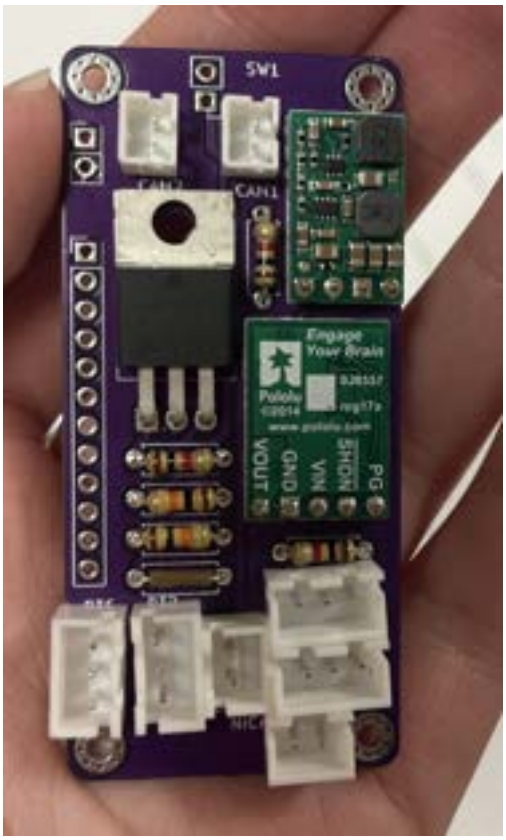


Fig. 50 Supernova, soldered together

4. Recovery Systems

Overview The recovery systems for Singularity are designed to facilitate the payload's primary objective of testing a parafoil with a flight computer to facilitate guided descent and landing of Singularity. Upon deployment from Event Horizon, Singularity descends under an immediately deployed 8 in drogue parachute. The drogue chute has two attachment points, one to the payload's NiCr wire cutter mechanism, and another to the parafoil. The parafoil is stowed in the upper third of the payload and retained via a velcro-attached cover. After descending to 1500 feet, the two independent NiCr cutters are fired by a COTS Raven4 and Supernova to release the drogue chute from Singularity. With the drogue released, it pulls out the parafoil from inside the payload, with the parafoil subsequently inflating. A few seconds after deployment, the flight software will begin running software to actuate two servo motors which will deflect the port and starboard trailing edges of the parafoil to steer Singularity.

Originally, both the parafoil and flight computer for Singularity were intended to be fully SRAD solutions. Due to issues in the design for both of these elements, the team decided to implement COTS solutions to both of these elements instead of their intended SRAD designs to ensure the safety and successful completion of the overall design. This section of the report will discuss the design and manufacturing of the SRAD parafoil and explain the potential shortcomings that led to it being replaced with a COTS solution. All conops diagrams apply both to the SRAD and COTS parafoils. In the following sections, "the parafoil" refers to the SRAD parafoil unless otherwise stated.

Parachute	Size (in)	Type	Descent Speed (ft/s)	Range from 1500 ft (ft)
Drogue	8	Flat	125	N/A
COTS Parafoil (Primary)	70.8 x 18	Parafoil	15.8	3698
SRAD Parafoil	60 x 15	Parafoil (WASPSM)	19.6	2850

Table 13 Singularity Recovery Summary



Fig. 52 WASP Airfoil Profile

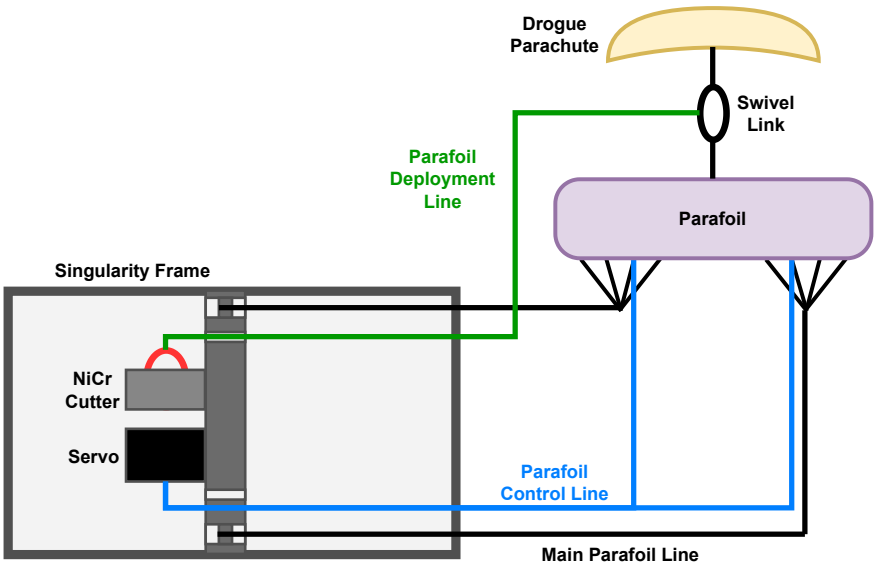


Fig. 51 Singularity Recovery Layout Diagram

Parafoil Design Singularity's parafoil recovery system is designed to achieve the maximum glide ratio possible while maintaining a small enough footprint to fit entirely within the recovery section of the payload. Overall, the design of the parafoil is that of a ram air parachute, which is a style of parafoil that uses the incoming air to inflate pockets, or cells, to maintain shape. The parafoil has a span of 5 ft with a chord of 1.25 ft. The parafoil uses the airfoil WASP smoothed (waspsm). It is broken up into 11 cells of equal length. The parafoil sits at a height of 3 feet above the top of the payload and is connected via four d-rings into the recovery bulkhead. Attached to the trailing edge of the parafoil are control lines that deflect the trailing edges to induce yaw and roll. By connecting the control lines to servos inside Singularity, the whole assembly can be steered.

The design of the parafoil is broken into four major steps: Target values, trade studies, simulation, and CAD. To drive the design of the parafoil, the team decided on target values that were both achievable and provided reasonable goals for the system to achieve. The system needed to achieve 8.8 lbs of lift to support the weight of the payload. Packing volume is also a concern, and it is decided to limit the wingspan of the parafoil to 5 ft. For Singularity to travel more horizontal distance than vertical distance, a target lift/drag, or glide ratio of over 1.5. Using these parameters, a trade study is conducted on the parafoil's flight characteristics. The trade studies utilized both standard flight mechanics equations and parafoil-specific calculations to determine the appropriate sizing for the parafoil. The trade studies approximated the drag of the parafoil and payload, which when combined with the lift of the parafoil, allowed for the sizing of the system and the selection of the airfoil. The airfoils considered for the parafoil were s7055, sd2030, sd2083, waspsm, sa7035, and sa7036, and were found on [6]. Other features of the parafoil that were determined during the trade studies were the 11 cells of the parafoil and the 3 ft height above the payload.

To ensure the flight characteristics of the parafoil result in a safe and stable flight, the software XFLR5 is used to simulate the parafoil and payload [7]. In this software, the geometric and mass properties of Singularity were imputed to the software. XFLR5 is used to determine two major characteristics of the flight performance of Singularity: static

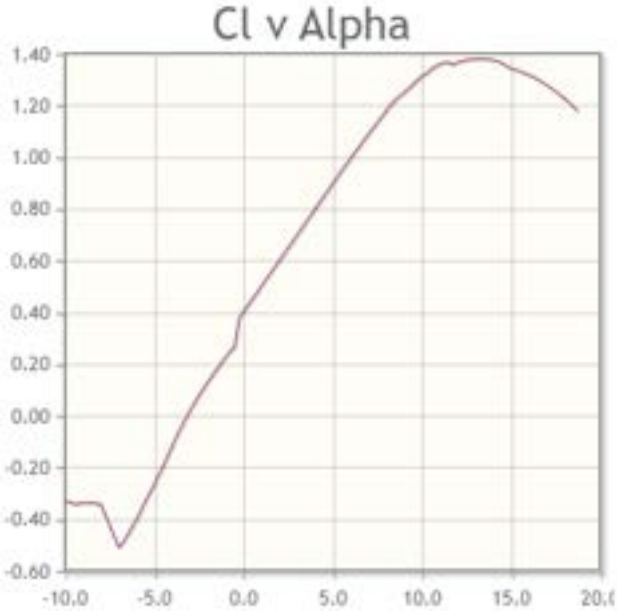


Fig. 53 WASP lift coefficient vs Angle of attack

stability and dynamic stability. Static stability represents the ability of Singularity to return to its neutral flight conditions after being disturbed. To assess this, XFLR5 develops a plot of the moment coefficient as a function of the angle of attack. If there are both positive x and y intercepts on the graph, this represents the tendency of the system to pitch downwards when disturbed upwards and vice versa. Figure 53 shows the plot generated by XFLR5. Dynamic stability also is a measure of response to disturbances but considers factors such as oscillatory behavior, damping, and response time to disturbances. It is typically broken into four lateral modes, which concern pitch, and four longitudinal modes, which concern yaw and roll. XFLR5 analysis showed that the system is dynamically stable as well.

Once the dimensions of the parafoil are determined, the canopy is constructed in SolidWorks. Using the CAD software, rigging lines were created that can be dynamically changed based on a series of overall variables driving the geometry of the model. By measuring the resultant line lengths, the appropriate length of the cords for rigging the parafoil can be determined. The main consideration when rigging the parafoil is maintaining the correct angle of attack relative to the incoming air. Since the payload will always end up normal to the ground, the parafoil has to be rigged at a negative angle of attack relative to the ground such that its angle of attack to the incoming air is correct. The lines for the parafoil were broken into riser, cascade, and control lines. The riser lines were connected to the underside canopy of the main parafoil The sizing of the riser lines is designed to ensure that the canopy will achieve the proper inflation geometry when deployed. The cascade lines ensured the correct angle of attack relative to the incoming air. CAD software is also used to generate laser cutting profiles for the various sections of the canopy.

Parafoil Manufacturing The parafoil is manufactured from ripstop nylon fabric for the canopy, paracord for the riser and cascade lines, shock cord for connections to the drogue, and braided nylon for the control lines. The upper and lower canopy of the parafoil is divided into three parts for manufacturability. The fabric is cut to the correct size in the laser cutter, which has a maximum bed length of 4 ft. Given the 5 ft span of the canopy, two large sections and one small section were cut and sewn together to create the full length. Additionally, the airfoil shaped ribs are cut on the laser cutter. The inner ribs had holes so air can flow between the cells, while the outermost two are sealed. Additional material was included on the top and bottom edges of the ribs to allow them to be sewn together. A wooden template with the exact rib shape was also cut, so the exact shape can be traced onto the oversized fabric ribs to assist sewing.

Once all the pieces were laser cut, the canopies were sewn together to reach the correct wingspan. Stitching lines drawn on the canopy to attach the ribs. The extra overlap on the ribs was used to sew all the ribs onto the upper canopy segment first, then onto the lower canopy. Enough slack in the fabric is left to to allow for the sewing machine to stitch the lower canopy without interfering with the upper one. After the canopy is constructed, the paracord rigging lines were cut to length and sewn both onto the canopy and to each other. After joining them, each knot is sealed with heat shrink to



Fig. 54 SRAD Parafoil Construction

prevent it from coming undone in flight. A drogue attachment line is sewn to the center of the upper canopy. Each of the four cascade lines has D-rings attached in a similar manner to connect to the four slots in the payload recovery bulkhead.

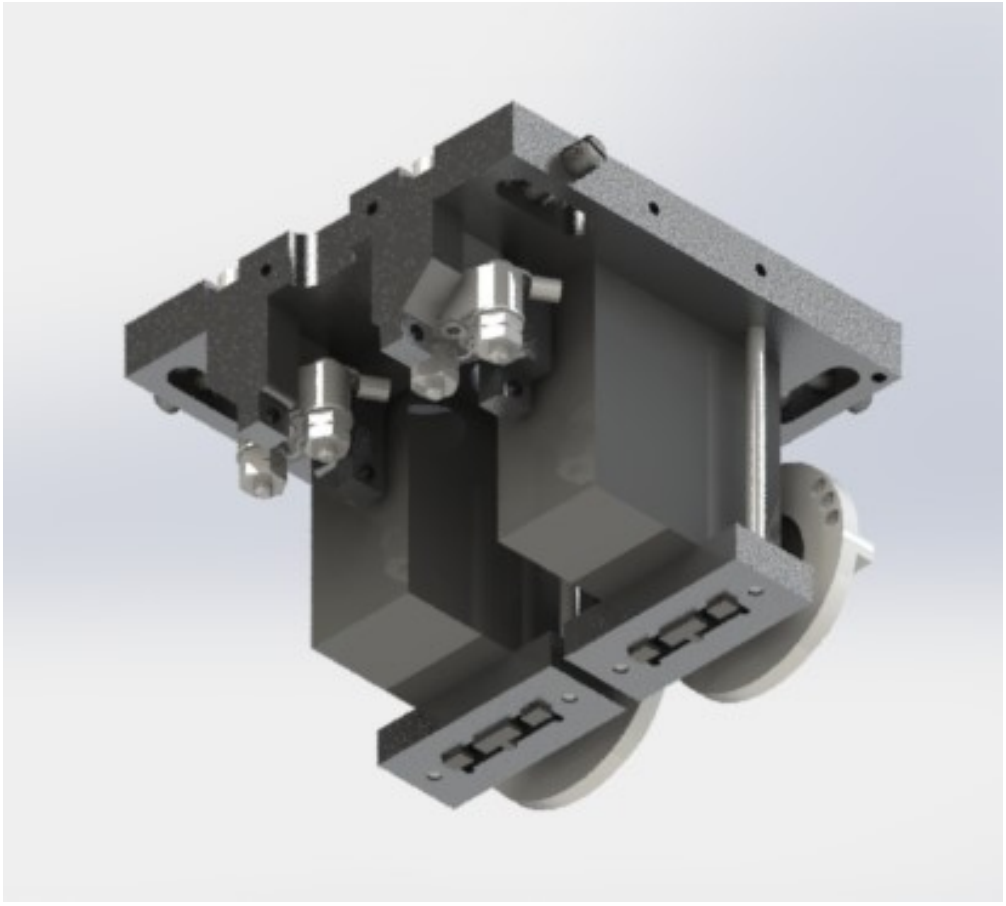


Fig. 55 Singularity NiCr Cutters and Parafoil Control Servos

NiCr Cutter Design Singularity uses a non-energetic recovery deployment system. A NiCr wire cutter mechanism was designed for this purpose. The mechanism is mounted underneath the recovery bulkhead and consists of a 1" length of NiCr wire, a sliding mount, and two support brackets. A loop of braided nylon cord runs past the NiCr wire and up through the bulkhead. Another line connects the drogue parachute to the nylon cord loop so that when the drogue parachute is released the parafoil is still held within the frame. When activated, current flows through a NiCr wire, which heats up and burns through the nylon cord, releasing the parafoil. The NiCr wire must be tensioned against the nylon cord to ensure it burns through it entirely. The wire is attached to a slide mount with internal springs to constantly pull the wire against the cord. The support brackets guide the nylon cord through the wire bulkhead and bear most of the force from the drogue parachute, ensuring that the NiCr wire will not break. The NiCr cutter is electrically connected to a flight computer which checks for continuity and activates it. To enable independent dual-redundant recovery deployment, Singularity includes two NiCr cutters with single loop of nylon cord running between both.

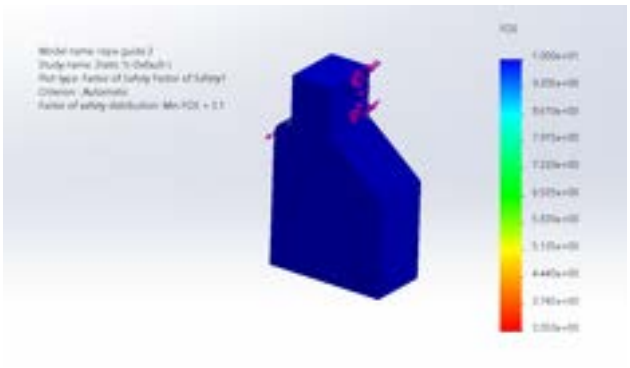


Fig. 56 NiCr Cutter Support Bracket FEA, 42 lbf, 3.1 FOS

NiCr Cutter Manufacturing The sliding mount is cut from delrin on a CNC router, with additional features drilled and tapped manually. The support structures are cut from aluminum by a waterjet. The NiCr wire and springs were purchased components.

Testing The NiCr wire cutter mechanism was tested before integration with the rest of the payload frame. The parafoil was mounted on a car for testing. A special test rig was constructed to attach the parafoil to the roof of a car. The car was driven at up to 40 mph to observe the performance of the parafoil at various air speeds. The parafoil did not inflate during the car mounted tests. Due to this issue, a COTS parafoil is used in the final design of Singularity.

COTS Parafoil A COTS parafoil is used on Singularity due to the SRAD parafoil failures in testing. The COTS parafoil has a span of 5.9 ft, a root chord of 1.8 ft, and a tip chord of 1.2 ft. Parafoil performance calculations were performed for COTS parafoil assuming a similar airfoil profile to the SRAD airfoil. The larger COTS parafoil increases the glide ratio of Singularity and a slows descent rate. To make the COTS parafoil compatible with Singularity, a jig is used to adjust the line lengths of the COTS parafoil to maintain the correct angle of attack. D-rings and a drogue attachment loop are also installed. The fabric cover on the parafoil section is elongated to accommodate the larger COTS parafoil.

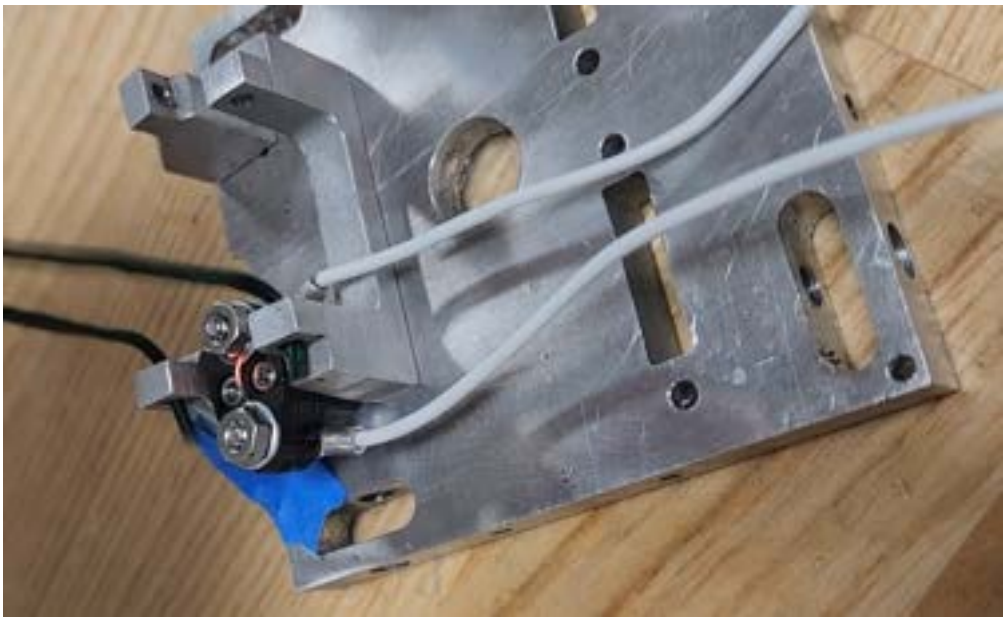


Fig. 57 NiCr Cutter Test



Fig. 58 COTS Parafoil, Drogue, and Fabric Cover

E. Airbrakes

1. Overview

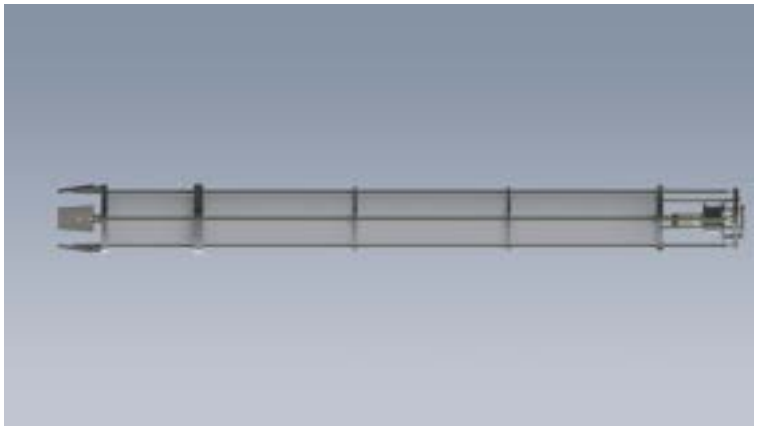


Fig. 59 Full Airbrakes Mechanism

The Airbrakes subsystem is designed to dynamically deploy flaps on ascent to actively control drag to target the desired apogee. This aims to mitigate the effects of varying motor performance and atmospheric conditions on the rocket's apogee, as well as account for errors in manufacturing changing the mass or drag of the rocket. The Airbrakes system uses barometric and accelerometer data to determine the current state of the rocket, then dynamically adjusts flap positioning based on the estimated apogee. The upper mechanism uses an electric motor with rotary encoder to turn a threaded rod and create linear motion in the moving plate. This motion is then transferred through the actuation tubes to the flap linkages. These linkages then convert the linear motion to angular motion of the flaps, adjusting the drag produced. The flaps extend from the boat tail, which prevents them from reducing rocket stability to an unsafe level as the flaps are located below the CG of the rocket. Further details about the operation of Airbrakes can be found in Analysis, section III.E.3.

This system is comprised of three main components: the superstructure, the upper mechanism, and the lower mechanism. The superstructure holds the upper and lower mechanisms together, while providing a simple interface with the rest of the rocket. The upper mechanism contains the drive system, as well as connections to the electronics bay where the control computer resides. The lower mechanism consists of the flaps and their associated linkages, which is where the drag is produced.

2. Structure

Superstructure The superstructure's primary function is connecting the upper and lower mechanisms. The superstructure is built around the motor tube, as the upper mechanism sits above the motor while the flaps are at the bottom of the rocket, extending through the boat tail. The motor tube provides structural rigidity to the Airbrakes subsystem, and several parts of the system act as centering rings for the motor tube, simplifying construction. All components of the superstructure are adhered to the motor tube using Aeropoxy ES6209, as there is not enough thickness for bolts to be effective. From top to bottom the superstructure consists of the motor retainer bulkhead, two centering rings, the actuation tube stabilizer bulkhead, and the actuation mount bulkhead.

The motor retainer bulkhead serves a dual purpose, motor retention and upper mechanism attachment. The threaded rod for motor retention is connected to this bulkhead, which the motor threads on to in order to keep it retained after burnout. The bulkhead also connects the upper mechanism to the superstructure, further discussed in upper mechanism, section III.E.2.

There are two centering rings equally spaced between the motor retainer and actuation tube stabilizer bulkheads. These rings mainly serve to prevent buckling in the actuation tubes. Centering rings with bushings are added to prevent bending of the actuation tubes. After the addition of two centering rings, the unsupported distance is reduced by a factor of three, providing a nine-fold increase in buckling resistance. At only 0.11lbs each, they also lead to an overall mass reduction as thinner walled tubes can be used. The rings also aid in alignment of the subsystem during integration, easing assembly.

The actuation tube stabilizer bulkhead serves to further stabilize the actuation tubes, connect the airframe to the boat tail, and transfer loads from the Airbrakes subsystem to the airframe. The presence of this bulkhead furthers the length of unsupported actuation tube sections, aiding in the rigidity of the system. The bulkhead's main purpose, however, is to connect the subsystem to the rest of the airframe. The bulkhead is connected to the lower airframe and boat tail by six bolts each. This is the only connection to the airframe, which was done to make manufacturing and integration easier, as there are fewer radial bolts to align and insert. Being the only connection, these bolts take all of the drag load of the airbrakes. FEA was run to ensure structural integrity of the bulkhead, and the factor of safety was found to be 24 under the maximum expected loads. As this bulkhead connects the boat tail to the airframe, the thrust of the motor also passes through it. The minimum factor of safety for this is 7.2, which assumes the worst possible load path.

At the bottom of the superstructure lies the actuation mount bulkhead, which connects the lower mechanism to the system. This bulkhead also serves as the lower centering ring for the motor tube. As the lower mechanism attaches to this bulkhead, the flap drag loads are also applied to this bulkhead. As the force is transferred to this bulkhead through bolts, FEA was also run to ensure integrity. The factor of safety under maximum expected loads was found to be 32.

Upper Mechanism The upper mechanism creates the linear motion required for flap actuation and transfers it to the actuation tubes to be sent to the lower mechanism. The motion begins in the DC motor, which is controlled by an SRAD flight computer in the Ebay and mounted to the bottom of the main bulkhead. The rotation is then transferred through a coupler to a lead screw, which moves the moving plate. A thrust bearing is placed above the coupler, against the main bulkhead, to prevent it from stretching due to the force of actuation, improving accuracy. This also prevents axial load on the motor shaft, which improves reliability of the motor. The moving plate has linear bearings that ride on linear rails to keep the plate square and ensure equal actuation of all flaps. The upper mechanism is held together by press fit connections on the linear rails and structural rails. The main bulkhead is pressed onto the linear rails which are pressed into the upper plate. The upper plate in turn has the structural rails pressed into it. The other end of the structural rails is pressed into the motor retainer bulkhead, which connects the mechanism to the superstructure. The main bulkhead and moving plate also have limit switches bolted on to them, which mark full extension and full retraction respectively.



Fig. 60 Airbrakes Upper Mechanism

Lower Mechanism The lower mechanism is comparatively simple, consisting of the flap mount, flap linkage, actuation linkage, flap, and actuation tube connection. The lower mechanism is a four-bar linkage, specifically an offset slider crank mechanism, with the actuation tube as the slider. This converts the linear motion transferred by the actuation tubes to the desired angular motion of the flaps. The linkage lengths chosen provide a range of motion of -8.8 degrees to +40 degrees relative to vertical with approximately 0.55" of linear travel while keeping forces relatively low. The flap linkage begins 0.375" from the bulkhead, 0.25" from the ID of the rocket, and is 2" long. The actuation linkage is 1.75in and the actuation tubes are offset 0.35" from the flap mount. The linkages connect via dowel pins, with reamed holes acting as the bearing surfaces. The pins are press fit into the flap mount and actuation linkages to keep the lower mechanism together. Press fits were chosen over retaining rings or set screws to ease assembly.

The flaps bolt on to the flap linkage, and are made of forged carbon fiber. This manufacturing method was chosen because of carbon fiber's high strength and the complex geometry of the part. Flap sizing was done using a python simulation, and verified using a combination of CFD, OpenRocket data, and custom simulation. The final flap dimensions are 3" long and 2" wide in the middle, with a taper matching the boat tail angle. This results in the remaining sections of the boat tail having no taper, maximizing the structural integrity.



Fig. 61 Airbrakes Lower Mechanism

3. Analysis

Design Constraints The main determining factor for the design of the Airbrakes subsystem is the rocket's center of gravity. There is not enough space to place the Airbrakes system alongside the motor tube, so it must be placed above. This causes the system to be at the center of gravity after burnout. On deployment, the system would shift the center of pressure forward significantly, potentially reducing the rocket's stability to an unsafe level. Flaps above the motor could

also disrupt airflow over the fins, further reducing stability. The flaps are therefore placed in the boat tail and deployed using actuation tubes to prevent instability. Another major design constraint is the amount of space the system can occupy. Space is radially limited to 0.825" for the lower mechanism, as the system must fit between the motor tube and body tube. Vertically, space is limited by the amount of surface drag that can be added while still reaching sufficient altitude to use the system. If the Airbrakes upper mechanism occupies too much space vertically, the added skin drag would reduce apogee to a level that renders the system useless. The upper mechanism must also be able to produce enough linear force to actuate the flaps into the airstream. This is the primary driver in lead screw and motor selection, as they must together produce enough force to actuate the flaps in a timely manner.

Operational Parameters The Airbrakes subsystem was designed to be able to reduce the rocket's apogee from 33,000ft to 30,000ft. This is larger than the discrepancy predicted by the simulations, intended to ensure the system is more than capable of reaching its goals. The flaps are designed to only deploy once the rocket is under Mach 0.8 to ensure accuracy of the control system, further discussed in the paragraph below. Flap sizing simulations were done with a maximum deployment angle of 30 degrees, further increasing the margin for error. The simulations found that a flap size of six square inches was more than sufficient to produce the required drag, so the flaps were designed to be three inches tall and an average of two inches wide. The motor was then sized using preliminary drag and actuation force estimates and is capable of fully actuating the system in under one second at zero load and less than two seconds at maximum expected loads. Since the rocket spends 20 seconds in the actuation window, this speed is sufficient to ensure consistent operation.

Control System The heart of the control system is an SRAD flight computer which reads barometer and accelerometer data as well as interfaces with the motor. The barometer and accelerometer data are combined to obtain an accurate model of the rocket's current state, which can then be used to predict apogee under current conditions. The flight computer can also read a rotary encoder on the motor to track its position. The upper and lower limit switches are also connected to the flight computer so it can reliably identify the fully retracted and extended positions. These inputs allow the flight computer to accurately know the position of the system at all times. The flight computer resides within the main Ebay, alongside the flight computers responsible for ejection events. The computer is connected to the upper mechanism through the lower Ebay bulkhead via a nine pin D-sub connector.

During the flight, data from the barometer and accelerometer are constantly read. This data is then used to maintain an accurate model of the rocket's state. Because this system relies on barometric data for accurate altitude measurements, deployment only occurs under Mach 0.8 where transonic and supersonic effects cannot compromise barometer accuracy. Once the state is known, apogee can be predicted accurately. This data can also be used to predict how the rocket's drag must change to hit the desired apogee. The position of the moving plate can be accurately inferred from the encoder data, which is required to determine the current position of the flaps. The kinematics of four bar linkages are well known, and there exist equations to obtain the angle of the flap using the linkage lengths and actuation distance. By knowing flap angle, data from CFD can be used to estimate the current drag of the rocket. This same data can be used to determine the needed angle for the calculated drag requirement. Once the desired flap angle is found, the actuation distance and encoder position can be calculated. A PID controller can then be used to accurately actuate the flaps to the desired position. The loop can then continue adjusting the estimate and flap deployment until apogee is reached, at which point the flaps are fully retracted and the system's function concludes.

IV. Mission Concept of Operations Overview

Integration Prior to launch, the rocket is assembled following an assembly checklist. First, the electronics bay is assembled with the necessary flight computers and batteries. Wire connections are made and tested before installing the electronics into the coupler. The coupler is then moved to the black powder table where the charge wells are packed. The electronics bay is installed in the lower body tube and connected to the recovery equipment. Next, the recovery equipment is packed into the recovery section of the upper body tube. The upper body tube is anchored in place with shear pins.

The payload is assembled in a similar manner. The electronics sled is assembled with all batteries, computers, cameras, and servos. Wiring connections are tested prior to integration to ensure no faults are made. Next, the parafoil is connected to the payload via the four dowel pins in the recovery bulkhead. Control lines are passed through the bulkhead and are secured to the servo drums. The parafoil is then packed and integrated into the recovery section of the payload. The fabric cover is installed and the drogue chute is folded and placed on top. Once the payload is assembled, it is inserted into the upper body tube, making sure to align its outward facing camera with the window in the tube.

Lastly, the nose cone electronics bay is assembled. The recovery line is prepped with the piranha cord cutters and then attached to the bulkhead. The nose cone bulkhead is placed within the nose cone and fastened in place with the nose cone tip. Lastly, recovery is packed into the remaining space of the nose cone and the nose cone is secured to the upper body tube using shear pins.

After all components are assembled, the motor is installed in the rocket marking the end of the integration process.

Arming Arming begins once the rocket is set up at the launch pad. The electronics on the payload are armed first by turning 3 screw switches through holes in the payload tube. Beep codes from the electronics confirm that the flight computers are activated. Secondly, the nose cone electronics are activated via screw switches and confirmed with beep codes. Lastly, the main electronics are activated via screw switches and confirmed with beep codes. During arming, GPS is also checked to ensure that signals are transmitting from the rocket, payload, and nose cone. After all electronics are confirmed on and transmitting, the igniter is installed and arming is complete.

Ignition Once all personnel are a safe distance from the rocket, the rocket is checked for continuity. After confirming continuity, ignition starts when a signal is sent to the igniter, causing the motor to ignite.

Liftoff Liftoff starts following ignition and constitutes the time during which the rocket is leaving the launch rail. During this time, accelerometers switch into flight mode to collect flight data.

Powered Ascent After the rocket leaves the launch rail at 100 ft/s, barometric devices start taking data as the rocket begins its powered ascent. Powered ascent includes the flight time during which the motor is burning out and ends once burnout has ceased.

Unpowered Ascent Unpowered ascent begins once the motor has burnt out and continues until the rocket reaches apogee. During this time the rocket coasts towards 30k feet, while decelerating due to drag.

Apogee Apogee occurs once the rocket has stopped its ascent, estimated to be around 41 seconds after liftoff. Flight computers detect apogee and cause a series of events. First, once apogee is detected, the charges in the nose cone are ignited 0.5 seconds apart causing the separation of the nose cone from the main body and releasing the payload. One second after apogee is detected, the charges in the main body also fire 0.5 seconds apart and cause the separation of the upper body from the lower part of the rocket and releases the drogue parachute.

Descent With Drogue Following the separation at apogee, the nose cone falls with its parachute reefed at around 78 ft/s. The main body and payload fall under a drogue at 110 ft/s and 125 ft/s respectively. Descent under drogue continues until main deployment.

Main Deployment Once the nose cone, main body, and payload flight computers detect an altitude of 1500 ft AGL the main recovery deployment is triggered. In the main rocket, charges in the Tendie Descendie fire and release the main parachute. In the nose cone, cord cutters fire cutting lines that unreef the main nose cone parachute. Finally, the payload fires NiCr cutters that release the parafoil.

Main Descent Descent under main begins following main deployment once the parachutes have opened, and continues until each component has reached the ground. The rocket body falls under main at a rate of 26.5 ft/s. The nose cone falls under main at a rate of 28 ft/sec. Lastly, the payload glides with its parafoil at a vertical descent rate of 15.8 ft/sec.

Ground Operations Once all components have landed on the ground, the rocket body, nose cone, and payload are located using GPS. A recovery team is set out to retrieve the components and take pictures of the landing conditions. Electronics are then powered off and the rocket/payload is returned to the recovery tent. Altimeter data is delivered and the payload and rocket are disassembled and packed.

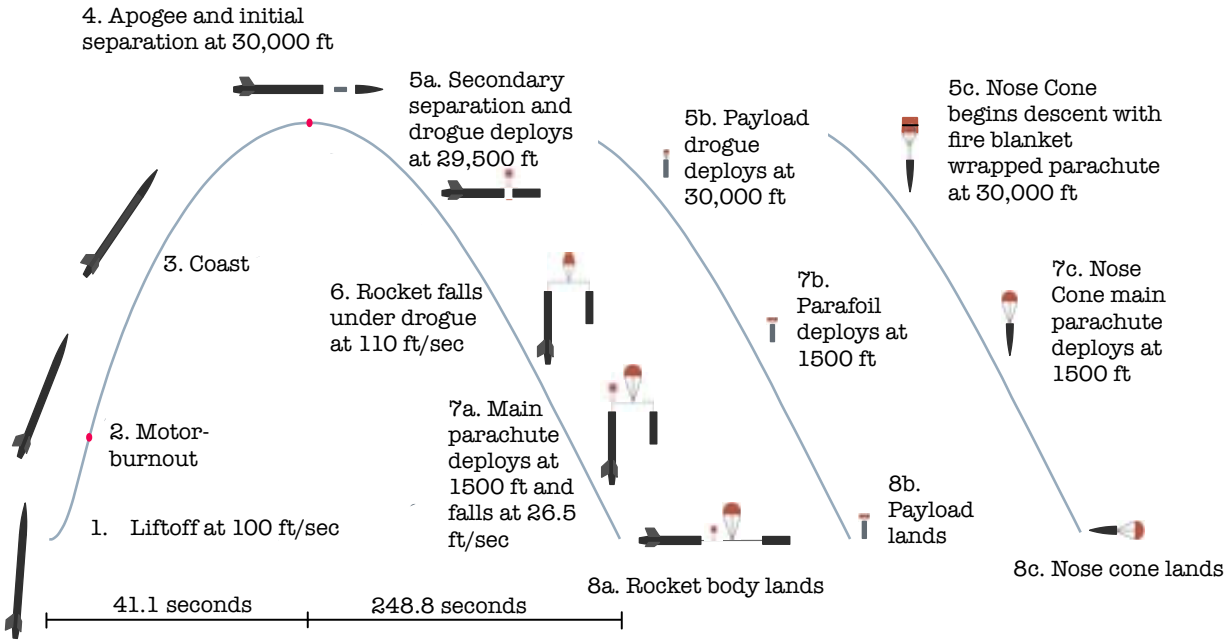


Fig. 62 Mission Concept of Operations Diagram

V. Conclusions and Lessons Learned

Event Horizon provided numerous design and manufacturing challenges as the team strived to implement new technical elements such as air brakes and custom made composites. For the teams' second year participating in the 30k COTS competition, the team strove to reach new technological heights. Apart from the initial challenges associated with designing a rocket that will reach 30k feet, these new technical elements required even more planning and experimentation to ensure that each element worked together to create a successful rocket.

The biggest hurdle faced by the team this competition season was manufacturing custom composite tubes made from carbon fiber. Very quickly, the team realized the importance of tenacity as the process required multiple different tests and failures before a final product was usable for the rocket. This year's success, and struggles, with custom composites proved the team was capable of undertaking unique challenges. The extensive documentation of testing, methods, and success/failures with composites sets the team up for future success in its composite endeavors.

Another lesson Event Horizon highlighted was the importance of balancing time and commitment during the project. The team ambitiously took on the challenge of implementing an air brakes system; however, was ultimately unsuccessful in creating a completed product. While an air brakes structure is in the frame of the rocket, functioning code is not. The biggest takeaway from this failure was the danger of over committing. In the future, the team strives to balance its energy more evenly across all projects to ensure our overall vision is completed.

Event Horizon is a testament to the creativity and innovation the team strives to bring to each competition season. While it is the second rocket the team has built for the 30k COTS competition, it is uniquely its own and deviates quite a bit from last year's design. Along with new innovation, it brought new challenges that highlight the team's ability to work together and problem solve. Event Horizon has expanded the knowledge base of the team and inspired new ideas for the years to come.

The payload team's goal was to optimize Singularity to its fullest extent. It is the second year the team has attempted a controlled descent using servo motors. Going off last year's lessons, all recommendations were implemented into Singularity's design. This included designing entirely in imperial units.

The team faced issues conserving volume in Singularity, hindering our optimization goal. Originally, the plan was to preserve the lower 1U for a scientific experiment. The banning of Lipo batteries was impeding this conservation, as non-Lipo batteries are significantly larger. It was decided to dedicate the entire lower two-thirds to electronics. A custom PCB was used to conserve the space taken up by wires, and it was successfully implemented. Several iterations of the electronic sled were designed to accommodate several changes. These changes include the removal of components and the addition of the Arduino Nano and the secondary Raven4.

Singularity commemorates the determination and resourcefulness of this team in the face of unique challenges. Singularity has opened the door for more complex electronics via PCBs and guidance algorithms in the future.

A. System Weights, Measures, and Performance Data Appendix

A. System Weights

Configuration	Weight (lbs)
Vehicle Weight	56.9
Launch Weight	76.3
Descent Weight	43.3

Table 14 Overall Rocket Weights

Subsystem	Weight (lbs)	Notes
Airframe	23.0	
Electronics Bay	3.5	with switchband and coupler
Nose Cone Electronics Bay	1.6	with Tip
Main Recovery	1.5	
Nose Cone Recovery	0.8	
Payload	8.8	including recovery
Motor	37.1	Casing, Grains, and Hardware

Table 15 Subsystem Weights

B. Measures

Characteristic	Measurement	Units	Notes
Airframe Length	105	in	
Airframe Diameter	6.17	in	
Number of Fins	4	–	
Fin Span	19.07	in	
Fin Root Chord	8.5	in	
Fin Tip Chord	5.75	in	
Fin Sweep Length	7.25	in	
Number of Stages	1	–	
Center of Gravity	65.0	in	At ignition, from tip
Center of Pressure	76.1	in	At ignition, from tip, OR

Table 16 Overall Rocket Measures

C. Performance Data

Flight simulations for Event Horizon were done both in OpenRocket and RASAero. RASAero was utilized in this analysis, as it is more accurate when passing through the transonic region. Simulations in both softwares were used and compared to verify results. Figures 64, 65 and 67 through 70 show the flight path with the O3400 in OpenRocket and RASAero respectively. The flight parameters used in the simulations are summarized in Tables 17 and 19.

1. OpenRocket Simulation Information

Parameter	Value	Units
Latitude	-107	E
Longitude	33	N
Altitude	4,550	ft
Wind Speed	8	mph
Turbulence Intensity	17	%
Launch Rail Length	204	in
Temperature	80	°F
Pressure	1.013	Bar
Launch Angle	4	°, from vertical

Table 17 OpenRocket Simulation Parameters

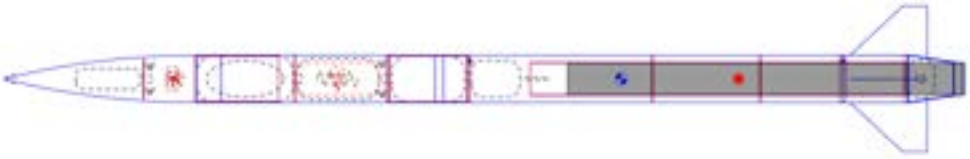


Fig. 63 Event Horizon OpenRocket Model

2. OpenRocket Simulation Results

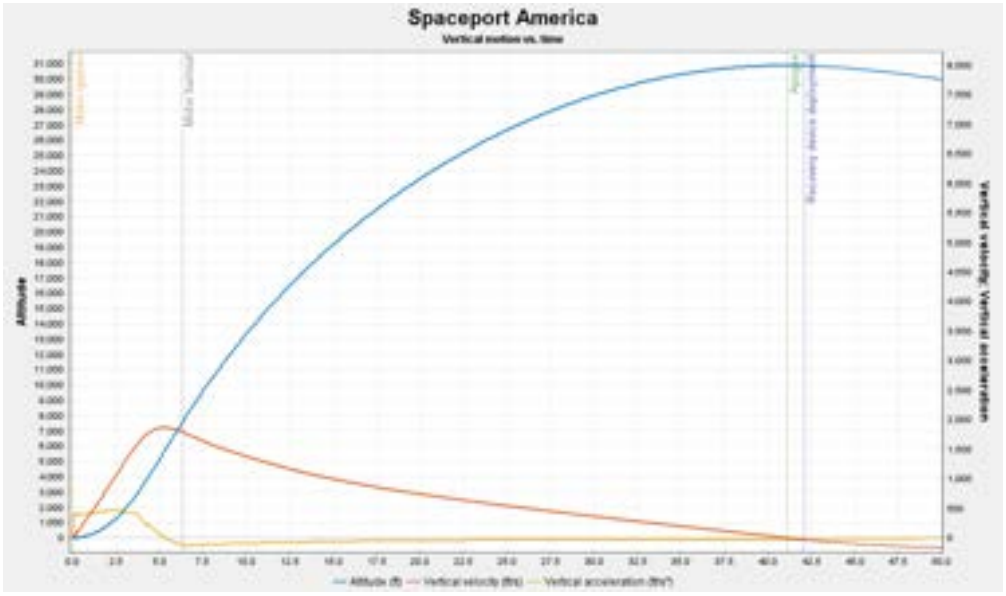


Fig. 64 Event Horizon OpenRocket Flight Path

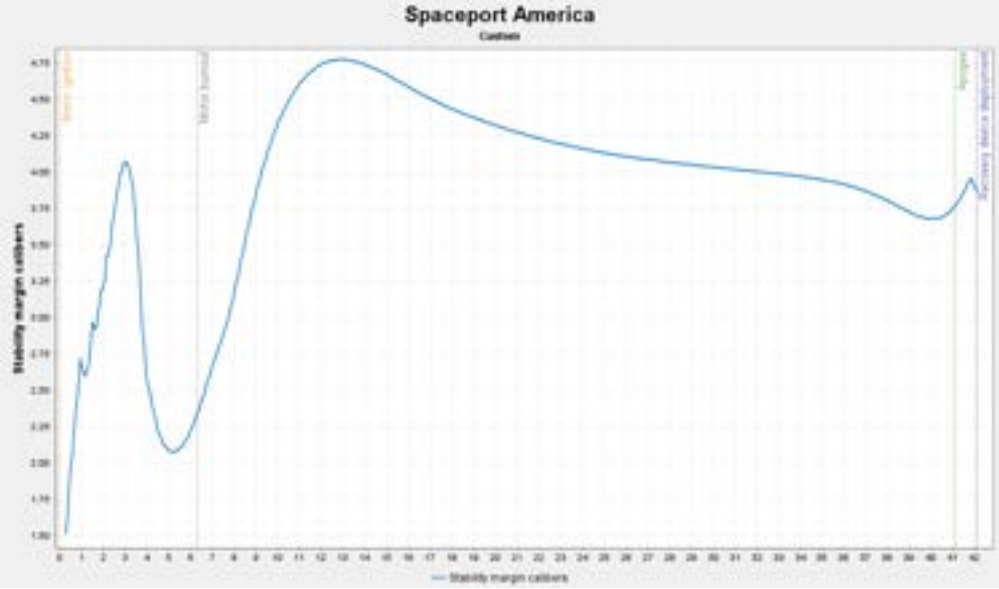


Fig. 65 Event Horizon OpenRocket Stability Profile

Characteristic	Value	Unit
Apogee	30884	ft
Maximum Velocity	1877	ft
Maximum Velocity	1.68	Mach
Maximum Acceleration	466.3	ft/s^2
Maximum Acceleration	14.5	G
Time to Apogee	41.1	s
Flight Time	289.9	s
Ground Hit Velocity	30.6	ft/s
Velocity at Main Deployment	121	ft/s
Rail Departure Velocity	100	ft/s^2
Stability at Mach 0.8	3.42	cal
Rail Departure Stability	1.51	cal

Table 18 OpenRocket Simulation Results

3. RASAero Simulation Information

Parameter	Value	Units
Elevation	4,550	ft
Temperature	80	°F
Wind Speed	8	mph
Launch Rail Length	204	in
Launch Angle	4	°, from vertical
Sustainer CG, from tip	65	in
Loaded Weight	76.3	lb
Nozzle Diameter	2.45	in

Table 19 RASAero Simulation Parameters

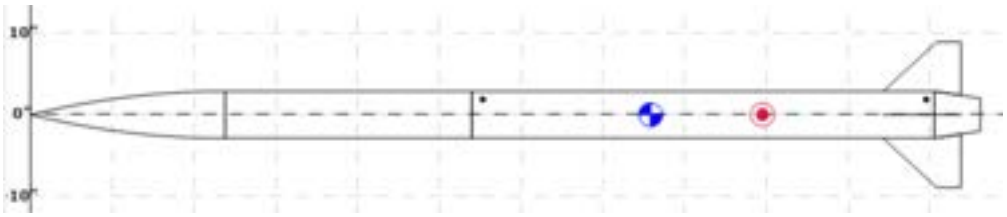


Fig. 66 Event Horizon RASAero Model

4. RASAero Simulation Results

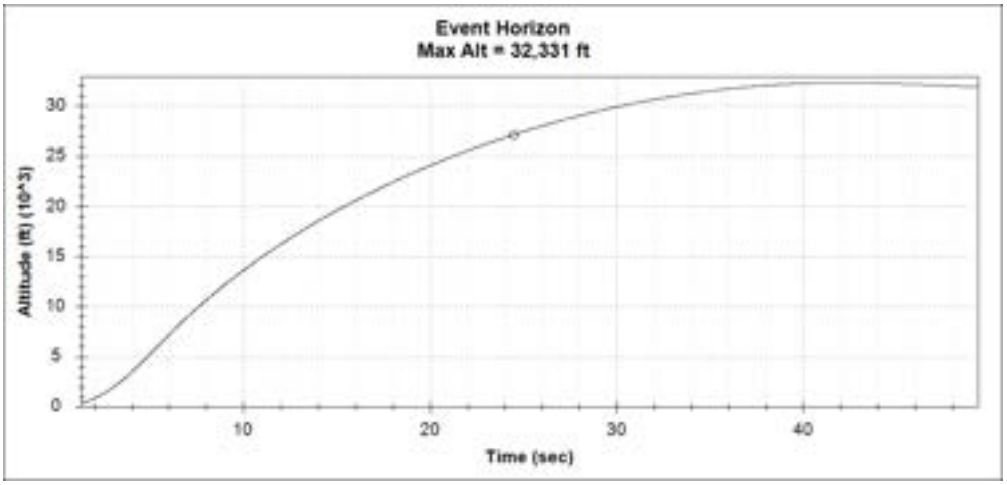


Fig. 67 Event Horizon RASAero Altitude Graph

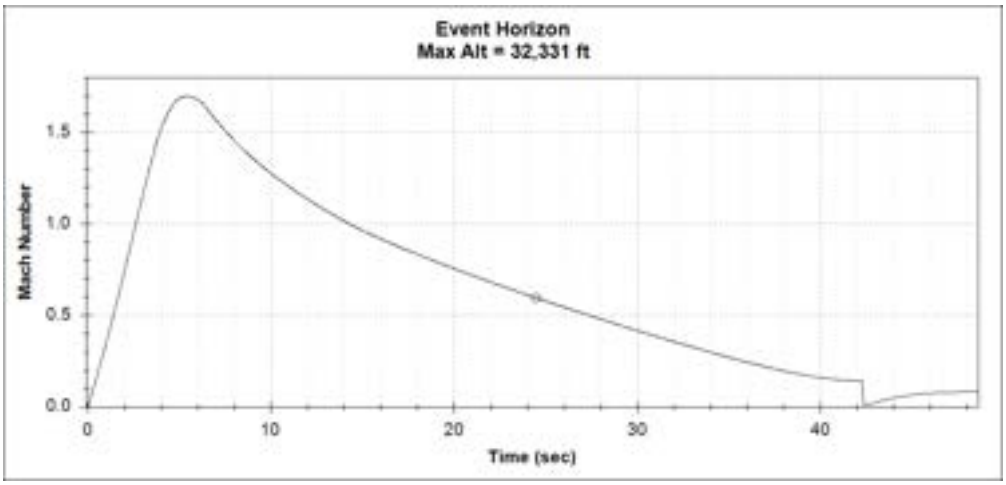


Fig. 68 Event Horizon RASAero Velocity Graph

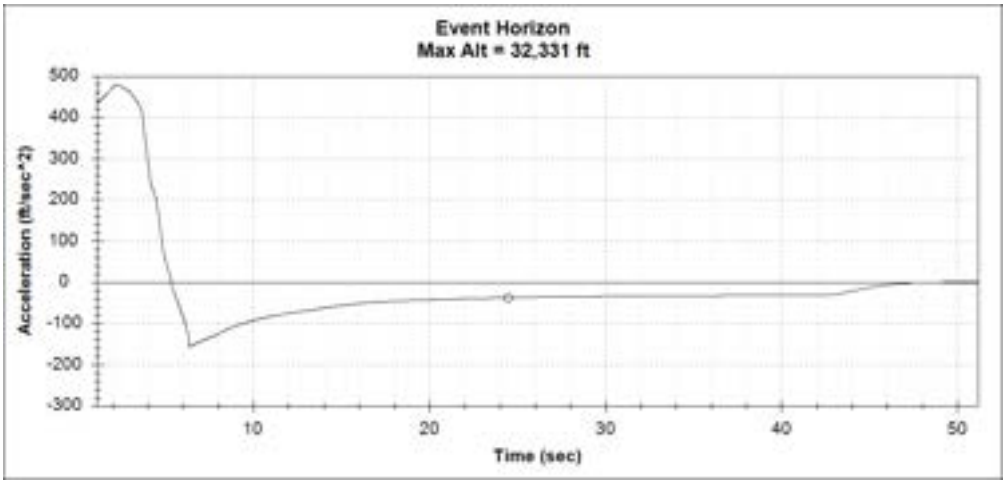


Fig. 69 Event Horizon RASAero Acceleration Graph

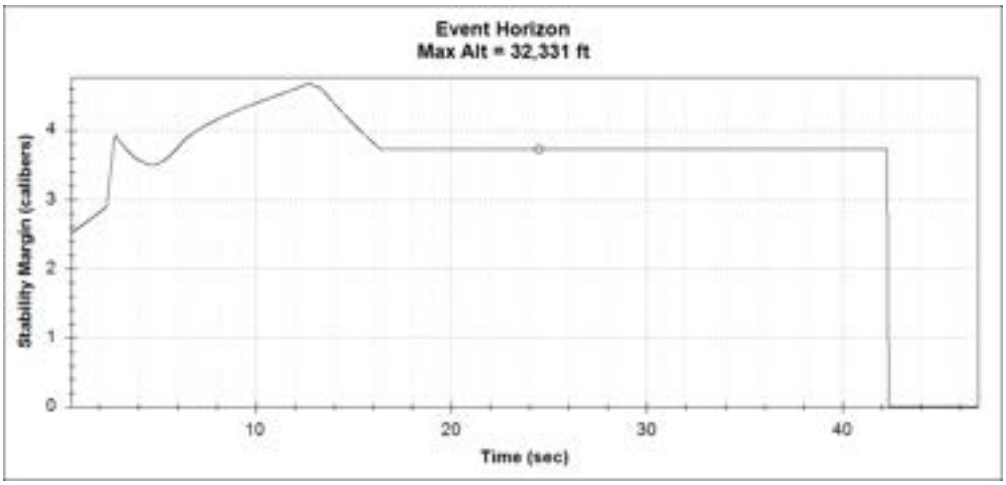


Fig. 70 Event Horizon RASAero Stability Graph

Characteristic	Value	Unit
Apogee	32331	ft
Maximum Velocity	1919.4	ft
Maximum Velocity	1.67	mach
Maximum Acceleration	478.9	ft/s^2
Maximum Acceleration	14.9	G
Time to Apogee	42.2	s
Maximum Stability	4.67	cal
Stability at Mach 0.8	2.84	cal
Rail Departure Stability	2.38	cal

Table 20 RASAero Simulation Results

B. Project Test Reports Appendix

A. Recovery System Testing

Test	Featherweight GPS Carbon Fiber Transmission		
The CF material of the body tubes attenuate RF signals to an unknown degree. This test was performed to determine if a Featherweight GPS module mounted inside the rocket could provide a GPS tracking solution. A Featherweight GPS module with a ¼ wavelength monopole antenna was mounted inside a test CF tube section. The tube was capped with 0.5" plate aluminum on both ends and left standing vertically. The entire test setup was taken to the roof of a parking garage with a clear line-of-sight to the sky. The GPS transmission was monitored through a Featherweight Ground Station module connected to the Featherweight Interface Program app.			
Event	**Success Criteria**	**Result**	
1. GPS Lock	>12 satellites connected, at least one with strength blue	PASS	4/7/2024
2. LORA Packet Transmission	Packets received at long distances	PASS	4/7/2024
	System Analysis	PASS	4/7/2024
Testing Notes			
The test transmission distance was limited by line-of-sight within the city to about 0.5mi. Attenuation effects of CF on GPS transmission is noticeable but within acceptable margins. There is an increased risk of losing GPS connection compared to rockets with CF-transparent tubes.			

Test 1	Main Body Ejection Testing		
The upper and lower body tubes need to separate to allow recovery to deploy. This test was performed on the body tubes and recovery of Event Horizon while on the ground. It confirmed that the in-flight ejection would successfully separate the lower body tube and upper body tube and allow the parachute to deploy without tangling. The specified amount of 2g of black powder successfully separated the tubes and deployed the drogue without tangling. 0.5g was added to the redundant charge well.			
Event	**Success Criteria**	**Result**	
Detonation	Successful detonation of charge	PASS	5/4/2024
Tube Separation	Upper body tube separates completely from lower body tube	PASS	5/4/2024
Drogue Deployment	Drogue parachute exits the recovery section and is not tangled	PASS	5/4/2024
Main Chute Stowed	Main parachute is still inside the recovery section	PASS	5/4/2024
	System Analysis	PASS	5/4/2024

Test 1	**Nose Cone Ejection Testing**		
The Nose Cone of Event Horizon needs to separate completely so that the payload can deploy. This test was performed on Singularity and the upper body tube and nose cone of Event Horizon while on the ground. 4g of black powder were used.			
Event	**Success Criteria**	**Result**	
Detonation	Successful detonation of the charge	PASS	05/04/2024
Nose Cone Separation	The nose cone shears all pins and separates	FAIL	5/4/2024
	System Analysis	FAIL	5/4/2024
Testing Notes			
After analyzing test footage, the payload retention bulkhead seemed to be rotating, the payload coupler was then epoxied in place			

Test 2	**Nose Cone Ejection Testing**		
The Nose Cone of Event Horizon needs to separate completely so that the payload can deploy. This test was performed on Singularity and the upper body tube and nose cone of Event Horizon while on the ground. The calculated 2g of black powder were used in this test.			
Event	**Success Criteria**	**Result**	
Detonation	Successful detonation of the charge	PASS	5/7/2024
Nose Cone Separation	The nose cone shears all pins and separates	FAIL	5/7/2024
	System Analysis	FAIL	5/7/2024
Testing Notes			
2g of black powder seemed to shear two of the four shear pins.			

Test 3			
The Nose Cone of Event Horizon needs to separate completely so that the payload can deploy. This test was performed on Singularity and the upper body tube and nose cone of Event Horizon while on the ground. The calculated 3g of black powder were used in this test.			
Event			
Detonation	Successful detonation of the charge	PASS	5/7/2024
Nose Cone Separation	The nose cone shears all pins and separates	PASS	5/7/2024
	System Analysis	PASS	5/7/2024
Testing Notes			
3g sheared all the pins successfully and separated the sections. An additional 0.5g was added to the redundant charge.			

B. Tube Manufacturing Testing

Test 1	**Compressed Tube Testing**			
In order to achieve a uniform cylindrical shape, as well as the targeted 0.050” tube thickness, shrink tubing was applied on top of a tube layup. This shrink tube would be applied with a heat gun, and once the tube was fully cured, it would be peeled off the tube, and then the tube would be released from the mandrel. Considering tube length as a factor, three tubes of varying length and composition were created to test the process.				
Tube Composition and Length	**Success Criteria**	**Resulting Thickness**	**Result**	
1. 1 layer 6k, 2 layers 3k fabric, 28” long	Tube releases and tube thickness achieved	0.0520”	FAIL	02/16/2024
2. 4 layers 3k sleeve, 10” long	Tube releases and tube thickness achieved	0.0520”	FAIL	03/02/2024
	System Analysis		FAIL	03/04/2024
Testing Notes				
While the targeted tube thickness was achieved within 0.005”, the tubes did not release from their respective mandrels after curing, making it a difficult procedure to use given a time constraint for making the rest of the rocket.				

Test 2	**Uncompressed Tube Testing for Sleeve**			
After unsuccessful attempts with compression, no compression was used, and the tests shifted to prioritizing tube thickness and testing the type of carbon fiber application technique used. Flat fabric and sleeves were used in varying combinations to try to find the most consistent layup for achieving as close to a 0.050” tube thickness as possible (within +0.010”)				
Tube Composition and Length	**Success Criteria**	**Resulting Thickness**	**Result**	
1. 1 layer 6k, 2 layers 3k, 11.40” long	Tube releases and tube thickness achieved	0.0510”	PASS	03/23/2024
2. 2 layers 6k, 1 layers 3k, 28.13” long	Tube releases and tube thickness achieved	0.060”	FAIL	03/30/2024
3. 4 layers 3k, 11” long	Tube releases and tube thickness achieved	0.0650”	FAIL	03/20/2024
4. 2 layer 6k, 10” long	Tube releases and tube thickness achieved	0.0455”	FAIL	03/20/2024
	System Analysis			04/01/2024
Testing Notes				
Carbon fiber sleeve tubing was found to be easier to apply over shorter sections, but were not the strongest without compression.				

Test 3	**Uncompressed Tube Testing for Flat Weave**			
After unsuccessful attempts with compression, no compression was used, and the tests shifted to prioritizing tube thickness and testing the type of carbon fiber application technique used. Flat fabric and sleeves were used in varying combinations to try to find the most consistent layup for achieving as close to a 0.050” tube thickness as possible.				
Tube Composition and Length	**Success Criteria**	**Resulting Thickness**	**Result**	
1. 1 layer 6k, 2 layers 3k, 13.50” long	Tube releases and tube thickness achieved	0.0570”	PASS	02/16/2024
2. 1 layer 3k, 2 layers 6k, 13.50” long	Tube releases and tube thickness achieved	0.0627”	FAIL	03/24/2024
3. 4 layers 3k, 11” long	Tube releases and tube thickness achieved	0.050”	PASS	03/22/2024
4. 2 layers 6k, 13.50” long	Tube releases and tube thickness achieved	0.0450”	FAIL	03/22/2024
	System Analysis			04/01/2024
Testing Notes				
After curing, the flat weaves were found to be easier to make over longer tube lengths and were found to be stronger in compression than sleeve layups.				

C. Hazard Analysis Appendix

Explosives Event Horizon is powered by a CTI O3400-P solid motor. This motor is powered by non-toxic propellant making it safe to be handled without any need for a breathing apparatus. The team will ensure that the motor is handled only by those with a TRA L3 certification. The motor will be properly stored around room temperature and kept away from sources of ignition.

Throughout flight, various events are initiated with black powder charges. During rocket assembly, all black powder is handled on a specific table isolating it from potential sources of danger such as power tools and electronics. As the rocket is assembled and integrated, any pieces of the rocket containing black powder will be moved to a designated black powder table and remain there. All members who work on black powder packing are required to wear eye-protection and participate in a black powder training. Any unused black powder is treated as waste and disposed of by dumping it into the soil. Safety data sheets for the black powder are available to members at all times and is included at the end of this appendix.

Composites Manufacturing Unlike past years, carbon fiber was used for the majority of airframe construction. Carbon fiber was used for main body tubes, coupler tubes, the boat tail and fin can assembly, fins, and tip-to-tip layups. As well as carbon fiber, 6K fiberglass sleeves and G12 fiberglass tubes were used for the nose cone and motor tube respectively. When laminating or sanding fiberglass composites, the same safety precautions were used as highlighted below for carbon fiber composites to avoid introducing large volumes of composite particulates into the air.

When carrying out composite surface preparation tasks using sandpaper, wet sanding, half-face respirators, and open-air spaces were used to prevent any exposure to composite dusts. When laminating composites via hand layups, a well ventilated, large area and double-layered nitrile gloves were used to prevent epoxy poisoning risks. When the laminated fins were water jet cut, higher water levels were used so as to avoid aerosolizing G10 fiberglass or carbon fiber particulates. In specific instances, glass microspheres (“glass bubbles”) or other epoxy fillers were used which can pose a respiratory health hazard. When using epoxy fillers, to prevent exposure to health hazards, half-face respirators, double-layered nitrile gloves, and well ventilated, open areas were used to prevent exposure to health hazards.

Launch Hazards While preparing for launch, all guidelines outlined by TRA [8], NAR [9], and NFPA 1127 [10] will be followed strictly. Only select members will go out to the launch pad to prepare for launch. Each member will be made aware of the necessary safety protocols. The rocket will be driven out to the pad with no electrons armed and when at the pad, a specific launch checklist will be followed to ensure everything is done correctly and safely. While at the launch site, all guidelines and decisions made by the Range Safety Officer will be adhered to.

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SAFETY DATA SHEET

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Pro-X® Rocket Motor Reload Kits & Fuel Grains

1.0 PRODUCT / COMPANY IDENTIFICATION

Product Name: Pro24, Pro29, Pro38, Pro54, Pro75, and Pro98 Rocket Motor Reload Kits
Synonyms: Rocket Motor, Hobby Rocket Motor, HPR Reload Kit
Part Numbers: Reload kits: P24R-Y-#G-XX, P29R-Y-#G-XX, P38R-Y-#G-XX, P54R-Y-#G-XX, P24R-Y-#GXL-XX, P29R-Y-#GXL-XX, P38R-Y-#GXL-XX, P54R-Y-#GXL-XX,
Propellant grains: P75AC-PG-XX, P98AC-PG-XX, P98AC-MB-PG-XX
Where: Y = reload type (A = adjustable delay, C = C-slot)
# = number of grains &
XX = propellant type

Product Use: Solid fuel motor for propelling hobby rockets

Manufacturer / Supplier: Cesaroni Technology Inc.
P.O. Box 246
2561 Stouffville Rd.
Gormley, Ont.
Canada L0H 1G0

Telephone Numbers:
Product Information: Tel: +1-905-887-2370 Fax: +1-905-887-2375
24 Hour Emergency Telephone Number: Tel: +1-613-996-6666 (CANUTEC)

2.0 HAZARDS IDENTIFICATION

Signal Word: **Warning** GHS Pictogram:  Hazard Statement: H204 Fire or Projection Hazard

Precautionary Statements

P210	**Keep away from heat/sparks/open flames/hot surfaces. No smoking**
P250	**Do not subject to grinding/shock/friction.**
P370+P380	**In case of fire: Evacuate Area.**
P372	**Explosion risk in case of fire.**
P373	**DO NOT fight fire when fire reaches explosives.**
P401	**Store in accordance with local/regional/national regulations.**
P501	**Dispose of in accordance with local/regional/national regulations.**

Emergency Overview:
There articles contain cylinders of ammonium perchlorate composite propellant, encased in inert plastic parts. The forward closure also contains a few grams of black powder. ProX Rocket motor reload kits are classified as explosives, and may cause serious injury, including death if used improperly. All explosives are dangerous and must be handled carefully and used following approved safety procedures under the direction of competent, experienced personnel in accordance with all applicable federal, state and local laws and regulations. Avoid inhaling exhaust products.

General Appearance:
Cardboard tubes contain various plastic parts. Inside the plastic tube are cylinders of composite propellant (rocket fuel). The forward closure also contains a small quantity of black powder. All parts are odourless solids.

Potential Health Effects:

Eye:
Not a likely route of exposure. May cause eye irritation.

Skin:
Not a likely route of exposure. Low hazard for usual industrial/hobby handling.

Ingestion:

Not a likely route of exposure.

Inhalation:

Not a likely route of exposure. May cause respiratory tract irritation. Do not inhale exhaust products.

3.0 COMPOSITION / INFORMATION ON INGREDIENTS

Propellant

Ingredient Name	CAS Number	Percentage
Ammonium Perchlorate	7790-98-9	40-85 %
Metal Powders		1-45 %
Synthetic Rubber		10-30 %

Black Powder Ignition pellet

Ingredient Name	CAS Number	Percentage
Potassium Nitrate	7757-79-1	70-76 %
Charcoal	n/a	8-18 %
Sulphur	7704-34-9	9-20 %
Graphite	7782-42-5	trace

4.0 FIRST AID MEASURES

Eyes:

Immediately flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid.

Skin:

Flush skin with plenty of soap and water for at least 15 minutes while removing contaminated clothing and shoes. Get medical aid if irritation develops or persists.

Ingestion:

Do NOT induce vomiting. If conscious and alert, rinse mouth and drink 2-4 cupfuls of milk or water.

Inhalation:

Remove from exposure to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.

Burns: Burns can be treated as per normal first aid procedures.

5.0 FIRE FIGHTING MEASURES

Extinguishing Media:

In case of fire, use water, dry chemical, chemical foam, or alcohol-resistant foam to contain surrounding fire.

Exposure Hazards During Fire:

Exposure to extreme heat may cause ignition.

Combustion Products from Fire:

During a fire, irritating and highly toxic gases may be generated by thermal decomposition or combustion.

Fire Fighting Procedures:

Keep all persons and hazardous materials away. Allow material to burn itself out. As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear.

Special Instructions / Notes:

These articles burn rapidly and generate a significant flame for a short period of time. Black powder is a deflagrating explosive. It is very sensitive to flame and spark and can also be ignited by friction and impact. When ignited unconfined, it burns with explosive violence and will explode if ignited under even slight confinement. Do not inhale exhaust products.

6.0 ACCIDENTAL RELEASE MEASURES

Safeguards (Personnel):
Spills: Clean up spills immediately. Replace articles in packaging and boxes and seal securely. Sweep or scoop up using non-sparking tools.

7.0 HANDLING AND STORAGE

Handling: Keep away from heat, sparks and flame. Avoid contamination. Do not get in eyes, on skin or on clothing. Do not taste or swallow. Avoid prolonged or repeated contact with skin. Follow manufacturer's instructions for use.

Storage: Store in a cool, dry place away from sources of heat, spark or flame. Keep in shipping packaging when not in use.

8.0 EXPOSURE CONTROLS / PERSONAL PROTECTION

Engineering Controls:
Use adequate explosion proof ventilation to keep airborne concentrations low. All equipment and working surfaces must be grounded.

Personal Protective Equipment:

Eyes:
Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.

Skin:
Clothing should be appropriate for handling pyrotechnic substances.

Clothing:
Clothing should be appropriate for handling pyrotechnic substances.

Respirators:
A respirator is not typically necessary. Follow the OSHA respirator regulations found in 29CFR1910.134 or European Standard EN 149. Always use a NIOSH or European Standard EN 149 approved respirator when necessary.

9.0 PHYSICAL AND CHEMICAL PROPERTIES

Physical State:	solid
Appearance:	rubber cylinders inside plastic parts
Odour:	none
Odour Threshold:	Not available.
pH:	Not available.
Vapour Pressure:	Not available.
Vapour Density:	Not available.
Viscosity:	Not available.
Evaporation Rate:	Not available.
Boiling Point:	Not available.
Freezing/Melting Point:	Not available.
Coefficient of water/oil distribution:	Not available.
Autoignition Temperature:	280°C
Flash Point:	Not available.
Explosion Limits, lower (LEL):	Not available.
Explosion Limits, upper (UEL):	Not available.
Sensitivity to Mechanical Impact:	unprotected black powder can be ignited by impact
Sensitivity to Static Discharge:	unprotected black powder can be ignited by static discharge
Decomposition Temperature:	> 400°C
Solubility in water:	black powder is soluble in water
Specific Gravity/Density:	black powder = 1.7-2.1 Propellant = not available
Molecular Formula:	Not applicable
Molecular Weight:	Not applicable.

10.0 STABILITY AND REACTIVITY

Chemical Stability:
Stable under normal temperatures and pressures.
Conditions to Avoid:
Heat, static electricity, friction, impact
Incompatibilities with Other Materials:
Combustible or flammable materials, explosive materials
Hazardous Products Of Decomposition:
Oxides of nitrogen
Hazardous Polymerization:
Will not occur.

11.0 TOXICOLOGICAL INFORMATION

Routes of Entry: Skin contact – not likely
Skin absorption – not likely
Eye contact – not likely
Inhalation – not likely
Ingestion – not likely

Effects of Acute Exposure to Product:
No data available

Effects of Chronic Exposure to Product:
No data available

Exposure Limits:

Black Powder Pellets

Ingredient Name	CAS Number	OSHA PEL	ACGIH TLV
Potassium Nitrate	7757-79-1	not established	not established
Charcoal	n/a	not established	not established
Sulphur	7704-34-9	not established	not established
Graphite	7782-42-5	2.5 mg/m^3	15 mmpct (TWA)

Propellant

Ingredient Name	CAS Number	OSHA PEL	ACGIH TLV
Ammonium Perchlorate	7790-98-9	not established	not established
metal powder		varies	varies
Synthetic Rubber		not established	not established

Irritancy of the Product:
No data available

Sensitization to the Product:
No data available

Carcinogenicity:
Not listed by ACGIH, IARC, NIOSH, NTP, or OSHA

Reproductive Toxicity:
No data available

Teratogenicity:
No data available

Mutagenicity:
No data available

Toxically Synergistic Products:
No data available

LD50:
No data available

12.0 ECOLOGICAL INFORMATION

Environmental Data:
Ecotoxicity Data:
Not determined.

EcoFaTE Data:
Not determined.

13.0 DISPOSAL CONSIDERATIONS

Product As Sold: Pack firmly in hole in ground with nozzle pointing up. Ignite motor electrically from a safe distance and wait 5 minutes before approaching. Dispose of spent components in inert trash.

Product Packaging: Dispose of used packaging materials in inert trash.

Special Considerations: Consult local regulations about disposal of explosive materials.

14.0 TRANSPORT INFORMATION

Shipping Information – Canada

TDG Classification:	Class 1.4 Explosive
Proper Shipping Name:	Articles, Explosive, N.O.S. (Model Rocket Motors)
UN Number:	0351
UN Classification Code:	1.4 C
Packing Group:	II
UN Packing Instruction:	101

Shipping Information - USA / IMO

Proper Shipping Name:	Articles, Explosive, N.O.S. (Model Rocket Motors)
UN Number:	0351
UN Classification Code:	1.4 C
DOT / IMO Label:	Class 1 – Explosive – Division 1.4C

Shipping Information - IATA

Proper Shipping Name:	Articles, Explosive, N.O.S. (Model Rocket Motors)
UN Number:	0351
UN Classification Code:	1.4 C
IATA Labels:	Class 1 – Explosive – Division 1.4C Cargo Aircraft Only

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15.0 REGULATORY INFORMATION

Canada

This product has been classified according to the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

WHMIS Classification: Not Controlled (explosive)

Domestic Substance List (DSL) Status:
All ingredients are listed on Canada's DSL List.

Canadian Explosives Classification: Rocket Motors - **R2, PE3**
This products are authorized explosives in Canada.

These products are not considered "Controlled Goods" in Canada under the Controlled Goods Regulations.

United States of America

TSCA Inventory Status:
All ingredients are listed on the TSCA inventory.

Hazardous Chemical Lists

CERCLA Hazardous Substance (40 CFR 302.4)	No
SARA Extremely Hazardous Substance (40CFR 355)	No
SARA Toxic Chemical (40CFR 372.65)	No

European/International Regulations

The product on this MSDS, or all its components, is included on the following countries' chemical inventories:
EINECS – European Inventory of Existing Commercial Chemical Substances

European Labelling in Accordance with EC Directives
Hazard Symbols: Explosive.
Risk Phrases:
- **R 2** Risk of explosion by shock, friction, fire or other sources of ignition.
- **R 11** Highly flammable
- **R 44** Risk of explosion if heated under confinement.

Safety Phrases:
- **S 1/2** Keep locked up and out of the reach of children.
- **S 8** Keep container dry.
- **S 15** Keep away from heat.
- **S 16** Keep away from sources of ignition -- No smoking.

S 17 Keep away from combustible material.
S 18 Handle and open container with care.
S 33 Take precautionary measures against static discharges.
S 41 In case of fire and/or explosion do not breathe fumes.

16.0 OTHER INFORMATION

MSDS Prepared by: Regulatory Affairs Department
Cesaroni Technology Inc.
P.O. Box 246
2561 Stouffville Rd.
Gormley, ON
Canada L0H 1G0

Telephone: 905-887-2370 x239
Fax: 905-887-2375
Web Sites: www.cesaronitech.com
www.Pro38.com

The data in this Material Safety Data Sheet relates only to the specific material or product designated herein and does not relate to use in combination with any other material or in any process.

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no way shall the company be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if the company has been advised of the possibility of such damages.

SAFETY DATA SHEET-BLACK POWDER

Section 1: Identification

Product Identifier: Black Powder (includes all grades)

Manufacturer's Name: GOEX Powder, Inc.

Address: P.O. Box 659
Doyline, LA 71023-0659

Informational Telephone Number:1-(318) 382-9300

Emerg. Phone Number: 1-(800) 255-3924 (Chem Tel)

Recommended Use: for use in competitive and recreational shooting, muzzleloading hunting and the U.S. Military .

Section 2: Hazard(s) Identification

Hazard category:	Signal Word	Hazard statement	Pictogram
Division 1.1	Danger	Explosive; mass explosion hazard	

Target Organ Warning: Above OSHA levels, chronic exposure may cause skin irritation and damage to the respiratory system, and acute exposure can cause skin, eye, and respiratory irritation.

Section 3: Composition/information on ingredients

Component	CAS-Number	Weight %
Charcoal	16291-96-6	8-18%
Sulfur	7704-34-9	9-20%
Potassium Nitrate	7757-79-1	70-76%
Graphite (note: not contained in all grades of black powder)	7782-42-5	<1%

Section 4: First-aid measures

Ingestion: * Not a likely route of exposure. If ingested, dilute by giving two glasses of water and induce vomiting. Avoid, when possible and contact a Poison control center for advice on treatment, if unsure.

Eye Contact: * Not a likely route of exposure. Flush eyes with water.

Inhalation: * Remove patient from area to fresh air. If not breathing, give artificial respiration, preferably by mouth to mouth. If breathing is difficult, give oxygen. Seek prompt medical attention. Avoid when possible.

Skin Contact: * wash the affected area with copious amounts of water. Some persons may be sensitive to product.

Injury from detonation: * Seek prompt medical attention immediately.

Note to Physician: * Treat symptomatically.

Section 5: Fire-fighting measures

Extinguishing media: * Water may be used as the extinguishing method. DO NOT FIGHT EXPLOSIVES FIRES. Evacuate the area according to Emergency Response Guide 112 guidelines. Isolate the area and guard against any intruders.

Special Procedures: * Black Powder is extremely flammable and may deflagrate. Get away and evacuate the area.

Unusual Hazards: * As with any pyrotechnic, if under confinement or piled in slight confinement, Black Powder can explode. No known toxic fumes are emitted, but good ventilation should still be present.

Flash Point: not applicable.

Auto ignition Temp: Approximate range: 392° -867°F /(200°-464°C)

NFPA Ratings: **Health=1** **Flammability=3** **Reactivity=1**

Advice and PPE for Firefighters: * Fires involving Black Powder should not be fought unless extinguishing media can be applied from a well protected and distant location from the point of fire. Self-contained breathing apparatus (SCBA) and protective clothing must be worn. Follow Emergency Response Guide 112. Wash all clothes prior to reuse.

Section 6: Accidental release measures

Personal precautions, protective equipment and emergency procedures:

* Non-flammable or flame retardant clothing should be worn when cleaning up spilled material. Material is sensitive to ignition from sources such as heat, flame, impact, friction or sparks. Therefore, non-sparking utensils should be used.

Spill/leak response: * Use appropriate personal protective equipment. Isolate area and remove sources of friction, impact, heat, low level electrical current, electrostatic or RF energy. Only competent, experienced persons should be involved in cleanup procedures.

Environmental precautions:

* Clean up spills immediately using non-sparking utensils Do not dispose of in the ground.

* Spill residues may be disposed of per guidelines under Section 13: Disposal Considerations.

Section 7: Handling and storage

Storage Conditions: * Store in a cool, dry place in accordance with requirements of 27CFR555.201-555.219 (ATF Subpart K)

* Avoid heat, impact, friction and static. Protect against heat effects. Keep away from heat, open flame and ignition sources.

* Absolutely no smoking around open powder or packages. Keep away from combustibles. Avoid electrostatic charges.

* Store in a cool, dry place Do not store in the same area with highly combustible materials.

* Keep containers closed at all times when not being used. Keep out of reach of children. Open and handle container with care.

* Follow all local, state and federal laws when storing this product.

Section 8: Exposure controls/personal protection

Personal protection for routine use:

* Respiratory protection is not normally needed. If significant dusting occurs, a NIOSH approved dust mask should be worn. Good ventilation is recommended when working with Black Powder. Gloves may be worn to protect skin. Safety glasses with side shields are recommended for eye protection. Flame retardant outerwear such as coveralls or lab coat may be worn.

Health Hazards (Acute or chronic): * TLV is unknown for ingestion of dust.

Signs/Symptoms of Exposure: * Burning or itching of the eyes, nose or skin; shortness of breath.

First Aid Procedures: * Remove the patient from exposure and if skin contact, wash the affected area with water

Section 9: Physical and chemical properties

Physical State:	Granular powder	**Solubility:**	Good in water
pH:	6.0-8.0	**Vapor Pressure/Density:**	not applicable
Appearance:	Black in color	**Auto-ignition Temp.:**	392° -867° F /200° -464° C
Odor:	No odor detectable	**Boiling Point:**	Not applicable

Section 10: Stability and reactivity

General Information: * Loading data and the instructions for loading must be observed.

Hazardous decomposition: * Detonation produces hazardous overpressures and fragments (if confined). Gases produced may be toxic if exposed in areas with inadequate ventilation.

Conditions to Avoid: Avoid heat, impact, friction or static. Protect against heat effects. Keep away from heat, open flame and ignition sources. A violent burn or deflagration could occur by above mentioned items.

Substances to Avoid: Avoid contact with alkaline substances or strong acids.

Section 11: Toxicological information

* LD_{50} Values: unknown

* TLV unknown for ingestion of dust. Some persons may be unusually sensitive to the product.

* None of the components of Black Powder are listed as a carcinogen by NTP, IARC or OSHA.

* Routes of entry include Skin, Inhalation and Ingestion. (Acute Toxicity=Category 4) per Table A.1.1 of 29CFR1910.1200

Section 12: Ecological information

* Do not dispose of powder or residues into any water streams or bodies of water. Avoid spilling powders onto any soils. Clean up any spills promptly.

* No known adverse effects on marine or other aquatic organisms.

Section 13: Disposal considerations

* Care must be taken to prevent environmental contamination from the use of this material. The user has the responsibility to dispose of unused material, residues and containers in compliance with all relevant laws and regulations regarding treatment, storage and disposal for hazardous and non-hazardous waste. Powder can be burned in very small quantities and in very thin layer and must only be ignited from a safe distance.

Waste Disposal: * Desensitize by diluting in water. Open train burning, by qualified personnel, may be used for disposal of small unconfined quantities. Dispose of in compliance with Federal Regulations under the authority of RCRA (40CFR Parts 260-271).

* Do not dispose of the black powder container into a fire.

Section 14: Transport information

Label required: Explosive



Highway:
Class or division: 1.1D or 4.1 Flam Solid-(if <100 pounds).
UN Number: UN0027 (NA0027 for 4.1 Flam Solid)
Shipping Name: Black Powder

Air Transport: **Forbidden!**

Maritime IMDG
Class or division: 1.1D
UN Number: UN0027
Shipping Name: Black Powder

Section 15: Regulatory information

* All products related to Black Powder are reported annually as per Community Right-to Know (Tier II). Black Powder has been approved by PHMSA and copies of the approvals are on file with Environmental, Health and Safety Manager.

Section 16: Other information

Prepared By: Mark Wendt, Environmental, Health and Safety Manager email: mwendt@hodgdon.com
SDS Creation Date: April 1, 2014
SDS Print Date: April 1, 2014

Disclaimer:

The information provided on this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guide for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered as a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other material or in any process, unless specified in the text.

GHS SAFETY DATA SHEET (SDS)

SECTION 1 — PRODUCT AND COMPANY IDENTIFICATION

Product: AEROPOXY ES6209A

PTM & W INDUSTRIES, INC. **PHONE NUMBER: (562) 946-4511**
10640 S. PAINTER AVE. ***CHEMICAL TRANSPORTATION EMERGENCY:***
SANTA FE SPRINGS, CA. 90670-4092 **CHEMTREC (800) 424-9300**

DATE OF PREPARATION: 4/30/2015 SUPERSEDES: 4/22/2015

Product Type: Epoxy Resin

Product Use: Industrial Epoxy Resin supplied exclusively for workplace use.

Signal Word: Warning

Hazard Label(s):

Irritant



Hazard statement(s):
H320: Causes eye irritation. (Eye Irrit. 2B)
H303: May be harmful if swallowed. (Acute Tox. 5 Oral)
H315: Causes skin irritation. (Skin Irrit. 2)
H317: May cause an allergic skin reaction. (Skin Sens. 1)
H335: May cause respiratory irritation. (STOT SE3)

Precautionary statement(s):
P202: Do not handle until all safety precautions have been read and understood
P261: Avoid breathing dust/fume/gas/mist/vapours/spray.
P270: Do not eat, drink or smoke when using this product.
P281: Use personal protective equipment as required.
P285: In case of inadequate ventilation wear respiratory protection.
P273: Avoid release to the environment.

SECTION 2 — HAZARD(S) IDENTIFICATION

NO.	CANCER	REPRO-TOX	TARGET ORGANS	ACGIH/TLV	OSHA/PEL
P	NO	NO	UNKNOWN	N.A.mg/M^3	N.A.mg/M^3

NOTE: CONTAINS MATERIAL(S) REGULATED AS DUST HAZARDS, DISPERSED IN A NON-HAZARDOUS FORM.
IF DUST IS RECREATED, APPROPIATE RESPIRATORY AND/OR EXPLOSION PRECAUTIONS MUST STILL BE USED.

SECTION 3 — COMPOSITION / INFORMATION ON INGREDIENTS

UNDER GHS-OSHA §4.11 THE PRECISE COMPOSITION OF THIS PRODUCT IS WITHHELD AS CONFIDENTIAL BUSINESS INFORMATION (CBI). A MORE COMPLETE DISCLOSURE CAN BE PROVIDED TO A HEALTH, OR SAFETY PROFESSIONAL WHEN NECESSARY.

Substance/Mixture: Mixture

NO.	COMPONENT	CAS. NO.	PERCENT
P	EPOXY RESIN BASED MIXTURE	N.A.	< 100%

SECTION 4 — FIRST–AID MEASURES

EMERGENCY AND FIRST AID PROCEDURES:
- **EYES**: IMMEDIATELY FLUSH EYES WITH LARGE AMOUNTS OF WATER FOR 15 MINUTES. GET MEDICAL ATTENTION.
- **SKIN:** WASH AFFECTED AREA IMMEDIATELY WITH LARGE AMOUNTS OF SOAP AND WATER. REMOVE AND WASH CONTAMINATED CLOTHING BEFORE REUSE. CONTACT A PHYSICIAN IF IRRITATION OCCURS.
- **INHALATION:** REMOVE VICTIM TO FRESH AIR AND PROVIDE OXYGEN IF BREATHING IS DIFFICULT. GET MEDICAL ATTENTION.
- **INGESTION:** DO NOT INDUCE VOMITING. GIVE LARGE QUANITIES OF WATER. CALL A PHYSICIAN IMMEDIATELY. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

SECTION 5 — FIRE–FIGHTING MEASURES

FLASH POINT: ≥ 350°F (FOR PRODUCT OR LOWEST FLASH POINT INGREDIENT)
FLAMMABILITY CLASSIFICATION: COMBUSTIBLE CLASS (IIIB)
EXTINGUISHING MEDIA: WATER FOG, DRY CHEMICAL, CARBON DIOXIDE, OR FOAM.
NOTE: EITHER ATMOSPHERE-SUPPLY OR AIR-PURIFYING RESPIRATORS SHOULD BE AVAILABLE FOR FIRE FIGHTERS (20 CFR 1910.134).

SECTION 6 — ACCIDENTAL RELEASE MEASURES

- **IF MATERIAL IS SPILLED:** AVOID CONTACT WITH MATERIAL. PERSONS NOT WEARING PROPER PROTECTIVE EQUIPMENT (SEE BELOW) SHOULD BE EXCLUDED FROM THE AREA UNTIL CLEAN UP IS COMPLETE. DIKE AREA TO PREVENT SPILL SPREADING AND SCOOP UP EXCESS TO RECOVERY CONTAINERS. ABSORB REMNANT ON NONCOMBUSTIBLE MATERIAL SUCH AS CLAY AND SHOVEL INTO CONTAINERS FOR DISPOSAL.
- **WASTE DISPOSAL METHOD:** DISPOSE OF ANY WASTE(S) GENERATED ABOVE IN ACCORDANCE WITH FEDERAL, STATE, AND LOCAL REGULATIONS.

SECTION 7 — HANDLING AND STORAGE

- AVOID SKIN AND EYE CONTACT.
- AVOID BREATHING VAPOR, MIST OR FUMES.
- ENSURE THAT ALL CONTAINERS ARE PROPERLY LABELED TO PREVENT ACCIDENTAL INGESTION OR IMPROPER DISPOSAL.
- RESEAL PARTLY USED CONTAINERS.
- WASH WITH SOAP AND WATER BEFORE EATING, DRINKING OR USING TOILET FACILITIES.
- STORE UNDER COOL, DRY CONDITIONS AND AWAY FROM OPEN FLAMES AND HIGH TEMPERATURES.
- OBSERVE CONDITIONS OF GOOD INDUSTRIAL HYGIENE AND SAFE WORKING PRACTICE.

SECTION 8 — EXPOSURE CONTROLS/ PERSONAL PROTECTION

- **RESPIRATORY PROTECTION:** NOT NORMALLY NECESSARY UNLESS THE MATERIAL IS BEING USED IN SUCH A WAY AS TO PRODUCE DUST, MIST, VAPOR, FUMES, OR SMOKE, IN WHICH CASE NIOSH APPROVED RESPIRATORY PROTECTION SHOULD BE USED.
- **VENTILATION:** SHOULD BE SUFFICIENT TO CONTROL ANY DUST, MIST, VAPOR OR FUMES PRODUCED BY PROCESSING OR HANDLING METHOD. BREATHING OF VAPOR MUST BE AVOIDED.
- **HAND PROTECTION:** IMPERVIOUS GLOVES, NEOPRENE OR NILRILE RUBBER GLOVES.
- **EYE PROTECTION:** SPLASH PROOF GOGGLES OR SAFETY GLASSES WITH SIDE SHIELDS.
- **OTHER PROTECTIVE EQUIPMENT:** CLEAN, BODY COVERING CLOTHING AND FOOTWEAR.

SECTION 9 —PHYSICAL AND CHEMICAL PROPERTIES

- PHYSICAL STATE.....: LIQUID
- ODOR .....: BLAND
- COLOR .....: CLOUDY AMBER
- pH .....: NEUTRAL
- SP. GR.....: 1.17
- DENSITY .....: 9.7 lbs. / gal.
- VAPOR PRESSURE.....: NEGLIGIBLE

NOTE: OTHER PROPERTIES ARE EITHER NOT AVAILABLE, OR DO NOT APPLY.

SECTION 10 — STABILITY AND REACTIVITY

- **STABILITY:** STABLE UNDER NORMAL STORAGE CONDITIONS. UNSTABLE AT ELEVATED TEMPERATURES.
- **INCOMPATIBILITY:** STRONG OXIDIZING AGENTS, STRONG LEWIS OR MINERAL ACIDS, AND STRONG MINERAL AND ORGANIC BASES / ESPECIALLY ALIPHATIC AMINES.
- **HAZARDOUS DECOMPOSITION PRODUCTS:** CARBON OXIDES, ALDEHYDES, ACIDS, PHENOLICS, AND OTHER UNKNOWN COMPOUNDS.

SECTION 11 — TOXICOLOGICAL INFORMATION

EFFECTS OF OVEREXPOSURE:

ACUTE:

- **EYES:** PRODUCT IS MODERATELY IRRITATING TO THE EYES.
- **SKIN:** PRODUCT IS MODERATELY IRRITATING TO THE SKIN AND MAY CAUSE SKIN SENSITIZATION.
- **INHALATION:** BECAUSE OF ITS LOW VOLATILITY THIS PRODUCT IS NOT LIKELY TO BE AN INHALATION HAZARD.
- **INGESTION:** PRODUCT IS CONSIDERED TO HAVE A LOW ORDER OF ACUTE ORAL TOXICITY.

CHRONIC:

- NO SPECIFIC HAZARDS KNOWN TO PTM & W. PREXISTING EYE, SKIN OR LUNG DISORDERS MAY BE AGGRAVATED BY EXPOSURE TO THIS PRODUCT.

SECTION 12 — ECOLOGICAL INFORMATION

ECOTOXICITY EFFECTS:

- **AQUATIC TOXICITY:** NO DATA IS AVAILABLE ON THE PRODUCT ITSELF.
- **TOXICITY TO OTHER ORGANISMS:** NO DATA AVAILABLE.

PERSISTANCE AND DEGRADABILITY:

- **MOBILITY:** NO DATA IS AVAILABLE ON THE PRODUCT ITSELF.
- **BIOACCUMULATION:** NO DATA IS AVAILABLE ON THE PRODUCT ITSELF.

SECTION 13 — DISPOSAL CONSIDERATIONS

- **WASTE DISPOSAL METHOD:** DISPOSE OF WASTE IN ACCORDANCE WITH ALL FEDERAL, STATE, AND LOCAL REGULATIONS.
- **CONTAINER DISPOSAL:** SINCE EMPTIED CONTAINERS RETAIN PRODUCT RESIDUE, ALL LABELED HAZARD PRECAUTIONS MUST BE OBSERVED. CONSULT WITH FEDERAL, STATE. AND LOCAL AUTHORITIES FOR DEFINITIONS OF "EMPTY" AND PROPER DISPOSAL PRACTICES.

SECTION 14 — TRANSPORT INFORMATION

- **U.S. Department of Transportation Ground (49 CFR)**

UN NUMBER.....: N.A.
PROPER SHIPPING NAME.....: PLASTIC MATERIAL LIQUID, N.O.I.
CONTAINS.....: NOT REGULATED*****
HAZARD CLASS.....: N.A.
PACKAGING GROUP.....: N.A.

- **International Air Transportation (ICAO/IATA)**

UN NUMBER.....: N.A.
PROPER SHIPPING NAME.....: PLASTIC MATERIAL LIQUID, N.O.I.
CONTAINS.....: NOT REGULATED*****
HAZARD CLASS.....: N.A.
PACKAGING GROUP.....: N.A.

- **Water Transportation (IMO/IMDG)**

UN NUMBER.....: N.A.
PROPER SHIPPING NAME.....: PLASTIC MATERIAL LIQUID, N.O.I.
CONTAINS.....: NOT REGULATED*****
HAZARD CLASS.....: N.A.
PACKAGING GROUP.....: N.A.
MARINE POLLUTANT .....: NO

*****Non-Bulk Packages may be shipped as Non-Regulated under §49 CFR 173.150(f).

SECTION 15 — REGULATORY INFORMATION

A. CAL SAFE DRINKING WATER & TOXIC ENFORCEMENT ACT OF 1986

NO.	CHEMICAL NAME	CAS. NO.	CANCER/REPRO.TOX	QUANTITY

THIS PRODUCT MAY CONTAIN TRACES OF PROP. 65 LISTED CHEMICALS AS IMPURITIES. HOWEVER, ANY USED AS INGREDIENTS ARE LISTED ABOVE.

B. CERCLA — §40 CFR 302.4

RELEASES EXCEEDING THE REPORTABLE QUANTITY **(RQ)** MUST BE REPORTED TO THE NATIONAL RESPONSE CENTER. (800)424-8802

RQ NOT ESTABLISHED OR REQUIRED FOR THIS PRODUCT.

C. RCRA — §40 CFR 261.33

NOT A HAZARDOUS WASTE BY RCRA CRITERIA (40CFR261.20-24).

D. SARA TITLE III — §52 CFR 13378, §52 CFR 21152

NO.	RQ (lbs.) (•1)	TPQ (lbs.) (•2)	SEC.313 (•3)	313 CAT. (•4)	311/312 (•5)
P	NONE	NOT LISTED	NOT LISTED	NONE	H1

•1 = REPORTABLE QUANTITY OF EXTREMELY HAZARDOUS SUBSTANCE, SEC. 302
•2 = THRESHOLD PLANNING QUANTITY, EXTREMELY HAZARDOUS SUBSTANCE, SEC. 302
•3 = TOXIC CHEMICAL, SEC. 313 (INDIVIDUAL CHEMICAL LISTED)
•4 = TOXIC RELEASE INVENTORY FORM CATEGORY SEC. 313 (40 CFR 372.65 C)
•5 = HAZARD CATEGORY FOR SARA SEC. 311/312 REPORTING
H1 = IMMED. (ACUTE) HEALTH HAZARD **H2** = DELAYED (CHRONIC) HEALTH HAZARD
P3 = FIRE HAZARD **P4** = SUDDEN PRESSURE RELEASE HAZARD **P5** = REACTIVE HAZ.

E. VOC — SCAQMD RULES

NO.	CHEMICAL	QUANTITY	VP mm Hg	gms./l. @ 20ºC
	NIL			

NOTE: THIS PRODUCT DOES NOT CONTAIN SOLVENTS, BUT MAY CONTAIN INGREDIENTS WITH VP'S LOW ENOUGH TO BE EMITTED IF HEATED ALONE. WHEN 2 PART RESINS AND HARDENERS ARE PROPERLY MIXED TOGETHER THESE INGREDIENTS REACT TOGETHER AND ARE CONSUMED WITHOUT SIGNIFICANT ATMOSPHERIC EMISSIONS.

F. INTERNATIONAL CHEMICAL INVENTORY STATUS:

EINECS-EU	Listed, Exempted, Polymer substance, or as no longer polymer.
AICS-AUSTRALIA	All components are listed or exempted.
ENCS-JAPAN	All components are listed or exempted.
ISHL-JAPAN	All components are listed or exempted.
KECI/ECL-KOREA	All components are listed or exempted.
IECSC/SEPA-CHINA	All components are listed or exempted.
PICCS-PHILIPPINES	All components are listed or exempted.
DSL-CANADA	All components are listed or exempted.
TSCA-USA	All components are listed or exempted.

G. WHMIS (CANADA):

- WHMIS: D2B Materials Causing Other Toxic Effects –Toxic Material

SECTION 16 — OTHER INFORMATION

HMIS III CODES:		RATINGS:	
HEALTH	= **2**	0 = MINIMAL	3 = SERIOUS
FLAMMABILITY	= **1**	1 = SLIGHT	4 = SEVERE
REACTIVITY	= **0**	2 = MODERATE	

⇒ PERSONAL PROTECTION RATING TO BE SUPPLIED BY USER DEPENDING ON CONDITIONS OF USE.

DATE OF PREPARATION: 4/30/2015 SUPERSEDES: 4/22/2015

We believe that the information contained herein is correct as of the date of this Safety Data Sheet. Since the use of this information and these opinions and the conditions of use of this product are not within the control of PTM & W, it is the user's obligation to determine the conditions of safe use of the product.

PTM & W makes no warranty, expressed or implied regarding the accuracy of these data. PTM & W assumes no responsibility for injury from the use of the product described herein. Further, there are many international, federal, state, and local laws and regulations governing chemical products and as it is beyond the scope of this SDS to determine which of these apply, it is the responsibility of the user to determine how these affect their use of the product.

PTM&W assumes no obligation or liability for the information given, or results obtained, all such being given and accepted at users' risk.

Alteration of this document is strictly prohibited.

— END OF SDS —

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GHS SAFETY DATA SHEET (SDS)

SECTION 1 — PRODUCT AND COMPANY IDENTIFICATION

Product: AEROPOXY ES6209B

PTM & W INDUSTRIES, INC. **PHONE NUMBER: (562) 946-4511**
10640 S. PAINTER AVE. ***CHEMICAL TRANSPORTATION EMERGENCY:***
SANTA FE SPRINGS, CA. 90670-4092 **CHEMTREC (800) 424-9300**

DATE OF PREPARATION: 4/30/2015 SUPERSEDES: 5/2/2014

Product Type: Modified Amine Mixture

Product Use: Industrial Curing Agent supplied exclusively for workplace use.

Signal Word: Danger

Hazard Label(s):

Corrosive Irritant



Hazard statement(s):
H318: Causes serious eye damage. (Eye Dam. 1)
H302: Harmful if swallowed. (Acute Tox. 4 Oral)
H332: Harmful if inhaled. (Acute Tox. 4 Inhalation)
H317: May cause an allergic skin reaction. (Skin Sens. 1)

Precautionary statement(s):
P202: Do not handle until all safety precautions have been read and understood
P261: Avoid breathing dust/fume/gas/mist/vapours/spray.
P270: Do not eat, drink or smoke when using this product.
P281: Use personal protective equipment as required.
P285: In case of inadequate ventilation wear respiratory protection.
P273: Avoid release to the environment.

SECTION 2 — HAZARD(S) IDENTIFICATION

NO.	CANCER	REPRO-TOX	TARGET ORGANS	ACGIH/TLV	OSHA/PEL
P	NO	NO	UNKNOWN	N.A.mg/M^3	N.A.mg/M^3
2	NO	NO	EYES, SKIN	N.A.mg/M^3	N.A.mg/M^3

SECTION 3 — COMPOSITION / INFORMATION ON INGREDIENTS

UNDER GHS-OSHA §4.11 THE PRECISE COMPOSITION OF THIS PRODUCT IS WITHHELD AS CONFIDENTIAL BUSINESS INFORMATION (CBI). A MORE COMPLETE DISCLOSURE CAN BE PROVIDED TO A HEALTH, OR SAFETY PROFESSIONAL WHEN NECESSARY.

Substance/Mixture: Mixture

NO.	COMPONENT	CAS. NO.	PERCENT
P	FATTY ACIDS, C18-UNSATD., DIMERS, POLYMERS WITH POLYETHYLENEPOLYAMINES	68410-23-1	< 100%
2	TRIETHYLENETETRAMINE OR, TETRAETHYLENEPENTAMINE	112-57-2, 112-24-3	< 10%

SECTION 4 — FIRST–AID MEASURES

EMERGENCY AND FIRST AID PROCEDURES:
- **EYES**: IMMEDIATELY FLUSH EYES WITH LARGE AMOUNTS OF WATER FOR 15 MINUTES. GET MEDICAL ATTENTION.
- **SKIN:** WASH AFFECTED AREA IMMEDIATELY WITH LARGE AMOUNTS OF SOAP AND WATER. REMOVE AND WASH CONTAMINATED CLOTHING BEFORE REUSE. CONTACT A PHYSICIAN IF IRRITATION OCCURS.
- **INHALATION:** REMOVE VICTIM TO FRESH AIR AND PROVIDE OXYGEN IF BREATHING IS DIFFICULT. GET MEDICAL ATTENTION.
- **INGESTION:** DO NOT INDUCE VOMITING. GIVE LARGE QUANITIES OF WATER. CALL A PHYSICIAN IMMEDIATELY. NEVER GIVE ANYTHING BY MOUTH TO AN UNCONSCIOUS PERSON.

SECTION 5 — FIRE–FIGHTING MEASURES

FLASH POINT: ≥ 250ºF (FOR PRODUCT OR LOWEST FLASH POINT INGREDIENT)
FLAMMABILITY CLASSIFICATION: COMBUSTIBLE CLASS (IIIB)
EXTINGUISHING MEDIA: WATER FOG, DRY CHEMICAL, CARBON DIOXIDE, OR FOAM.
NOTE: EITHER ATMOSPHERE-SUPPLY OR AIR-PURIFYING RESPIRATORS SHOULD BE AVAILABLE FOR FIRE FIGHTERS (20 CFR 1910.134).

SECTION 6 — ACCIDENTAL RELEASE MEASURES

- **IF MATERIAL IS SPILLED:** AVOID CONTACT WITH MATERIAL. PERSONS NOT WEARING PROPER PROTECTIVE EQUIPMENT (SEE BELOW) SHOULD BE EXCLUDED FROM THE AREA UNTIL CLEAN UP IS COMPLETE. DIKE AREA TO PREVENT SPILL SPREADING AND SCOOP UP EXCESS TO RECOVERY CONTAINERS. ABSORB REMNANT ON NONCOMBUSTIBLE MATERIAL SUCH AS CLAY AND SHOVEL INTO CONTAINERS FOR DISPOSAL.
- **WASTE DISPOSAL METHOD:** DISPOSE OF ANY WASTE(S) GENERATED ABOVE IN ACCORDANCE WITH FEDERAL, STATE, AND LOCAL REGULATIONS.

SECTION 7 — HANDLING AND STORAGE

- AVOID SKIN AND EYE CONTACT.
- AVOID BREATHING VAPOR, MIST OR FUMES.
- ENSURE THAT ALL CONTAINERS ARE PROPERLY LABELED TO PREVENT ACCIDENTAL INGESTION OR IMPROPER DISPOSAL.
- RESEAL PARTLY USED CONTAINERS.
- WASH WITH SOAP AND WATER BEFORE EATING, DRINKING OR USING TOILET FACILITIES.
- STORE UNDER COOL, DRY CONDITIONS AND AWAY FROM OPEN FLAMES AND HIGH TEMPERATURES.
- OBSERVE CONDITIONS OF GOOD INDUSTRIAL HYGIENE AND SAFE WORKING PRACTICE.

SECTION 8 — EXPOSURE CONTROLS/ PERSONAL PROTECTION

- **RESPIRATORY PROTECTION:** NOT NORMALLY NECESSARY UNLESS THE MATERIAL IS BEING USED IN SUCH A WAY AS TO PRODUCE DUST, MIST, VAPOR, FUMES, OR SMOKE, IN WHICH CASE NIOSH APPROVED RESPIRATORY PROTECTION SHOULD BE USED.
- **VENTILATION:** SHOULD BE SUFFICIENT TO CONTROL ANY DUST, MIST, VAPOR OR FUMES PRODUCED BY PROCESSING OR HANDLING METHOD. BREATHING OF VAPOR MUST BE AVOIDED.
- **HAND PROTECTION:** IMPERVIOUS GLOVES, NEOPRENE OR NILRILE RUBBER GLOVES.
- **EYE PROTECTION:** SPLASH PROOF GOGGLES OR SAFETY GLASSES WITH SIDE SHIELDS.
- **OTHER PROTECTIVE EQUIPMENT:** CLEAN, BODY COVERING CLOTHING AND FOOTWEAR.

SECTION 9 —PHYSICAL AND CHEMICAL PROPERTIES

- PHYSICAL STATE.....: LIQUID
- ODOR .....: AMMONIA LIKE
- COLOR .....: AMBER
- pH .....: ALKALINE
- SP. GR.....: 0.97
- DENSITY .....: 8.1 lbs. / gal.
- VAPOR PRESSURE.....: NEGLIGIBLE

NOTE: OTHER PROPERTIES ARE EITHER NOT AVAILABLE, OR DO NOT APPLY.

SECTION 10 — STABILITY AND REACTIVITY

- **STABILITY:** STABLE UNDER NORMAL STORAGE CONDITIONS. UNSTABLE AT ELEVATED TEMPERATURES. SLOWLY CORRODES COPPER, ALUMINUM, ZINC AND GALVANIZED SURFACES.
- **INCOMPATIBILITY:** STRONG OXIDIZING AGENTS, ORGANIC, LEWIS, OR MINERAL ACIDS, NITROUS ACID, SODIUM HYPOCHLORITE, AND PEROXIDES.
- **HAZARDOUS DECOMPOSITION PRODUCTS:** OXIDES OF CARBON AND NITROGEN, NITRIC ACID, NITROSOAMINE, AND OTHER UNKNOWN ORGANIC COMPOUNDS.

SECTION 11 — TOXICOLOGICAL INFORMATION

EFFECTS OF OVEREXPOSURE:

ACUTE:

- **EYES:** CAUSES SEVERE CONJUNCTIVAL IRRITATION, CORNEAL INJURY AND IRITIS.
- **SKIN:** MAY CAUSE IRRITATION, BURNS, ULCERATION, OR SKIN SENSITIZATION.
- **INHALATION:** VAPORS ARE IRRITATING AND MAY CAUSE TEARS, BURNING OF NOSE AND THROAT, COUGHING, WHEEZING, NAUSEA, AND VOMITING.
- **INGESTION:** MODERATELY TOXIC, MAY CAUSE MOUTH AND THROAT BURNS, ABDOMINAL PAIN, NAUSEA, VOMITING, WEAKNESS, THIRST, AND COMA.

CHRONIC:

- AMINE VAPORS MAY CAUSE LIVER & KIDNEY INJURY. EYE, SKIN OR LUNG DISORDERS MAY DEVELOP OR BE AGGRAVATED BY AMINES.

SECTION 12 — ECOLOGICAL INFORMATION

ECOTOXICITY EFFECTS:

- **AQUATIC TOXICITY:** NO DATA IS AVAILABLE ON THE PRODUCT ITSELF.
- **TOXICITY TO OTHER ORGANISMS:** NO DATA AVAILABLE.

PERSISTANCE AND DEGRADABILITY:

- **MOBILITY:** NO DATA IS AVAILABLE ON THE PRODUCT ITSELF.
- **BIOACCUMULATION:** NO DATA IS AVAILABLE ON THE PRODUCT ITSELF.

SECTION 13 — DISPOSAL CONSIDERATIONS

- **WASTE DISPOSAL METHOD:** DISPOSE OF WASTE IN ACCORDANCE WITH ALL FEDERAL, STATE, AND LOCAL REGULATIONS.
- **CONTAINER DISPOSAL:** SINCE EMPTIED CONTAINERS RETAIN PRODUCT RESIDUE, ALL LABELED HAZARD PRECAUTIONS MUST BE OBSERVED. CONSULT WITH FEDERAL, STATE. AND LOCAL AUTHORITIES FOR DEFINITIONS OF "EMPTY" AND PROPER DISPOSAL PRACTICES.

SECTION 14 — TRANSPORT INFORMATION

- **U.S. Department of Transportation Ground (49 CFR)**

UN NUMBER.....: UN 1760
PROPER SHIPPING NAME.....: CORROSIVE LIQUID, N.O.S.
CONTAINS.....: MODIFIED AMINE MIXTURE
HAZARD CLASS.....: 8
PACKAGING GROUP.....: III

- **International Air Transportation (ICAO/IATA)**

UN NUMBER.....: UN 1760
PROPER SHIPPING NAME.....: CORROSIVE LIQUID, N.O.S.
CONTAINS.....: MODIFIED AMINE MIXTURE
HAZARD CLASS.....: 8
PACKAGING GROUP.....: III

- **Water Transportation (IMO/IMDG)**

UN NUMBER.....: UN 1760
PROPER SHIPPING NAME.....: CORROSIVE LIQUID, N.O.S.
CONTAINS.....: MODIFIED AMINE MIXTURE
HAZARD CLASS.....: 8
PACKAGING GROUP.....: III
MARINE POLLUTANT .....: NO



SAFETY DATA SHEET
WICKED COLORS
10/22/15

Manufacturer or Distributor:	**Color Craft, Ltd./Createx Colors** **14 Airport Park Road** **East Granby, Connecticut 06026** **Phone: 800-509-6563** **Fax: 1-860-653-0643**
Information Telephone Number:	**800-243-2712**
Emergency Telephone Number:	**800-243-2712**
For Health Emergencies:	**Poison Control Center: 1-888-516-2502**

SECTION I – PRODUCT IDENTIFICATION

Product Name:	Wicked Colors / Wicked Detail Colors
Product Number:	Air-Brush
Product Sizes:	NA
Brand Name:	Wicked Colors
Product Class:	ART MATERIAL - Consumer Product

SECTION II – HAZARDS IDENTIFICATION

Information pertaining to particular dangers for man and environment:	Not a hazardous mixture

Emergency Overview

Non-Hazardous.

Label elements:	Conforms to ASTM D-4236
Pictograms:	No Pictograms are required for the mixture.
Signal Word:	No signal word required.
Hazard Statement:	No specific hazard warnings are required.
Precaution Statement:	Not hazardous mixture.
Children's Statement:	KEEP OUT OF REACH OF CHILDREN
Classification of the Product:	
NFPA:	Health 0 - Minimal Hazard Flammability 0 - Not Combustible Reactivity 0 - Stable
HMIS:	Health 0 - Minimal Hazard Flammability 0 -Minimal Hazard Physical Hazard 0 - Minimal Hazard
Regulation (EC) No. 1272/2008:	This mixture is not classified as hazardous.
Export and Import of Dangerous Chemicals Regulation (EC)No. 649/2012:	This mixture is not classified as hazardous.
Directive 67/548/EEC & Directive 1999/45/EC:	This mixture is not classified as hazardous.



SAFETY DATA SHEET
WICKED COLORS
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SECTION III – COMPOSITION / INFORMATION ON INGREDIENTS

Substances:	This mixture is a proprietary not hazardous acrylic based product.
Risk and Safety Phrases:	Ingredients are marked according to CLP Regulation (CLP-Regulation (EC) No 1272/2008) and according to DSD (Dangerous Substances Directive (67/548/EEC)) and DPD (Dangerous Preparations Directive (1999/45/EC)) These ingredients are regarded as trade secrets.

SECTION IV – FIRST AID MEASURES

Inhalation:	If affected, get fresh air.
Skin Contact:	Wash affected area thoroughly with plenty of soap and water.
Eye Contact:	Carefully flush with water for 15 minutes. If irritation occurs, contact a physician.
Ingestion:	Drink water or milk to dilute. Do not induce vomiting. Contact a physician.

SECTION V – FIRE FIGHTING MEASURES

Flammable Summary:	Product is not known to be flammable, combustible, pyrophoric or explosive.
Fire/Explosion Hazards:	Not combustible. Polymers will not burn. However, dried polymer films are capable of burning. Material may spatter if temperatures exceed the
Flashpoint:	Not Flammable
Firefighting Instructions:	In case of fire, use normal firefighting equipment and the personal protective equipment recommended in Section 8 to include NIOSH approved self-contained breathing apparatus.
Hazardous Combustion Products:	Decomposition or combustion of the dry solids may generate irritating vapors, monomers, hydrocarbons, carbon monoxide and carbon dioxide.
Unusual Fire and Explosion Hazards:	None known.

SECTION VI – ACCIDENTAL RELEASE MEASURES

Environmental precautions:	No product should be released to the environment without due care.
Methods and Materials for Containment and Cleaning up:	Contain spill. Recover as much as possible with sand, soil or similar product. Place into closed container and store in a safe location to await disposal. Wash the spill area with soap and water.

SECTION VII – HANDLING AND STORAGE

Safe Handling:	Use under ventilated conditions. Avoid eye contact. For personal protection, we recommend that employees wash thoroughly after handling product. Always wash before eating, smoking or using toilet facilities. Keep container closed when not in use.
Storage:	Keep the sample in a cool dry ventilated area.

SECTION VIII - EXPOSURE CONTROLS / PERSONAL PROTECTION

Personal Protective Equipment:	Wear safety goggles and protective gloves to avoid dust contact.
Exposure Limits:	N/A to this mixture.
Respiratory and Ventilation:	Wear approved NIOSH/MSHA respirator if exposure to mist or vapor exceed applicable PEL/TLV limits. Use in accordance with manufacturer's use limitations and OSHA STANDARD 1910-34. Local ventilation may be used to prevent routine inhalation.
Skin Protection:	Handle with non-porous nitrile gloves.
Eye Protection:	Safety glasses conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

SECTION IX – PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Colored paint
Physical State:	Liquid
VOC Content:	27.7 g/L Regulatory
Solids percentage:	17
Color:	See product list in Section 16
Odor:	Detergent-like
Boiling Point:	Not determined
Freezing Point:	Not determined
State (pH):	7.5-8.5
Specific Gravity:	1.0 - 2.0
Viscosity:	25 mPas
Flashpoint:	Greater than 200 °F
Vapor Pressure:	Not applicable
Vapor Density:	Not applicable
Solubility in water:	Miscible

SECTION X – STABILITY AND REACTIVITY

Reactivity:	Not reactive under conditions of normal use.
Chemical Stability:	Stable under conditions of normal use.
Conditions to Avoid:	All sources of ignition. Avoid heat. Avoid strong oxidizing agents.
Incompatible materials:	Strong oxidizing agents, strong acids, strong bases, amines, ammonia, halogenated compounds

Hazardous Decomposition Products:	Thermal decomposition or combustion may liberate carbon oxides and other toxic gases or vapors.

SECTION XI – TOXICOLOGICAL INFORMATION

Health Effects:	Studies have not been performed on this particular mixture. The information below is based on data on the individual ingredients.
Oral:	Expected to be greater than 2,000 mg/kg (rats)
Ingestion:	No effects known in usual and ordinary uses of product.
Inhalation:	This product poses no inhalation risk.
Dermal:	Not a skin sensitizer.
Eye Effects:	Not an eye irritant.

SECTION XII – ECOLOGICAL INFORMATION

Toxicity:	No information available.
Aquatic toxicity:	No information available.
Persistence and degradability:	A mixture of biodegradable and non biodegrable ingredients. No other information is available.
Bio accumulative potential:	Not expected to bioaccumulate significantly.
Mobility in soil:	No information available.
Additional ecological information:	No information available.

SECTION XIII – DISPOSAL CONSIDERATIONS

Waste is classified as hazardous waste. Disposal to licensed waste disposal site in accordance with the local Waste Disposal Authority. Contact specialist disposal companies. Dispose of waste and residues in accordance with local authority requirements. Recover and reclaim or recycle, if practical.

SECTION XIV – TRANSPORTATION INFORMATION

The following transportation categories do not apply to this mixture sold as a consumer use product (non-bulk).

DOT Non-Bulk

Shipping Name	Not regulated.
Technical Shipping Name	Not regulated.
Hazard Class	Not regulated.
UN Number	Not regulated.
Packing Group	Not regulated.

IMDG

Shipping Name	Not regulated.
Technical Shipping Name	Not regulated.
Hazard Class	Not regulated.
UN Number	Not regulated.
Packing Group	Not regulated.
EmS Number	Not regulated.
Marine Pollutant	Not regulated.

ICAO/IATA

Shipping Name	Not regulated.

Technical Shipping Name	Not regulated.
Hazard Class	Not regulated.
UN Number	Not regulated.
Packing Group	Not regulated.
Marine Pollutant	Not regulated.

This information is not intended to convey all specific regulatory or operational requirements/information relating to this product. It is the responsibility of the transporting organization to follow all applicable laws, regulations and rules relating to the transportation of the materials.

SECTION XV – REGULATORY INFORMATION

Safety, health and environmental regulations/legislation specific for the substance or mixture.

SARA:	Not applicable
Section 355 (extremely hazardous substances):	Not applicable
Section 313 (Specific toxic chemical listing):	Not applicable
TSCA (Toxic Substance Control Act):	All ingredients are listed.
The Safe Drinking Water and Toxic Enforcement Act of 1986 - California Proposition 65:	As of August 3, 2017, this product contains no listed substances known to the State of California to cause cancer, birth defects or other reproductive harm, at levels which would require a warning under the statue.
Chemicals known to cause cancer:	None of the ingredients are listed as of August 3, 2017.
Chemicals known to cause reproductive toxicity for females:	None of the ingredients are listed as of August 3, 2017.
Chemicals known to cause reproductive toxicity for males:	None of the ingredients are listed as of August 3, 2017.
Chemicals known to cause developmental toxicity:	None of the ingredients are listed as of August 3, 2017.
Carcinogenicity categories: EPA (Environmental Protection Agency):	Not applicable to this mixture.
TLV (Threshold Limit Value established by ACGIH):	Not applicable to this mixture.
MAK (German Maximum Workplace Concentration):	Not applicable to this mixture.
NOISH-Ca (National Institute for Occupational Safety & Health):	Not applicable to this mixture.
OSHA-Ca (Occupational Safety & Health Administration):	Not applicable to this mixture

International Regulations

Canadian WHMIS:

This product is a controlled product under Canada's workplace hazardous materials information system.

It contains the following toxic or highly toxic materials:	Aluminum Oxide Ferric Oxide Mica Propylene Glycol
This product contains the following chemical(s) listed under New Jersey's Right to Know Program:	Aluminum Oxide Mica Pigment Red 101



SAFETY DATA SHEET
WICKED COLORS
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This product contains the following chemical(s) requiring notification to the state of Washington under their Children's Safe Products Act: None

Under CPSC's consumer product regulations (16CFR1500.3 and 150014), this product has the following required acute and chronic hazard labeling: None

SECTION XVI – OTHER INFORMATION

COLOR INFORMATION

Product Color	SKU	Hazardous Ingredient
W001 Wicked White		(None)
W002 Wicked Black		(None)
W003 Wicked Yellow		(None)
W004 Wicked Orange		(None)
W005 Wicked Red		(None)
W006 Wicked Violet		(None)
W007 Wicked Blue		(None)
W008 Wicked Deep Blue		(None)
W009 Wicked Pthalo Green		(None)
W010 Wicked Brown		(None)
W011 Wicked Golden Yellow		(None)
W012 Wicked Red Oxide		(None)
W013 Wicked Laguna Blue		(None)
W014 Wicked Grey		(None)
W015 Wicked Crimson		(None)
W016 Wicked Apple Green		(None)
W019 Wicked Fluorescent Aqua		(None)
W020 Wicked Fluorescent Purple		(None)
W021 Wicked Fluorescent Raspberry		(None)
W022 Wicked Fluorescent Red		(None)
W023 Wicked Fluorescent Green		(None)
W024 Wicked Fluorescent Yellow		(None)
W025 Wicked Fluorescent Sunburst		(None)
W026 Wicked Fluorescent Pink		(None)
W027 Wicked Fluorescent Orange		(None)
W028 Wicked Fluorescent Blue		(None)
W029 Wicked Fluorescent Magenta		(None)
W030 Wicked Opaque White		(None)
W031 Wicked Jet Black		(None)
W032 Wicked Detail Opaque Flat White		(None)
W050 Wicked Detail White		(None)
W051 Wicked Detail Black		(None)
W052 Wicked Detail Yellow		(None)
W053 Wicked Detail Scarlet		(None)
W054 Wicked Detail Orange		(None)
W055 Wicked Detail Violet		(None)
W056 Wicked Detail Red Violet		(None)
W057 Wicked Detail Blue Violet		(None)
W058 Wicked Detail Blue Green		(None)
W059 Wicked Detail Moss Green		(None)
W060 Wicked Detail Viridian		(None)
W061 Wicked Detail Cobalt Blue		(None)
W062 Wicked Detail Cerulean Blue		(None)



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Product Color	SKU	Hazardous Ingredient
W063 Wicked Detail Carmine		(None)
W064 Wicked Detail Magenta		(None)
W065 Wicked Detail Yellow Ochre		(None)
W066 Wicked Detail Burnt Orange		(None)
W067 Wicked Detail Raw Sienna		(None)
W068 Wicked Detail Raw Umber		(None)
W069 Wicked Detail Burnt Umber		(None)
W070 Wicked Detail Sepia		(None)
W071 Wicked Detail Paynes Grey		(None)
W072 Wicked Detail Smoke Black		(None)
W073 Wicked Detail Driscoll Tone		(None)
W074 Wicked Detail Burnt Sienna		(None)
W075 Wicked Detail Black-Magenta		(None)
W076 Wicked Detail Cory Saint Clair's Universal Fleshtone		(None)
W200 Wicked Transparent Base		(None)
W300 Wicked Pearl Black		(None)
W301 Wicked Pearl White		(None)
W302 Wicked Pearl Yellow		(None)
W303 Wicked Pearl Red		(None)
W304 Wicked Pearl Blue		(None)
W305 Wicked Pearl Lime Green		(None)
W306 Wicked Pearl Orange		(None)
W307 Wicked Pearl Plum		(None)
W350 Wicked Gold		(None)
W351 Wicked Silver		(None)
W352 Wicked Platinum		(None)
W353 Wicked Fastback Green		(None)
W354 Wicked Aluminum		(None)
W210 Wicked UV Glow Base		(None)
W211 Wicked UV Glow White		(None)
W212 Wicked Transparent Glow in the Dark		(None)

Original Date: 10/22/15
Last Revision Date: 08/03/2017

Reason for Issue: Updated formula information
Prepared by: Rudolph J. Jaeger, Ph.D., DABT, ERT (UK)
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Brand Names

This SDS applies to the following brand names: Wicked Colors / Wicked Detail Colors

SAFETY DATA SHEET

FC710

Section 1. Identification

Product name : FINISH 1™ Ultimate Spot/Panel Clearcoat (Part A)

Product code : FC710

Other means of identification : Not available.

Product type : Liquid.

Relevant identified uses of the substance or mixture and uses advised against

Paint or paint related material.

Manufacturer : ACME AUTOMOTIVE FINISHES
101 W. Prospect Avenue
Cleveland, OH 44115

Emergency telephone number of the company : US / Canada: (800) 424-9300
Mexico: SETIQ 800-00-214-00 / 55-5559-1588 Available 24 hours and 365 days a year

Product Information Telephone Number : US / Canada: (216) 566-3031
Mexico: Not Available

Regulatory Information Telephone Number : US / Canada: (216) 566-2902
Mexico: Not Available

Transportation Emergency Telephone Number : US / Canada: (800) 424-9300
Mexico: SETIQ 800-00-214-00 / 55-5559-1588 Available 24 hours and 365 days a year

Section 2. Hazards identification

OSHA/HCS status : This material is considered hazardous by the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Classification of the substance or mixture : FLAMMABLE LIQUIDS - Category 2
SKIN CORROSION/IRRITATION - Category 2
SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 2A
SKIN SENSITIZATION - Category 1
TOXIC TO REPRODUCTION - Category 2
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Narcotic effects) - Category 3
SPECIFIC TARGET ORGAN TOXICITY (REPEATED EXPOSURE) - Category 2

Percentage of the mixture consisting of ingredient(s) of unknown acute toxicity: 1.8% (dermal), 1.8% (inhalation)

GHS label elements

Hazard pictograms :



Signal word : Danger

Section 2. Hazards identification

Hazard statements : Highly flammable liquid and vapor.
Causes skin irritation.
May cause an allergic skin reaction.
Causes serious eye irritation.
May cause drowsiness or dizziness.
Suspected of damaging fertility or the unborn child.
May cause damage to organs through prolonged or repeated exposure.

Precautionary statements

Prevention : Obtain special instructions before use. Do not handle until all safety precautions have been read and understood. Wear protective gloves, protective clothing and eye or face protection. Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking. Use explosion-proof electrical, ventilating or lighting equipment. Use non-sparking tools. Take action to prevent static discharges. Use only outdoors or in a well-ventilated area. Do not breathe vapor. Wash thoroughly after handling. Contaminated work clothing must not be allowed out of the workplace.

Response : IF exposed or concerned: Get medical advice or attention. IF INHALED: Remove person to fresh air and keep comfortable for breathing. Call a POISON CENTER or doctor if you feel unwell. IF ON SKIN (or hair): Take off immediately all contaminated clothing. Rinse skin with water. Wash contaminated clothing before reuse. IF ON SKIN: Wash with plenty of water. If skin irritation or rash occurs: Get medical advice or attention. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If eye irritation persists: Get medical advice or attention.

Storage : Store locked up. Store in a well-ventilated place. Keep container tightly closed. Keep cool.

Disposal : Dispose of contents and container in accordance with all local, regional, national and international regulations.

Supplemental label elements : DELAYED EFFECTS FROM LONG TERM OVEREXPOSURE. Contains solvents which can cause permanent brain and nervous system damage. Intentional misuse by deliberately concentrating and inhaling the contents can be harmful or fatal. WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm. FOR PROFESSIONAL USE ONLY. This product must be mixed with other components before use. Before opening the packages, READ AND FOLLOW WARNING LABELS ON ALL COMPONENTS.

Please refer to the SDS for additional information. Keep out of reach of children. Do not transfer contents to other containers for storage.

Hazards not otherwise classified : None known.

Section 3. Composition/information on ingredients

Substance/mixture : Mixture

Other means of identification : Not available.

CAS number/other identifiers

Ingredient name	% by weight	CAS number
n-Butyl Acetate	≥25 - ≤50	123-86-4
n-Butyl Propionate	≥10 - ≤25	590-01-2
Methyl Ethyl Ketone	≤10	78-93-3
Acetone	≤7.8	67-64-1
Ethyl 3-Ethoxypropionate	≤3	763-69-9
Bis(pentamethyl-4-piperidyl)sebacate	≤0.3	41556-26-7

Any concentration shown as a range is to protect confidentiality or is due to batch variation.

Section 3. Composition/information on ingredients

There are no additional ingredients present which, within the current knowledge of the supplier and in the concentrations applicable, are classified and hence require reporting in this section.

Occupational exposure limits, if available, are listed in Section 8.

Section 4. First aid measures

Description of necessary first aid measures

Eye contact : Immediately flush eyes with plenty of water, occasionally lifting the upper and lower eyelids. Check for and remove any contact lenses. Continue to rinse for at least 10 minutes. Get medical attention.

Inhalation : Remove victim to fresh air and keep at rest in a position comfortable for breathing. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. If not breathing, if breathing is irregular or if respiratory arrest occurs, provide artificial respiration or oxygen by trained personnel. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Get medical attention. If necessary, call a poison center or physician. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Skin contact : Wash with plenty of soap and water. Remove contaminated clothing and shoes. Wash contaminated clothing thoroughly with water before removing it, or wear gloves. Continue to rinse for at least 10 minutes. Get medical attention. In the event of any complaints or symptoms, avoid further exposure. Wash clothing before reuse. Clean shoes thoroughly before reuse.

Ingestion : Wash out mouth with water. Remove dentures if any. If material has been swallowed and the exposed person is conscious, give small quantities of water to drink. Stop if the exposed person feels sick as vomiting may be dangerous. Do not induce vomiting unless directed to do so by medical personnel. If vomiting occurs, the head should be kept low so that vomit does not enter the lungs. Get medical attention. If necessary, call a poison center or physician. Never give anything by mouth to an unconscious person. If unconscious, place in recovery position and get medical attention immediately. Maintain an open airway. Loosen tight clothing such as a collar, tie, belt or waistband.

Most important symptoms/effects, acute and delayed

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : Can cause central nervous system (CNS) depression. May cause drowsiness or dizziness.

Skin contact : Causes skin irritation. May cause an allergic skin reaction.

Ingestion : Can cause central nervous system (CNS) depression.

Over-exposure signs/symptoms

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : Adverse symptoms may include the following:
nausea or vomiting
headache
drowsiness/fatigue
dizziness/vertigo
unconsciousness
reduced fetal weight
increase in fetal deaths
skeletal malformations

Section 4. First aid measures

Skin contact : Adverse symptoms may include the following:
irritation
redness
reduced fetal weight
increase in fetal deaths
skeletal malformations

Ingestion : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Indication of immediate medical attention and special treatment needed, if necessary

Notes to physician : Treat symptomatically. Contact poison treatment specialist immediately if large quantities have been ingested or inhaled.

Specific treatments : No specific treatment.

Protection of first-aiders : No action shall be taken involving any personal risk or without suitable training. If it is suspected that fumes are still present, the rescuer should wear an appropriate mask or self-contained breathing apparatus. It may be dangerous to the person providing aid to give mouth-to-mouth resuscitation. Wash contaminated clothing thoroughly with water before removing it, or wear gloves.

See toxicological information (Section 11)

Section 5. Fire-fighting measures

Extinguishing media

Suitable extinguishing media : Use dry chemical, CO_2, water spray (fog) or foam.

Unsuitable extinguishing media : Do not use water jet.

Specific hazards arising from the chemical : Highly flammable liquid and vapor. Runoff to sewer may create fire or explosion hazard. In a fire or if heated, a pressure increase will occur and the container may burst, with the risk of a subsequent explosion. The vapor/gas is heavier than air and will spread along the ground. Vapors may accumulate in low or confined areas or travel a considerable distance to a source of ignition and flash back.

Hazardous thermal decomposition products : Decomposition products may include the following materials:
carbon dioxide
carbon monoxide

Special protective actions for fire-fighters : Promptly isolate the scene by removing all persons from the vicinity of the incident if there is a fire. No action shall be taken involving any personal risk or without suitable training. Move containers from fire area if this can be done without risk. Use water spray to keep fire-exposed containers cool.

Special protective equipment for fire-fighters : Fire-fighters should wear appropriate protective equipment and self-contained breathing apparatus (SCBA) with a full face-piece operated in positive pressure mode.

Remark : Flammable liquid.

Section 6. Accidental release measures

Personal precautions, protective equipment and emergency procedures

For non-emergency personnel : No action shall be taken involving any personal risk or without suitable training. Evacuate surrounding areas. Keep unnecessary and unprotected personnel from entering. Do not touch or walk through spilled material. Shut off all ignition sources. No flares, smoking or flames in hazard area. Avoid breathing vapor or mist. Provide adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Put on appropriate personal protective equipment.

For emergency responders : If specialized clothing is required to deal with the spillage, take note of any information in Section 8 on suitable and unsuitable materials. See also the information in "For non-emergency personnel".

Environmental precautions : Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers. Inform the relevant authorities if the product has caused environmental pollution (sewers, waterways, soil or air).

Methods and materials for containment and cleaning up

Small spill : Stop leak if without risk. Move containers from spill area. Use spark-proof tools and explosion-proof equipment. Dilute with water and mop up if water-soluble. Alternatively, or if water-insoluble, absorb with an inert dry material and place in an appropriate waste disposal container. Dispose of via a licensed waste disposal contractor.

Large spill : Stop leak if without risk. Move containers from spill area. Use spark-proof tools and explosion-proof equipment. Approach release from upwind. Prevent entry into sewers, water courses, basements or confined areas. Wash spillages into an effluent treatment plant or proceed as follows. Contain and collect spillage with non-combustible, absorbent material e.g. sand, earth, vermiculite or diatomaceous earth and place in container for disposal according to local regulations (see Section 13). Dispose of via a licensed waste disposal contractor. Contaminated absorbent material may pose the same hazard as the spilled product. Note: see Section 1 for emergency contact information and Section 13 for waste disposal.

Section 7. Handling and storage

Precautions for safe handling

Protective measures : Put on appropriate personal protective equipment (see Section 8). Persons with a history of skin sensitization problems should not be employed in any process in which this product is used. Avoid exposure - obtain special instructions before use. Avoid exposure during pregnancy. Do not handle until all safety precautions have been read and understood. Do not get in eyes or on skin or clothing. Do not breathe vapor or mist. Do not ingest. Use only with adequate ventilation. Wear appropriate respirator when ventilation is inadequate. Do not enter storage areas and confined spaces unless adequately ventilated. Keep in the original container or an approved alternative made from a compatible material, kept tightly closed when not in use. Store and use away from heat, sparks, open flame or any other ignition source. Use explosion-proof electrical (ventilating, lighting and material handling) equipment. Use only non-sparking tools. Take precautionary measures against electrostatic discharges. Empty containers retain product residue and can be hazardous. Do not reuse container.

Advice on general occupational hygiene : Eating, drinking and smoking should be prohibited in areas where this material is handled, stored and processed. Workers should wash hands and face before eating, drinking and smoking. Remove contaminated clothing and protective equipment before entering eating areas. See also Section 8 for additional information on hygiene measures.

Section 7. Handling and storage

Conditions for safe storage, including any incompatibilities : Store in accordance with local regulations. Store in a segregated and approved area. Store in original container protected from direct sunlight in a dry, cool and well-ventilated area, away from incompatible materials (see Section 10) and food and drink. Store locked up. Eliminate all ignition sources. Separate from oxidizing materials. Keep container tightly closed and sealed until ready for use. Containers that have been opened must be carefully resealed and kept upright to prevent leakage. Do not store in unlabeled containers. Use appropriate containment to avoid environmental contamination. See Section 10 for incompatible materials before handling or use.

Section 8. Exposure controls/personal protection

Control parameters

Occupational exposure limits (OSHA United States)

Ingredient name	CAS #	Exposure limits
n-Butyl Acetate	123-86-4	**NIOSH REL (United States, 10/2020).** TWA: 150 ppm 10 hours. TWA: 710 mg/m³ 10 hours. STEL: 200 ppm 15 minutes. STEL: 950 mg/m³ 15 minutes. **OSHA PEL (United States, 5/2018).** TWA: 150 ppm 8 hours. TWA: 710 mg/m³ 8 hours. **ACGIH TLV (United States, 1/2022). [Butyl acetates]** STEL: 150 ppm 15 minutes. TWA: 50 ppm 8 hours.
n-Butyl Propionate	590-01-2	None.
Methyl Ethyl Ketone	78-93-3	**ACGIH TLV (United States, 1/2022).** TWA: 200 ppm 8 hours. TWA: 590 mg/m³ 8 hours. STEL: 300 ppm 15 minutes. STEL: 885 mg/m³ 15 minutes. **NIOSH REL (United States, 10/2020).** TWA: 200 ppm 10 hours. TWA: 590 mg/m³ 10 hours. STEL: 300 ppm 15 minutes. STEL: 885 mg/m³ 15 minutes. **OSHA PEL (United States, 5/2018).** TWA: 200 ppm 8 hours. TWA: 590 mg/m³ 8 hours.
Acetone	67-64-1	**ACGIH TLV (United States, 1/2022).** TWA: 250 ppm 8 hours. STEL: 500 ppm 15 minutes. **NIOSH REL (United States, 10/2020).** TWA: 250 ppm 10 hours. TWA: 590 mg/m³ 10 hours. **OSHA PEL (United States, 5/2018).** TWA: 1000 ppm 8 hours. TWA: 2400 mg/m³ 8 hours.
Ethyl 3-Ethoxypropionate	763-69-9	None.
Bis(pentamethyl-4-piperidyl)sebacate	41556-26-7	None.

Occupational exposure limits (Canada)

Section 8. Exposure controls/personal protection

Ingredient name	CAS #	Exposure limits
n-butyl acetate	123-86-4	**CA Alberta Provincial (Canada, 6/2018).** 15 min OEL: 200 ppm 15 minutes. 15 min OEL: 950 mg/m³ 15 minutes. 8 hrs OEL: 150 ppm 8 hours. 8 hrs OEL: 713 mg/m³ 8 hours. **CA Saskatchewan Provincial (Canada, 7/2013).** STEL: 200 ppm 15 minutes. TWA: 150 ppm 8 hours. **CA Ontario Provincial (Canada, 6/2019). [butyl acetates, all isomers]** STEL: 150 ppm 15 minutes. TWA: 50 ppm 8 hours. **CA British Columbia Provincial (Canada, 3/2022). [butyl acetate, all isomers]** STEL: 150 ppm 15 minutes. TWA: 50 ppm 8 hours. **CA Quebec Provincial (Canada, 6/2021). [butyl acetates]** STEV: 150 ppm 15 minutes. TWAEV: 50 ppm 8 hours.
Methyl ethyl ketone	78-93-3	**CA Alberta Provincial (Canada, 6/2018).** 15 min OEL: 300 ppm 15 minutes. 8 hrs OEL: 200 ppm 8 hours. 8 hrs OEL: 590 mg/m³ 8 hours. 15 min OEL: 885 mg/m³ 15 minutes. **CA British Columbia Provincial (Canada, 3/2022).** TWA: 50 ppm 8 hours. STEL: 100 ppm 15 minutes. **CA Ontario Provincial (Canada, 6/2019).** TWA: 200 ppm 8 hours. STEL: 300 ppm 15 minutes. **CA Quebec Provincial (Canada, 6/2021).** TWAEV: 50 ppm 8 hours. TWAEV: 150 mg/m³ 8 hours. STEV: 100 ppm 15 minutes. STEV: 300 mg/m³ 15 minutes. **CA Saskatchewan Provincial (Canada, 7/2013).** STEL: 300 ppm 15 minutes. TWA: 200 ppm 8 hours.
acetone	67-64-1	**CA Alberta Provincial (Canada, 6/2018).** 8 hrs OEL: 1200 mg/m³ 8 hours. 15 min OEL: 1800 mg/m³ 15 minutes. 8 hrs OEL: 500 ppm 8 hours. 15 min OEL: 750 ppm 15 minutes. **CA British Columbia Provincial (Canada, 3/2022).** TWA: 250 ppm 8 hours. STEL: 500 ppm 15 minutes. **CA Ontario Provincial (Canada, 6/2019).** TWA: 250 ppm 8 hours. STEL: 500 ppm 15 minutes. **CA Quebec Provincial (Canada, 6/2021).**

Section 8. Exposure controls/personal protection

		TWAEV: 500 ppm 8 hours. TWAEV: 1190 mg/m³ 8 hours. STEV: 1000 ppm 15 minutes. STEV: 2380 mg/m³ 15 minutes. **CA Saskatchewan Provincial (Canada, 7/2013).** STEL: 750 ppm 15 minutes. TWA: 500 ppm 8 hours.
Ethylene glycol butyl ether acetate	112-07-2	**CA British Columbia Provincial (Canada, 3/2022).** TWA: 20 ppm 8 hours. **CA Ontario Provincial (Canada, 6/2019).** TWA: 20 ppm 8 hours. **CA Alberta Provincial (Canada, 6/2018).** 8 hrs OEL: 131 mg/m³ 8 hours. 8 hrs OEL: 20 ppm 8 hours. **CA Saskatchewan Provincial (Canada, 7/2013).** STEL: 30 ppm 15 minutes. TWA: 20 ppm 8 hours. **CA Quebec Provincial (Canada, 6/2021).** TWAEV: 10 ppm 8 hours.

Occupational exposure limits (Mexico)

	CAS #	Exposure limits
n-Butyl Acetate	123-86-4	**NOM-010-STPS-2014 (Mexico, 4/2016).** TWA: 150 ppm 8 hours. STEL: 200 ppm 15 minutes.
Methyl Ethyl Ketone	78-93-3	**NOM-010-STPS-2014 (Mexico, 4/2016).** TWA: 200 ppm 8 hours. STEL: 300 ppm 15 minutes.
Acetone	67-64-1	**NOM-010-STPS-2014 (Mexico, 4/2016).** TWA: 500 ppm 8 hours. STEL: 750 ppm 15 minutes.

Appropriate engineering controls : Use only with adequate ventilation. Use process enclosures, local exhaust ventilation or other engineering controls to keep worker exposure to airborne contaminants below any recommended or statutory limits. The engineering controls also need to keep gas, vapor or dust concentrations below any lower explosive limits. Use explosion-proof ventilation equipment.

Environmental exposure controls : Emissions from ventilation or work process equipment should be checked to ensure they comply with the requirements of environmental protection legislation. In some cases, fume scrubbers, filters or engineering modifications to the process equipment will be necessary to reduce emissions to acceptable levels.

Individual protection measures

Hygiene measures : Wash hands, forearms and face thoroughly after handling chemical products, before eating, smoking and using the lavatory and at the end of the working period. Appropriate techniques should be used to remove potentially contaminated clothing. Contaminated work clothing should not be allowed out of the workplace. Wash contaminated clothing before reusing. Ensure that eyewash stations and safety showers are close to the workstation location.

Eye/face protection : Safety eyewear complying with an approved standard should be used when a risk assessment indicates this is necessary to avoid exposure to liquid splashes, mists, gases or dusts. If contact is possible, the following protection should be worn, unless the assessment indicates a higher degree of protection: chemical splash goggles.

Section 8. Exposure controls/personal protection

Skin protection

Hand protection : Chemical-resistant, impervious gloves complying with an approved standard should be worn at all times when handling chemical products if a risk assessment indicates this is necessary. Considering the parameters specified by the glove manufacturer, check during use that the gloves are still retaining their protective properties. It should be noted that the time to breakthrough for any glove material may be different for different glove manufacturers. In the case of mixtures, consisting of several substances, the protection time of the gloves cannot be accurately estimated.

Body protection : Personal protective equipment for the body should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product. When there is a risk of ignition from static electricity, wear anti-static protective clothing. For the greatest protection from static discharges, clothing should include anti-static overalls, boots and gloves.

Other skin protection : Appropriate footwear and any additional skin protection measures should be selected based on the task being performed and the risks involved and should be approved by a specialist before handling this product.

Respiratory protection : Based on the hazard and potential for exposure, select a respirator that meets the appropriate standard or certification. Respirators must be used according to a respiratory protection program to ensure proper fitting, training, and other important aspects of use.

Section 9. Physical and chemical properties

The conditions of measurement of all properties are at standard temperature and pressure unless otherwise indicated.

Appearance

Physical state : Liquid.

Color : Not available.

Odor : Not available.

Odor threshold : Not available.

pH : Not applicable.

Melting point/freezing point : Not available.

Boiling point, initial boiling point, and boiling range : 55°C (131°F)

Flash point : Closed cup: -7°C (19.4°F) [Pensky-Martens Closed Cup]

Evaporation rate : 5.6 (butyl acetate = 1)

Flammability : Flammable liquid.

Lower and upper explosion limit/flammability limit : Lower: 1.05%
Upper: 12.8%

Vapor pressure : 24 kPa (180 mm Hg)

Relative vapor density : 2 [Air = 1]

Relative density : 0.96

Solubility(ies) :

Media	Result
cold water	Not soluble

Partition coefficient: n-octanol/water : Not applicable.

Auto-ignition temperature : Not available.

Decomposition temperature : Not available.

Viscosity : Kinematic (40°C (104°F)): >20.5 mm^2/s (>20.5 cSt)

Section 9. Physical and chemical properties

Molecular weight : Not applicable.

Aerosol product

Heat of combustion : 16.628 kJ/g

Section 10. Stability and reactivity

Reactivity : No specific test data related to reactivity available for this product or its ingredients.

Chemical stability : The product is stable.

Possibility of hazardous reactions : Under normal conditions of storage and use, hazardous reactions will not occur.

Conditions to avoid : Avoid all possible sources of ignition (spark or flame). Do not pressurize, cut, weld, braze, solder, drill, grind or expose containers to heat or sources of ignition. Do not allow vapor to accumulate in low or confined areas.

Incompatible materials : Reactive or incompatible with the following materials:
oxidizing materials

Hazardous decomposition products : Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11. Toxicological information

Information on toxicological effects

Acute toxicity

Product/ingredient name	Result	Species	Dose	Exposure
n-Butyl Acetate	LD50 Dermal	Rabbit	>17600 mg/kg	-
	LD50 Oral	Rat	10768 mg/kg	-
n-Butyl Propionate	LD50 Dermal	Rabbit	>14 g/kg	-
	LD50 Oral	Rat	11031 mg/kg	-
Methyl Ethyl Ketone	LD50 Dermal	Rabbit	6480 mg/kg	-
	LD50 Oral	Rat	2737 mg/kg	-
Acetone	LD50 Oral	Rat	5800 mg/kg	-
Ethyl 3-Ethoxypropionate	LD50 Oral	Rat	3200 mg/kg	-

Irritation/Corrosion

Product/ingredient name	Result	Species	Score	Exposure	Observation
n-Butyl Acetate	Eyes - Moderate irritant	Rabbit	-	100 mg	-
	Skin - Moderate irritant	Rabbit	-	24 hours 500 mg	-
n-Butyl Propionate	Eyes - Moderate irritant	Rabbit	-	0.1 Ml	-
	Eyes - Severe irritant	Rabbit	-	100 mg	-
	Skin - Mild irritant	Guinea pig	-	0.3 Ml	-
	Skin - Mild irritant	Rabbit	-	0.5 Ml	-
	Skin - Moderate irritant	Rabbit	-	24 hours 500 mg	-
Methyl Ethyl Ketone	Skin - Mild irritant	Rabbit	-	24 hours 14 mg	-
	Skin - Moderate irritant	Rabbit	-	24 hours 500 mg	-
Acetone	Eyes - Mild irritant	Human	-	186300 ppm	-
	Eyes - Mild irritant	Rabbit	-	10 uL	-

Section 11. Toxicological information

	Eyes - Moderate irritant	Rabbit	-	24 hours 20 mg	-
	Eyes - Severe irritant	Rabbit	-	20 mg	-
	Skin - Mild irritant	Rabbit	-	395 mg	-
	Skin - Mild irritant	Rabbit	-	24 hours 500 mg	-
Ethyl 3-Ethoxypropionate	Skin - Mild irritant	Rabbit	-	24 hours 500 mg	-

Sensitization

Not available.

Mutagenicity

Not available.

Carcinogenicity

Not available.

Reproductive toxicity

Not available.

Teratogenicity

Not available.

Specific target organ toxicity (single exposure)

Name	Category	Route of exposure	Target organs
n-Butyl Acetate	Category 3	-	Narcotic effects
Methyl Ethyl Ketone	Category 3	-	Respiratory tract irritation
	Category 3		Narcotic effects
Acetone	Category 3	-	Respiratory tract irritation
	Category 3		Narcotic effects

Specific target organ toxicity (repeated exposure)

Name	Category	Route of exposure	Target organs
Methyl Ethyl Ketone	Category 2	-	-
Acetone	Category 2	-	-

Aspiration hazard

Not available.

Information on the likely routes of exposure : Not available.

Potential acute health effects

Eye contact : Causes serious eye irritation.

Inhalation : Can cause central nervous system (CNS) depression. May cause drowsiness or dizziness.

Skin contact : Causes skin irritation. May cause an allergic skin reaction.

Ingestion : Can cause central nervous system (CNS) depression.

Symptoms related to the physical, chemical and toxicological characteristics

Section 11. Toxicological information

Eye contact : Adverse symptoms may include the following:
pain or irritation
watering
redness

Inhalation : Adverse symptoms may include the following:
nausea or vomiting
headache
drowsiness/fatigue
dizziness/vertigo
unconsciousness
reduced fetal weight
increase in fetal deaths
skeletal malformations

Skin contact : Adverse symptoms may include the following:
irritation
redness
reduced fetal weight
increase in fetal deaths
skeletal malformations

Ingestion : Adverse symptoms may include the following:
reduced fetal weight
increase in fetal deaths
skeletal malformations

Delayed and immediate effects and also chronic effects from short and long term exposure

Short term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Long term exposure

Potential immediate effects : Not available.

Potential delayed effects : Not available.

Potential chronic health effects

Not available.

General : May cause damage to organs through prolonged or repeated exposure. Once sensitized, a severe allergic reaction may occur when subsequently exposed to very low levels.

Carcinogenicity : No known significant effects or critical hazards.

Mutagenicity : No known significant effects or critical hazards.

Teratogenicity : No known significant effects or critical hazards.

Developmental effects : No known significant effects or critical hazards.

Fertility effects : Suspected of damaging fertility.

Numerical measures of toxicity

Acute toxicity estimates

Route	ATE value
Oral	28938.15 mg/kg

Section 12. Ecological information

Toxicity

Product/ingredient name	Result	Species	Exposure
n-Butyl Acetate	Acute LC50 32 mg/l Marine water	Crustaceans - Artemia salina	48 hours
	Acute LC50 18000 µg/l Fresh water	Fish - Pimephales promelas	96 hours
Methyl Ethyl Ketone	Acute EC50 >500000 µg/l Marine water	Algae - Skeletonema costatum	96 hours
	Acute EC50 5091000 µg/l Fresh water	Daphnia - Daphnia magna - Larvae	48 hours
	Acute LC50 3220000 µg/l Fresh water	Fish - Pimephales promelas	96 hours
Acetone	Acute EC50 7200000 µg/l Fresh water	Algae - Selenastrum sp.	96 hours
	Acute LC50 4.42589 ml/L Marine water	Crustaceans - Acartia tonsa - Copepodid	48 hours
	Acute LC50 7460000 µg/l Fresh water	Daphnia - Daphnia cucullata	48 hours
	Acute LC50 5600 ppm Fresh water	Fish - Poecilia reticulata	96 hours
	Chronic NOEC 4.95 mg/l Marine water	Algae - Ulva pertusa	96 hours
	Chronic NOEC 0.016 ml/L Fresh water	Crustaceans - Daphniidae	21 days
	Chronic NOEC 0.1 ml/L Fresh water	Daphnia - Daphnia magna - Neonate	21 days
	Chronic NOEC 5 µg/l Marine water	Fish - Gasterosteus aculeatus - Larvae	42 days

Persistence and degradability

Product/ingredient name	Aquatic half-life	Photolysis	Biodegradability
n-Butyl Acetate	-	-	Readily
Methyl Ethyl Ketone	-	-	Readily
Acetone	-	-	Readily

Bioaccumulative potential

Not available.

Mobility in soil

Soil/water partition coefficient (K_{OC}) : Not available.

Other adverse effects : No known significant effects or critical hazards.

Section 13. Disposal considerations

Disposal methods : The generation of waste should be avoided or minimized wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Dispose of surplus and non-recyclable products via a licensed waste disposal contractor. Waste should not be disposed of untreated to the sewer unless fully compliant with the requirements of all authorities with jurisdiction. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. This material and its container must be disposed of in a safe way. Care should be taken when handling emptied containers that have not been cleaned or rinsed out. Empty containers or liners may retain some product residues. Vapor from product residues may create a highly flammable or explosive atmosphere inside the container. Do not cut, weld or grind used containers unless they have been cleaned thoroughly internally. Avoid dispersal of spilled material and runoff and contact with soil, waterways, drains and sewers.

Section 14. Transport information

	DOT Classification	TDG Classification	Mexico Classification	IATA	IMDG
UN number	UN1263	UN1263	UN1263	UN1263	UN1263
UN proper shipping name	PAINT	PAINT	PAINT	PAINT	PAINT
Transport hazard class(es)	3 	3 	3 	3 	3 
Packing group	II	II	II	II	II
Environmental hazards	No.	No.	No.	No.	No.
Additional information	- **ERG No.** 128	Product classified as per the following sections of the Transportation of Dangerous Goods Regulations: 2.18-2.19 (Class 3). **ERG No.** 128	- **ERG No.** 128	-	**Emergency schedules** F-E, S-E

Special precautions for user : Multi-modal shipping descriptions are provided for informational purposes and do not consider container sizes. The presence of a shipping description for a particular mode of transport (sea, air, etc.), does not indicate that the product is packaged suitably for that mode of transport. All packaging must be reviewed for suitability prior to shipment, and compliance with the applicable regulations is the sole responsibility of the person offering the product for transport. People loading and unloading dangerous goods must be trained on all of the risks deriving from the substances and on all actions in case of emergency situations.

Transport in bulk according to IMO instruments : Not available.

Proper shipping name : Not available.

Section 15. Regulatory information

SARA 313

SARA 313 (40 CFR 372.45) supplier notification can be found on the Environmental Data Sheet.

California Prop. 65

WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

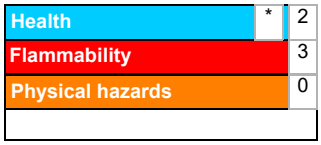
International regulations

Section 15. Regulatory information

International lists : **Australia inventory (AIIC)**: Not determined.
China inventory (IECSC): Not determined.
Japan inventory (CSCL): Not determined.
Japan inventory (ISHL): Not determined.
Korea inventory (KECI): Not determined.
New Zealand Inventory of Chemicals (NZIoC): Not determined.
Philippines inventory (PICCS): Not determined.
Taiwan Chemical Substances Inventory (TCSI): Not determined.
Thailand inventory: Not determined.
Turkey inventory: Not determined.
Vietnam inventory: Not determined.

Section 16. Other information

Hazardous Material Information System (U.S.A.)



The customer is responsible for determining the PPE code for this material. For more information on HMIS® Personal Protective Equipment (PPE) codes, consult the HMIS® Implementation Manual.

Caution: HMIS® ratings are based on a 0-4 rating scale, with 0 representing minimal hazards or risks, and 4 representing significant hazards or risks. Although HMIS® ratings and the associated label are not required on SDSs or products leaving a facility under 29 CFR 1910.1200, the preparer may choose to provide them. HMIS® ratings are to be used with a fully implemented HMIS® program. HMIS® is a registered trademark and service mark of the American Coatings Association, Inc.

Procedure used to derive the classification

Classification	Justification
FLAMMABLE LIQUIDS - Category 2	On basis of test data
SKIN CORROSION/IRRITATION - Category 2	Calculation method
SERIOUS EYE DAMAGE/ EYE IRRITATION - Category 2A	Calculation method
SKIN SENSITIZATION - Category 1	Calculation method
TOXIC TO REPRODUCTION - Category 2	Calculation method
SPECIFIC TARGET ORGAN TOXICITY (SINGLE EXPOSURE) (Narcotic effects) - Category 3	Calculation method
SPECIFIC TARGET ORGAN TOXICITY (REPEATED EXPOSURE) - Category 2	Calculation method

History

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Key to abbreviations : ATE = Acute Toxicity Estimate
BCF = Bioconcentration Factor
GHS = Globally Harmonized System of Classification and Labelling of Chemicals
IATA = International Air Transport Association
IBC = Intermediate Bulk Container
IMDG = International Maritime Dangerous Goods
LogPow = logarithm of the octanol/water partition coefficient
MARPOL = International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978. ("Marpol" = marine pollution)
N/A = Not available

Section 16. Other information

SGG = Segregation Group
UN = United Nations

Indicates information that has changed from previously issued version.

Notice to reader

It is recommended that each customer or recipient of this Safety Data Sheet (SDS) study it carefully and consult resources, as necessary or appropriate, to become aware of and understand the data contained in this SDS and any hazards associated with the product. This information is provided in good faith and believed to be accurate as of the effective date herein. However, no warranty, express or implied, is given. The information presented here applies only to the product as shipped. The addition of any material can change the composition, hazards and risks of the product. Products shall not be repackaged, modified, or tinted except as specifically instructed by the manufacturer, including but not limited to the incorporation of products not specified by the manufacturer, or the use or addition of products in proportions not specified by the manufacturer. Regulatory requirements are subject to change and may differ between various locations and jurisdictions. The customer/buyer/user is responsible to ensure that his activities comply with all country, federal, state, provincial or local laws. The conditions for use of the product are not under the control of the manufacturer; the customer/buyer/user is responsible to determine the conditions necessary for the safe use of this product. The customer/buyer/user should not use the product for any purpose other than the purpose shown in the applicable section of this SDS without first referring to the supplier and obtaining written handling instructions. Due to the proliferation of sources for information such as manufacturer-specific SDS, the manufacturer cannot be responsible for SDSs obtained from any other source.

SAFETY DATA SHEET
AUTOBORNE SEALERS
10/05/15

Manufacturer or Distributor:	**Color Craft, Ltd./Createx Colors** **14 Airport Park Road** **East Granby, Connecticut 06026** **Phone: 800-509-6563** **Fax: 1-860-653-0643**
Information Telephone Number:	**800-243-2712**
Emergency Telephone Number:	**800-243-2712**
For Health Emergencies:	**Poison Control Center: 1-888-516-2502**

SECTION I – PRODUCT IDENTIFICATION

Product Name:	AutoBorne Sealers
Product Number:	AutoBorne
Product Sizes:	NA
Brand Name:	AutoBorne
Product Class:	Acrylic/Polymer Sealers

SECTION II – HAZARDS IDENTIFICATION

Classification in accordance with paragraph (d) of 29 CFR 1910.1200.

Acute Toxicity Oral:	Category 4
Skin Irritation:	Category 2
Eye Irritation:	Category 2
Label elements:	 GHS07
Signal Word:	Danger
Hazard Statement:	Harmful if swallowed
Precautionary Statements:	**Prevention:** Wash hands thoroughly after handling. Do not eat, drink or smoke when using this product. Wear protective gloves/protective clothing/eye protection/face protection. **Response:** Call a POISON CENTER/doctor if you feel unwell. Get medical advice/attention. Specific treatment (see label). Rinse mouth. Remove contact lenses, if present and easy to do. Continue rinsing. Rinse cautiously with water for several minutes. Take off contaminated clothing. *IF SWALLOWED:* Immediately call a POISON CENTER/doctor. *IF ON SKIN:* Wash with plenty of water. *If skin irritation occurs:* Get medical advice/attention.

SAFETY DATA SHEET
AUTOBORNE SEALERS
10/05/15

SECTION III – COMPOSITION / INFORMATION ON INGREDIENTS

Ingredient:	2-Butoxy Ethanol
CAS#:	111-76-2
PEL/TLV (MG/M#):	N/A
Max % Weight:	4.0
NTP:	N
IARC:	N

SECTION IV – FIRST AID MEASURES

First Aid Measures:	If eye contact occurs, rinse with tap water for 5-10 minutes. If irritation persists, seek medical care. If skin contact occurs, wash with soap and water for 5 minutes. If swallowed, get prompt medical attention.

SECTION V – FIRE FIGHTING MEASURES

Flash Point (Method):	N/A
Autoignition Temperature:	N/A
Explosion Limits in Air (% by Volume):	Not Explosive
Extinguishing Media:	No special media required.
Required Fire Fighting Procedures:	No special firefighting procedures required.
Unusual Fire & Explosion Hazards:	Not Combustible

SECTION VI – ACCIDENTAL RELEASE MEASURES

Steps to be taken in case a material is spilled:	Clean up in accordance with all applicable regulations. Absorb spillage with non-combustible, absorbent material. For waste disposal, see Section XIII

SECTION VII – HANDLING AND STORAGE

Precautions to be taken during storage and handling:	Good industrial hygiene practice requires that exposure be maintained below the TLV. This is preferably achieved through the provision of adequate ventilation. When exposure cannot be adequately controlled in this way, personal respiratory protection should be employed.

SECTION VIII - EXPOSURE CONTROLS / PERSONAL PROTECTION

Respiratory Protection and Special Ventilation Requirements:	Use only with adequate ventilation. Wear a NIOSH / MSHA approved respirator
Other Protective Equipment (Gloves, Goggles, etc):	When using wear impermeable protective gloves.
Work / Hygiene Practices:	Avoid prolonged contact with skin. Wash hands immediately after use. Keep away from eyes.
Engineering Controls:	**KEEP OUT OF REACH OF CHILDREN**

SAFETY DATA SHEET
AUTOBORNE SEALERS
10/05/15

SECTION IX – PHYSICAL AND CHEMICAL PROPERTIES

Appearance:	Colored paint
Physical State:	Liquid
VOC Content:	63.54 g/L Regulatory
Solids percentage:	43.61
Boiling Point:	N/A
Melting Point:	N/A
Vapor Pressure:	N/A
Specific Vapor Density (Air=1):	N/A
Specific Gravity:	N/A
Solubility In Water:	N/A
Reactivity In Water:	Non-Reactive

SECTION X – STABILITY AND REACTIVITY

Hazardous Polymerization Products:	None
Stability: Stable Conditions to Avoid:	None
Incompatibility (Materials to Avoid):	None
Hazardous Decomposition Products:	None

SECTION XI – TOXICOLOGICAL INFORMATION

Acute Effects Associated with Use of this Material:	Skin irritant. Eye irritant. May be harmful if swallowed, by skin contact or by breathing vapors. May be harmful if swallowed. May be harmful by skin contact. Contact may result in irritation of the skin. Contact may result in redness or pain of the eyes.

The summated LD50 is 1228.6 mg/kg.
The summated LC50 is 914.0 mg/cubic meter.
This product is not considered to be a known or suspected human carcinogen by NTP, IARC or OSHA (see section III)

SECTION XII – ECOLOGICAL INFORMATION

No harmful effects known other than those associated with suspended inert solids in water.

SECTION XIII – DISPOSAL CONSIDERATIONS

RCRA Hazard Class (40 CFR 261):	This product is not classified as a hazardous waste.
Waste Disposal Method:	Dispose of in accordance with federal, state and local regulations.

SECTION XIV – TRANSPORTATION INFORMATION

The following transportation categories do not apply to this mixture sold as a consumer use product (non-bulk).

DOT Non-Bulk	
Shipping Name	Not regulated.
Technical Shipping Name	Not regulated.
Hazard Class	Not regulated.
UN Number	Not regulated.
Packing Group	Not regulated.
IMDG	
Shipping Name	Not regulated.
Technical Shipping Name	Not regulated.
Hazard Class	Not regulated.
UN Number	Not regulated.
Packing Group	Not regulated.
EmS Number	Not regulated.
Marine Pollutant	Not regulated.
ICAO/IATA	
Shipping Name	Not regulated.
Technical Shipping Name	Not regulated.
Hazard Class	Not regulated.
UN Number	Not regulated.
Packing Group	Not regulated.
Marine Pollutant	Not regulated.

This information is not intended to convey all specific regulatory or operational requirements/information relating to this product. It is the responsibility of the transporting organization to follow all applicable laws, regulations and rules relating to the transportation of the materials.

SECTION XV – REGULATORY INFORMATION

Contents of this SDS comply with Osha Hazard Communication Standard 29 CFR 1910.1200EPA

SARA Title III Chemical Listings: None

Section 302.4 Extremely Hazardous Substances (40 CFR 355): None

Section 313 Toxic Chemicals (40 CFR 372): None

International Regulations

Canadian WHMIS:

This product is a controlled product under Canada's workplace hazardous materials information system.

It contains the following toxic or highly toxic materials: 1-Methoxy-2-Propanol
2-Butoxy Ethanol

Supplemental State Compliance Information:

This product contains the following chemical(s) listed in the state of California under their Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) as being known to cause cancer, birth defects or other reproductive harm: None

This product contains the following chemical(s) listed under New Jersey's Right to Know Program: 1-Methoxy-2-Propanol
2-Butoxy Ethanol

SAFETY DATA SHEET
AUTOBORNE SEALERS
10/05/15

This product contains the following chemical(s) requiring notification to the state of Washington under their Children's Safe Products Act:	None
Under CPSC's consumer product regulations (16CFR1500.3 and 150014), this product has the following required acute and chronic hazard labeling:	Warning: May be harmful if swallowed, or by skin contact. Skin irritant. Eye Irritant. Contains: 2-Butoxy Ethanol Precautions: Keep away from eyes. Keep out of reach of children. First Aid Treatment: If eye contact occurs, rinse with tap water for 5-10 minutes. If irritation persists, seek medical care. For acutely hazardous products, the name and place of business of the manufacturer, packer, distributor or seller must appear on the label. A US telephone # to obtain more information is recommended but not required.

SECTION XVI – OTHER INFORMATION

Last Revision Date: 10/05/2015

Prepared by Duke OEM Toxicology

COLOR INFORMATION

This SDS applies to the following colors which are associated with hazardous and /or non-hazardous ingredients.

Product Color	SKU	Hazardous Ingredient
6000 Transparent		(None)
6001 White		(None)
6002 Black		(None)
6003 Gray		(None)
6004 Yellow		(None)
6005 Orange		(None)
6006 Red		(None)
6007 Lilac		(None)
6008 Blue		(None)
6009 Process Blue		(None)
6010 Green		(None)
6011 Tan		(None)
6012 Burgundy		(None)
6013 Silver		(None)

Brand Names

This SDS applies to the following brand names: Autoborne Sealers
Auto Air Colors

MATERIAL SAFETY DATA SHEET

FH611
04 00

DATE OF PREPARATION
Dec 30, 2008

SECTION 1 — PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NUMBER
FH611
PRODUCT NAME
FINISH 1™ Hardener (Part B), Fast
MANUFACTURER'S NAME
ACME AUTOMOTIVE FINISHES
101 Prospect Avenue N.W.
Cleveland, OH 44115

Telephone Numbers and Websites

Regulatory Information	(216) 566-2902
Medical Emergency	(216) 566-2917
Transportation Emergency*	(800) 424-9300
**for Chemical Emergency ONLY (spill, leak, fire, exposure, or accident)*	

SECTION 2 — COMPOSITION/INFORMATION ON INGREDIENTS

% by Weight	CAS Number	Ingredient	Units	Vapor Pressure
43	**123-86-4**	**n-Butyl Acetate**		
		ACGIH TLV	150 PPM	10 mm
		ACGIH TLV	200 PPM STEL	
		OSHA PEL	150 PPM	
		OSHA PEL	200 PPM STEL	
0.1	**822-06-0**	**Hexamethylene Diisocyanate (max.)**		
		ACGIH TLV	0.005 PPM	0.05 mm
		OSHA PEL	Not Available	
57	**3779-63-3**	**Hexamethylene Diisocyanate Polymer**		
		ACGIH TLV	Not Available	
		OSHA PEL	Not Available	

SECTION 3 — HAZARDS IDENTIFICATION

ROUTES OF EXPOSURE
INHALATION of vapor or spray mist.
EYE or SKIN contact with the product, vapor or spray mist.

HMIS Codes

Health	3*
Flammability	2
Reactivity	1

EFFECTS OF OVEREXPOSURE
EYES: Irritation.
SKIN: Prolonged or repeated exposure may cause irritation.
INHALATION: Irritation of the upper respiratory system.

May cause nervous system depression. Extreme overexposure may result in unconsciousness and possibly death.
Prolonged overexposure to solvent ingredients in Section 2 may cause adverse effects to blood forming systems.

SIGNS AND SYMPTOMS OF OVEREXPOSURE
Headache, dizziness, nausea, and loss of coordination are indications of excessive exposure to vapors or spray mists.
Redness and itching or burning sensation may indicate eye or excessive skin exposure.

MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE
May cause allergic respiratory and/or skin reaction in susceptible persons or sensitization. This effect may be delayed several hours after exposure.
Persons sensitive to isocyanates will experience increased allergic reaction on repeated exposure.

CANCER INFORMATION
For complete discussion of toxicology data refer to Section 11.

SECTION 4 — FIRST AID MEASURES

EYES: Flush eyes with large amounts of water for 15 minutes. Get medical attention.
SKIN: Wash affected area thoroughly with soap and water.
Remove contaminated clothing and launder before re-use.
INHALATION: If any breathing problems occur during use, **LEAVE THE AREA** and get fresh air. If problems remain or occur later, **IMMEDIATELY** get medical attention.
INGESTION: Do not induce vomiting. Get medical attention immediately.

SECTION 5 — FIRE FIGHTING MEASURES

FLASH POINT	LEL	UEL	FLAMMABILITY CLASSIFICATION
135° F SETA	1.4	7.6	Combustible, Flash above 99 and below 200° F

EXTINGUISHING MEDIA
Carbon Dioxide, Dry Chemical, Foam
UNUSUAL FIRE AND EXPLOSION HAZARDS
Closed containers may explode when exposed to extreme heat.
Application to hot surfaces requires special precautions.
During emergency conditions overexposure to decomposition products may cause a health hazard. Symptoms may not be immediately apparent. Obtain medical attention.
SPECIAL FIRE FIGHTING PROCEDURES
Full protective equipment including self-contained breathing apparatus should be used.
Water spray may be ineffective. If water is used, fog nozzles are preferable. Water may be used to cool closed containers to prevent pressure build-up and possible autoignition or explosion when exposed to extreme heat.

SECTION 6 — ACCIDENTAL RELEASE MEASURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED
- Remove all sources of ignition. Ventilate the area.
- All personnel in the area should be protected as in Section 8.
- Cover spill with absorbent material. Deactivate spilled material with a 10% ammonium hydroxide solution (household ammonia). After 10 minutes, collect in open containers and add more ammonia. Cover loosely. Wash spill area with soap and water.

SECTION 7 — HANDLING AND STORAGE

STORAGE CATEGORY
DOL Storage Class II
PRECAUTIONS TO BE TAKEN IN HANDLING AND STORAGE
Contents are COMBUSTIBLE. Keep away from heat and open flame.
Consult NFPA Code. Use approved Bonding and Grounding procedures.
Keep container closed when not in use. Transfer only to approved containers with complete and appropriate labeling. Do not take internally. Keep out of the reach of children.

SECTION 8 — EXPOSURE CONTROLS/PERSONAL PROTECTION

PRECAUTIONS TO BE TAKEN IN USE
NO PERSON SHOULD USE THIS PRODUCT, OR BE IN THE AREA WHERE IT IS BEING USED, IF THEY HAVE CHRONIC (LONG-TERM) LUNG OR BREATHING PROBLEMS OR IF THEY EVER HAD A REACTION TO ISOCYANATES.
Use only with adequate ventilation.
Avoid contact with skin and eyes. Avoid breathing vapor and spray mist.
Wash hands after using.
This coating may contain materials classified as nuisance particulates (listed "as Dust" in Section 2) which may be present at hazardous levels only during sanding or abrading of the dried film. If no specific dusts are listed in Section 2, the applicable limits for nuisance dusts are ACGIH TLV 10 mg/m3 (total dust), 3 mg/m3 (respirable fraction), OSHA PEL 15 mg/m3 (total dust), 5 mg/m3 (respirable fraction).
VENTILATION
Local exhaust preferable. General exhaust acceptable if the exposure to materials in Section 2 is maintained below applicable exposure limits. Refer to OSHA Standards 1910.94, 1910.107, 1910.108.
RESPIRATORY PROTECTION
Where overspray is present, a positive pressure air supplied respirator (TC19C NIOSH/MSHA approved) should be worn. If unavailable, a properly fitted organic vapor/particulate respirator approved by NIOSH/MSHA for protection against materials in Section 2 may be effective. Follow respirator manufacturers directions for use. Wear the respirator for the whole time of spraying and until all vapors and mists are gone. **NO PERSONS SHOULD BE ALLOWED IN THE AREA WHERE THIS PRODUCT IS BEING USED UNLESS EQUIPPED WITH THE SAME RESPIRATOR PROTECTION RECOMMENDED FOR THE PAINTERS.**
When sanding or abrading the dried film, wear a dust/mist respirator approved by NIOSH/MSHA for dust which may be generated from this product, underlying paint, or the abrasive.
PROTECTIVE GLOVES
To prevent skin contact, wear gloves which are recommended by glove supplier for protection against materials in Section 2.

EYE PROTECTION
Wear safety spectacles with unperforated sideshields.
OTHER PROTECTIVE EQUIPMENT
Use barrier cream on exposed skin.
OTHER PRECAUTIONS
This product must be mixed with other components before use. Before opening the packages, READ AND FOLLOW WARNING LABELS ON ALL COMPONENTS.
Intentional misuse by deliberately concentrating and inhaling the contents can be harmful or fatal.

SECTION 9 — PHYSICAL AND CHEMICAL PROPERTIES

PRODUCT WEIGHT	8.46 lb/gal	1013 g/l
SPECIFIC GRAVITY	1.02	
BOILING POINT	255 - 264° F	123 - 128° C
MELTING POINT	Not Available	
VOLATILE VOLUME	49%	
EVAPORATION RATE	Slower than ether	
VAPOR DENSITY	Heavier than air	
SOLUBILITY IN WATER	N.A.	

VOLATILE ORGANIC COMPOUNDS (VOC Theoretical - As Packaged)

3.63lb/gal	435g/l	Less Water and Federally Exempt Solvents
3.63lb/gal	435g/l	Emitted VOC

SECTION 10 — STABILITY AND REACTIVITY

STABILITY — Stable
CONDITIONS TO AVOID
None known.
INCOMPATIBILITY
Contamination with Water, Alcohols, Amines and other compounds which react with isocyanates, may result in dangerous pressure in, and possible bursting of, closed containers.
HAZARDOUS DECOMPOSITION PRODUCTS
By fire: Carbon Dioxide, Carbon Monoxide
HAZARDOUS POLYMERIZATION
Will not occur

SECTION 11 — TOXICOLOGICAL INFORMATION

CHRONIC HEALTH HAZARDS
No ingredient in this product is an IARC, NTP or OSHA listed carcinogen.
Reports have associated repeated and prolonged overexposure to solvents with permanent brain and nervous system damage.
TOXICOLOGY DATA

CAS No.	Ingredient Name			
123-86-4	**n-Butyl Acetate**			
		LC50 RAT	4HR	2000 ppm
		LD50 RAT		13100 mg/kg
822-06-0	**Hexamethylene Diisocyanate (max.)**			
		LC50 RAT	4HR	Not Available
		LD50 RAT		738 mg/kg
3779-63-3	**Hexamethylene Diisocyanate Polymer**			
		LC50 RAT	4HR	Not Available
		LD50 RAT		Not Available

SECTION 12 — ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL INFORMATION
No data available.

SECTION 13 — DISPOSAL CONSIDERATIONS

WASTE DISPOSAL METHOD
Waste from this product may be hazardous as defined under the Resource Conservation and Recovery Act (RCRA) 40 CFR 261.
Waste must be tested for ignitability to determine the applicable EPA hazardous waste numbers.
Incinerate in approved facility. Do not incinerate closed container. Dispose of in accordance with Federal, State/Provincial, and Local regulations regarding pollution.

SECTION 14 — TRANSPORT INFORMATION

US Ground (DOT)
May be Classed as a Combustible Liquid for U.S. Ground.
UN1263, PAINT RELATED MATERIAL, 3, PG III, (ERG#128)
DOT (Dept of Transportation) Hazardous Substances & Reportable Quantities
n-Butyl acetate 5000 lb RQ
Bulk Containers may be Shipped as (check reportable quantities):
UN1263, PAINT RELATED MATERIAL, COMBUSTIBLE LIQUID, PG III, (ERG#128)
Canada (TDG)
May be Classed as a Combustible Liquid for Canadian Ground.
UN1263, PAINT RELATED MATERIAL, CLASS 3, PG III, (ERG#128)
IMO
UN1263, PAINT RELATED MATERIAL, CLASS 3, PG III, (57 C c.c.), EmS F-E, S-E

SECTION 15 — REGULATORY INFORMATION

SARA 313 *(40 CFR 372.65C)* SUPPLIER NOTIFICATION

CAS No.	CHEMICAL/COMPOUND	% by WT	% Element

No ingredients in this product are subject to SARA 313 (40 CFR 372.65C) Supplier Notification.
TSCA CERTIFICATION
All chemicals in this product are listed, or are exempt from listing, on the TSCA Inventory.

SECTION 16 — OTHER INFORMATION

This product has been classified in accordance with the hazard criteria of the Canadian Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

The above information pertains to this product as currently formulated, and is based on the information available at this time. Addition of reducers or other additives to this product may substantially alter the composition and hazards of the product. Since conditions of use are outside our control, we make no warranties, express or implied, and assume no liability in connection with any use of this information.

D. Risk Assessment Appendix

A. Event Horizon Risk Assessment Matrix

Component	Failure Mode	Effects of Failure	Causes of Failure	Detection	Severity Ranking	Occurance Ranking	Detection Ranking	Risk Priority Number
Motor	CATO	Rocket explodes	Defect, or blockage of exhaust	Oberseve motor before putting in rocket	9	2	7	126
Main GPS	GPS does not transmit data	No location for recovery	Product defect	Test GPS prior to launch	7	3	3	63
	GPS does not transmit data	No location for recovery	Electral connection fails	Test GPS prior to launch	7	3	3	63
	GPS signal is not retrievable	No location for recovery	GPS signal is not able to clear carbon fiber	Test GPS in carbon fiber to ensure it works	7	3	3	63
Main Raven4	Does not output electrical signal	Rocket loses control	Product defect	Test computer prior to launch	4	2	2	16
	Does not output electrical signal	Rocket loses control	Electrical connection fails	Test ebay prior to launch	4	3	2	24
	Outputs signal at incorrect time	Early/late main deployment	Programmed wrong	Run a launch simulation to observe signal timing	3	2	1	6
Main Easymini	Does not output electrical signal	Rocket loses control	Product defect	Test computer prior to launch	4	2	2	16
	Does not output electrical signal	Rocket loses control	Electrical connection fails	Test ebay prior to launch	4	3	2	24
	Outputs signal at incorrect time	Early/late main deployment	Programmed wrong	Run a launch simulation to observe signal timing	3	2	1	6
General Electrical Failure	Electronics Fail	Loss of control	Electrical short	Check electronics before complete integration	7	2	4	56
Battery	Does not provide power to the rocket	Loss of electronic communication	Not charged	Measure charge of battery before installation on ebay	6	1	1	6
Charge Well	Fails to ignite	Rocket does not seperate	Improperly packed	Test seperation with black powder and determine correct methodology	7	2	5	70
Tendie Descendie	Fails to ignite	Main does not inflate	Ematch defect	Observe quality of ematch before installation	8	3	7	168
	Ejector plate fails to seperate	Main does not inflate	Not enough black powder	Test seperation with black powder and determine correct measurment	8	2	5	80
	Ejector plate falls off	Lost piece of the rocket	Excessive force	Test structure of tendie before launch	3	1	4	12
Rolled Tubes	Cracks in the tubes	Rocket structure is compromised and unable to launch again	Excessive force	Observe airframe for any inital cracks/breaks	7	2	4	56
	Couplers break apart	Rocket structure is compromised and unable to launch again	Couplers are not thick enough	Measure thickness of couplers and run force analysis	7	2	4	56
Parachutes	Parachute falls apart at seams	Parachute does not work as effectively	Stitches in sewing are weak	Visually inspect chute	8	3	5	120
	Parachute is not open correctly	Parachute does not work effectively	Lines are sewn on poorly	Visually inspect chute	8	3	5	120
Recovery Line	Recovery lines become tangled	Parachute does not fully inflate	Recovery lines packed incorrectly	Inspect packing method	7	2	4	56
Nose Cone	Nose cone fails to seperate	Nose cone remains on rocket and payload remains in rocket	Charge wells were not packed correctly	Test seperation with black powder and determine correct measurment	6	2	5	60
	Payload does not clear airframe	Payload does not deploy	Clearance between payload and tube is not correct	Test payload ejection	5	3	5	75
Nose Cone GPS	GPS does not transmit data	No location for recovery	Product defect	Test GPS prior to launch	7	3	3	63
	GPS does not transmit data	No location for recovery	Electral connection fails	Test GPS prior to launch	7	3	3	63
	GPS signal is not retrievable	No location for recovery	GPS signal is not able to clear carbon fiber	Test GPS in carbon fiber to ensure it works	7	3	3	63
Nose Cone Raven4	Does not output electrical signal	Rocket loses control	Product defect	Test computer prior to launch	4	2	2	16
	Does not output electrical signal	Rocket loses control	Electrical connection fails	Test ebay prior to launch	4	3	2	24
	Outputs signal at incorrect time	Early/late main deployment	Programmed wrong	Run a launch simulation to observe signal timing	3	2	1	6
Nose Cone Easymini	Does not output electrical signal	Rocket loses control	Product defect	Test computer prior to launch	4	2	2	16
	does not output electrical signal	Rocket loses control	Electrical connection fails	Test ebay prior to launch	4	3	2	24
	Outputs signal at incorrect time	Early/late main deployment	Programmed wrong	Run a launch simulation to observe signal timing	3	2	1	6
Nose Cone Floating Charges	Fails to ignite	Rocket does not seperate	Improprely packing black powder charges	Test seperation with black powder and determine correct measurment	5	2	5	50
Piranhas	Fails to ignite	Parachute does not inflate	Improper assembly	Test pirhanas prior to launch	8	2	6	96
	Fails to cut zip tie	Parachute does not inflate	Improper assembly	Test separation with black powder and determine correct measurment	8	3	6	144

B. Singularity Risk Assessment Matrix

Component	Failure Mode	Effects of Failure	Causes of Failure	Detection	Severity Ranking	Occurance Ranking	Detection Ranking	Risk Priority Number
Drogue	Tangled/ not inflated	uncontrolled descent	not packed properly	observe no tears, holes, rips	8	5	1	40
Parafoil	tangled/ not inflated	no reduction in descent speed	not packed properly	observe no tears, holes, rips	6	7	3	126
	rigging line disconnects	parafoil performance decreases	manufacturing error	observe connection and no breakage	4	4	1	16
	control line disconnects	payload is unable to control	manufacturing error	observe connection and no breakage	4	3	1	12
Raven4	does not output electrical signal	loss of control	product defect	continuity check failure	7	2	1	14
	outputs electrical signal at incorrect time	early/late parafoil deployement	improper code	run a flight sim to observe when channels fire	4	2	3	24
	Arduino Nano connection failure	loss of recovery deployement	soldering, wire disconnects	observe free connections/ loose components	7	4	3	84
	Servo connection failure	loss of parafoil control	soldering, JST connector disconnects	observe free connections/ loose components	5	4	3	60
	Camera connection failure	no recorded video	soldering, JST connector disconnects	observe free connections/ loose components	2	4	3	24
	NiCr circuit connection failure	loss of recovery deployement	soldering, JST connector disconnects	observe free connections/ loose components	8	4	3	96
Servo	failed servo	payload cannot turn under parafoil	damaged/dead servo	power servos and run code to observe	5	2	2	20
			control line tangled in servo drum	check for tangling before flight	5	5	2	50
			electrical connections fail	observe no power to servos	5	4	2	40
	erratic Servo	payload turns unexpectedly	improper coding	run code to observe pattern	7	2	4	56
			electrical connections partially detatch	observe free/loose connections	7	4	4	112
	camera failure	no video recorded	power failure	camera does not turn on	2	5	2	20
		no video recorded	SD cards not inserted correctly	observe SD card	2	5	2	20
	obstructed lens	poor quality recording	improper packing/assembly	observe neat packing	1	6	7	42
NiCr Cutter	failure to cut	parafoil does not deploy	electrical connections detatch	observe free connections	7	6	4	168
			a short bypasses the NiCr wire	observe separation of wires/connections	7	5	7	245
Battery	dead/low charge	loss of power to flight computer/GPS/Supernova	not properly charged	check voltage with multimeter	7	4	2	56
	terminal leads detatch	loss of power to flight computer/GPS/Supernova	soldering failure	observe detatched leads	8	6	2	96
	turns off in flight	loss of power to flight computer/GPS/Supernova	screw not tightened	observe no power to electronics	8	2	3	48
915MHz radio antenna	interference with recieve/transmitt	unreliable connection to ground station	improper antennae placement/geographic connection	observe no signal	4	6	2	48
	mechanical failure	recovery detatches from payload from	improper design weighting	observe detatched/loose recovery	7	2	2	28
	does not output electrical signal	parafoil does not deploy	internal electronic failure, soldering/connections	observe free connections	8	4	3	96
		cameras do not turn on	internal electronic failure, soldering/connections	observe free connections	2	4	2	16
		servos do not move	internal electronic failure, soldering/connections	observe free connections	3	4	4	48
	outputs electrical signal at incorrect time	parafoil deploys too early/late	improper coding	run flight sim on Raven4 and observe timing	5	2	3	30
		servos move too early/late	improper coding	run flight sim on Raven4 and observe timing	6	2	3	36
		cameras record too early/late	improper coding	run flight sim on Raven4 and observe timing	1	2	3	6
	Outputs signal at incorrect time	Early/late main deployment	Programmed wrong	Run a launch simulation to observe signal timing	3	2	1	6
Nose Cone Floating Charges	Fails to ignite	Rocket does not seperate	Improprely packing black powder charges	Test seperation with black powder and determine correct measurment	5	2	5	50
Piranhas	Fails to ignite	Parachute does not inflate	Improper assembly	Test pirhanas prior to launch	8	2	6	96
	Fails to cut zip tie	Parachute does not inflate	Improper assembly	Test separation with black powder and determine correct measurment	8	3	6	144

E. Assembly, Preflight, Launch, Recovery, and Off-Nominal Checklists Appendix

1 - Pre Launchpad Checklist

1- Pre Launch Testing				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.1.1 GPS Prelaunch Verification	• Connect the GPS battery in the Electronics Bay and activate screw switch • Turn on and connect receiver for electronics Bay GPS • Connect the GPS battery in the Nose Electronics Bay and activate screw switch switch • Turn on and connect receiver for nose cone electronics Bay GPS • Turn off screw switches, disconnect all batteries, and turn off GPS receivers	• Electronics Bay GPS Accurately transmits data • Nose Electronic Bay GPS accurately transmits data		
1.1.2 Battery Checks	• Check all batteries for nominal charge using a digital multimeter • Charge any batteries that are under the required voltage of 4.0V	Electronics Bay Batteries: Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V Nose Electronics Bay Batteries: Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V		

1.1.3 Drogue Deployment Packing Test	• Dry pack all parachutes and line, including Tendie Descendie connection	• Parachutes fit inside the upper body tube without sticking out • Main parachute pulls out without tangling		
1.1.4 Main Deployment Packing Test	• Remove Tendie pin connection after 1.1.3	• Main parachute can fully inflate, and lines do not get tangled		
1.1.5 Main Electronics Bay Flight Computer Programming	• Program Raven4 • Program EasyMini • Calibrate Raven4	EasyMini: - Main Deploy Altitude (ft): 1500 - Apo Delay (s): 1 - Apo Lockout (s): 35 Raven: Apo - Flight Time > TVal Time: TVal = 35s - Pressure Increasing - Velocity < Vel1: Vel1 = 400 ft/s - Time Delay: Delay = 1.5s Main - Flight Time > TVal Time: TVal = 40s - Height Above Pad < AGL 3: AGL3 =1500 ft - Pressure Increasing - Velocity < Vel1: Vel1 = 400 ft/s		
1.1.6 Main Electronics Bay Altimeter Firing Sequence Verification	• Connect E-matches to proper channels • Run a simulated flight	EasyMini: • Apo charge fires one second simulated apo		

		• Main fires at 1,500ft Raven: • Apo charge fires shortly after 1 second after simulated apo • Main fires shortly after 1,500ft Note: 1b2b to Main Charge well 3b4b to Main Tendie Well 5b6b to Backup Tendie Well 7b8b to Backup Charge Well		
1.1.7 Nose Electronics Bay Flight Computer Programming	• Program Raven4 • Program EasyMini • Calibrate Raven4	EasyMini: - Main Deploy Altitude (ft): 1500 - Apo Delay (s): 0 - Apo Lockout (s): 35 Raven4: Apo - Flight Time > TVal Time: TVal = 35s - Pressure Increasing - Velocity < Vel1: Vel1 = 400 ft/s - Time Delay: Delay = 0.5s Main - Flight Time > TVal Time: TVal = 40s - Height Above Pad < AGL1: AGL1 = 1500 ft - Pressure Increasing - Velocity < Vel1: Vel1 = 400 ft/s		

1.1.8 Nose Electronics Bay Altimeter Firing Sequence Verification	• Connect E-matches to proper channels • Run a simulated flight	EasyMini: • Apo Charge fires at simulated apo • Main fires at 1,500 ft Raven: • Apo Charge fires 0.5 seconds after simulated apo • Main fires shortly after 1,500 ft		
1.1.9 Lower Section Black Powder Ejection Testing	• **Connect an E-match to the screw terminal that connects to the correct port** • **Insert E-match into a charge well and pour black powder** • Fill charge well with dog barf and seal with electrical tape • Fully install the electronics bay with an EasyMini programming cable attached. • Assemble electronics bay with upper body tube, using shear pins to secure the section in a proper orientation • Angle the tubes in an upward direction away from everyone, so it can eject safely and without interference • Activate the EasyMini using a screw switch, then plug cable into laptop • Run flight simulation, **BACK AWAY 10ft,** and wait for ejection	• Upper Section cleanly separates from the lower body without traveling an excessive distance (>10ft) • Main parachute comes out of the upper body tube • Minimal smoke is found in the Electronics Bay Note: Repeat process with an adjusted amount of black powder if necessary. Additional Note: May want to perform process with payload and nose cone attached in case nose cone does not eject during flight		
1.1.10 Nose Cone Black Powder Ejection	• **Connect an E-match to the screw terminal that**	• Nose cone cleanly separates without interference or		

Testing	**connects to the correct port** ● **Insert E-match into a charge well and pour black powder** ● Fill charge well with dog barf and seal with electrical tape ● Fully install the electronics bay with an Raven4 programming cable attached. ● Assemble nose cone electronics bay with upper body tube, using shear pins to secure the section in a proper orientation ● Angle the tubes in an upward direction away from everyone, so it can eject safely and without interference ● Activate the Raven4 using a screw switch, then plug cable into laptop ● Run flight simulation, **BACK AWAY 10ft,** and wait for ejection	excessive ejection distance (>15 feet) ● Payload ejects from the rocket ● No parachute or line tangling Note: repeat as necessary with adjusted black powder amount		
1.1.11 Tendie Descendie Ejection Testing	● Insert an E-match into the Tendie Descendie, with electrical tape wrapped around the wire to seal the hole ● **Pour Black powder into the delrin charge well of the pin assembly** ● Insert pin assembly into the body with a quick link hooked to the upper pin ● Suspend EBay assembly so	● Pin assembly cleanly ejects from the base without interference ● Pin assembly remains attached to the bulkhead via aircraft cable ● Suspended weight is released Note: repeat as necessary with adjusted black powder amount		

	that the upper bullhead points downward • Suspend a heavy weight (>10lbs) from the Tendie Descendie Quick link • Connect wires longer than 10 ft to the tendie E-match • Run a simulation to eject the pin, standing at least 10 ft away			
1.1.12 Nose Cone Wire Cutter Test	• Ensure matches are secure with 5 minute epoxy • Finish packing black powder and piston assembly • Connect electronic matches to screw terminal • Pass zip tie through hole in the bottom and secure around the main parachute	• Piston piece in wire cutter cleanly cuts through zip tie • Main parachute is free to unfurl		
2 - Main Electronics Bay				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.2.1 Battery Checks	• Check all batteries for nominal charge using a digital multimeter • Charge any batteries that are under the required voltage of 4.0V	Electronics Bay Batteries: Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V Nose Cone Electronics Bay Batteries: Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V		
1.2.2 Batteries and	• Connect Raven4 battery to	• Batteries are visually in their		

Power	Raven4 ● Connect EasyMini Battery to EasyMini ● Connect featherweight GPS battery to Featherweight GPs ● **Deactivate all switches and disconnect all batteries after verification**	correct locations ● Raven4 Can be activated by screw switch ● EasyMini can be activated by screw switch ● Featherweight GPS can be activated by screw switch		
1.2.3 Flight Continuity	● Connect all flight computer channels to correct bulkhead connectors ○ Note labels and colors ● Use a digital multimeter to verify continuity ● **Disconnect connectors after verification**	Raven: ● Raven apo to 1b2b, no cross-continuity ● Raven main to 3b4b, no cross continuity EasyMini: ● EasyMini apo to 7b8b, no cross continuity ● EasyMini main to 5b6b, no cross continuity		
1.2.4 Wire Connection Test	● Braid all wires ● Ensure that all connections will not come out during flight	● All wires are observed to be braided ● All connections stay connected after being multiple members independently tug on them), none feel loose		
1.2.5 Set Up Electronic Matches	● Cut 4 E-matches to needed length, strip ends ● Wrap electrical tape around the base of the head for the 2 tendie E-matches ● Place the E-match heads into the tendie, and the 2 untaped heads into the charge wells	● 1b2b to Main Charge well ● 3b4b to Main Tendie Well ● 5b6b to Backup Tendie Well ● 7b8b to Backup Charge Well		

1.2.6 Measure Black Powder Amounts	• Insert all measurements of 4F black powder into individual containers • **Label all containers with their destination and amount** • 2.0 g Charge Well • 2.5 g Backup Charge Well	• Visually inspect the amount of black powder in each container		
1.2.7 Final Battery Check	• Check all batteries for nominal charge using a digital multimeter • Charge any batteries that are under the required voltage of 4.0V	Electronics Bay Batteries: Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V Nose Cone Electronics Bay Batteries: Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V		
1.2.8 Final Assembly	• **Ensure all screw switches are off** • Connect all batteries • Insert upper bulkhead and e-bay assembly into e-bay coupler, making sure the notch lines up correctly • Put on lower e-bay bulkhead, and secure it with two ¼ - 20 jam nuts • Connect all stripped ends of e-matches to the screw terminal. Tighten the screws in the terminal so the e-matches cannot be pulled out	• Battery connections pass tug test (by 2+ people independently) • Electronics bay does not rattle when moved • All electronics are off		
1.2.9 Current Testing	• Using a multimeter, check the potential current through the	• All current readings are less than 100 mA		

	screw terminals • **Current is less than 100 mA**			
1.2.10 Pack Tendie Descendie	• Pour 0.1 g of black powder into delrin well in pin assembly • Turn electronics bay on its side so that pin assembly can be pushed up into body • Push pin assembly into body, hooking the kevlar loop, until the plate is flush with the body • Repeat 2x for both tendie charge wells	• Proper matches are properly installed • Pin restrains the kevlar loop • Aircraft cable passes the tug test		
1.2.9 Pack Ejection Charge Wells	• Pour black powder into correct charge wells • Fill in remaining volume with dog barf, pack tightly • Cover in blue tape making an “X”, and a final piece around the cylinder	• All main e-bay black powder vials are empty • All e-matches are inside charge wells, heads covered by black powder • Top of charge well feels solid when pushed on • Tape is firmly in place • Wires cannot be caught on other recovery hardware		
3 - Nose Electronics Bay				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.3.1 Epoxy Electronic Matches or Wire Cutters	• Ensure the E-match wires are long enough so that there is plenty of slack during flight • Epoxy matches to the cap of the wire cutter using 5 minute epoxy, following manufacturer's instructions	• Check the length of the E-match wire by holding them at the proper height inside the bulkhead and observing that they are longer than the nose cone • Epoxy is cured		

	exactly • Allow epoxy to cure until hard, approximately 30 minutes	Note: Do night before so epoxy cures fully		
1.3.2 Assemble Wire Cutters	• Assemble the wire cutters precisely following manufacturer's instructors	• Zip tie can fit through hole • Wire cutter is properly lubricated		
1.3.3 Parachute Quality	• Check parachute for size and damage, notably burn holes	• Parachute is: 28 in, flat • Shroud lines are untangled and secured • Parachute can easily inflate in the wind		
1.3.4 Parachute Folding and Wire Cutter Attachment	• Lay the parachute flat on the ground with the lines extended • Fold the sides of the parachute into triangular slices • Fold the slice in half across the height • Feed shock cord through hole in fire blanket • Snake the lines back and forth across the parachute until all lines are folded • Wrap the fire blanket "burrito style" • Thread the zip tie through the cutting holes of wire cutters and loop around the parachute bundle	• Parachute is folded correctly • All line is folded on top of parachute • Zip tie is tightened as much as possible • Loops of slack are loosely zip tied to shock cord		
1.3.5 Battery Checks	• Check all batteries for nominal charge using a digital multimeter • Charge any batteries that are	Electronics Bay Batteries: Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V		

	under the required voltage of 4.0V	Nose Cone Electronics Bay Batteries: Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V		
1.3.6 Batteries and Power	• Connect Raven4 battery to Raven4 • Connect EasyMini Battery to EasyMini • Connect featherweight GPS battery to Featherweight GPs • **Deactivate all switches and disconnect all batteries after verification**	• Raven4 Can be activated by screw switch • EasyMini can be activated by screw switch • Featherweight GPS can be activated by screw switch		
1.3.7 Flight Continuity	• Connect all flight computer channels to correct bulkhead connectors ○ Note labels and colors • Use a digital multimeter to verify continuity • **Disconnect connectors after verification**	Raven • 1a2a to apo, no cross continuity • 3a4a to main, no cross continuity EasyMini • 5a6a to main, no cross continuity • 7a8a to apo, no cross continuity		
1.3.8 Wire Connection Test	• Braid all wires • Ensure that all connections will not come out during flight	• All wires are observed to be braided • All connections stay connected after being multiple members independently tug on them), none feel loose		
1.3.9 Measure Black Powder Amounts	• Insert all measurements of 4F black powder into individual	• Visually inspect the amount of black powder in each		

	containers • **Label all containers with their destination and amount** • 3.0 g Main Charge • 3.5 Backup Charge	container		
1.3.10 Assemble Floating Charges	• Cut 1.5” to 2” of the finger of a nitrile glove • Pour in black powder • Insert electronic match into glove, ensuring black powder fully covers the match head • Twist the nitrile glove, sealing the charge • Starting from the twisted end, wrap electrical tape tightly	• Glove is visibly sealed • Glove does not have air in it, but is also able to deform • Electrical tape is tightly wrapped, and does not move when handled		
1.3.11 Final Battery Checks	• Check all batteries for nominal charge using a digital multimeter • Charge any batteries that are under the required voltage of 4.0V	Electronics Bay Batteries: Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V Nose Cone Electronics Bay Batteries: Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V		
1.3.12 Nose Cone Bulkhead Final Assembly	• **Ensure all screw switches are off** • Connect all batteries	• Raven4 can be activated by screw switch • EasyMini can be activated by screw switch • Featherweight GPS can be activated by screw switch		
1.3.13 Attach	• Connect the recovery line to	• No lines are tangled		

Recovery Line to Bulkhead	the eyenut with a quicklink	• Quick link is secured • Parachute is attached with a swivel link • **Connections are accurate to Event Horizon Nose Cone Line Layout**		
1.3.14 Connect Electronic Matches to Screw Terminals	• Connect all stripped ends of E-matches to the screw terminal. Tighten the screws in the terminal so the E-matches cannot be pulled out	• 1a2a to Apo Charge • 3a4a to Main Piranha • 5a6a to Backup Piranha • 7a8a to Backup Charge		
1.3.15 Nose Cone Bulkhead Install	• Apply loctite to the top ½" of the nose cone suspension rod • Insert bulkhead, E-match, and recovery assembly into nose cone, make sure the notches lineup • Screw on nose cone tip • Allow blue loctite to cure, approximately 20 minutes • Insert E-match wire and parachute into remaining space in nose cone	• Nose cone bulkhead does not rotate or move vertically • 20 minutes have passed since loctite was applied		
4 - Lower Body				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.4.1 Assemble Motor	• Follow all manufacturer's instructions precisely	• Motor is securely assembled		
1.4.2 Inspect Motor	• Inspect grains for crystallization	• Nozzle is clear • No significant distortion within		

		the grains		
1.4.3 Assemble Lower Body Tube & Fin Can	• Use six #10-24 - ⅜” bolts to secure fin can to motor tube, using clocking marks on fin can and motor tube • Put 15-15 rail button on #10-24 - ¾” countersink bolt • Screw in rail button & bolt assembly through lower body tube clocked hole and clocked bulkhead hole • Use five #10-24 - ⅜” bolts to secure lower body tube to motor tube on five remaining radial holes • Ensure proper clock	• Fin can and lower body tube are firmly attached to motor tube • Rail button is attached to bolt on clocking line • Clocking marks line up • Check tightness of bolts with hex key		
1.4.4 Electronics Bay Install	• Put 15-15 rail button on #10-24 - ¾” countersink bolt • Screw in rail button & bolt assembly through lower body tube clocked hole and clocked bulkhead hole • Use three #10-24 - ⅜” bolts to secure the electronics bay to the lower body on three remaining radial holes • Ensure proper clock	• Check tightness of bolts with hex key • Clocking marks line up		
1.4.5 Install Motor	• Slide spacer tube onto motor casing • Screw motor onto threaded rod	• Motor cannot move freely • Spacer motion is constrained		

5 - Main Recovery				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.5.1 Main Parachute Quality	• Check main and drogue parachutes for size and damage, notably burn holes	• Parachute is an 70 in toroidal • Drogue is a 22 in toroidal • Shroud lines are untangled and have a stable connection • Parachute inflates easily when pulled in the wind		
1.5.2 Main Parachute Folding	• Lay the parachute flat on the ground with the lines extended • Fold the sides of the parachute in the form of a rectangle • Fold the rectangle in half • Snake all parachute lines back and forth across the rectangle until all lines are folded	• Lines are not tangled • Parachute is connected via swivel link • Quick links are secured • Parachute appears neatly packed		
1.5.3 Shock Cord Folding	• Coil the shock cord and wrap with blue tape to prevent unraveling	• All shock cord is neatly packed		
1.5.4 Main Shock Cord Installation	• Insert the parachute and then shock cord into deployment bag	• No lines are tangled • **Connections are accurate to Event Horizon Main Recovery Diagram**		
1.5.5 Main Parachute Install	• Coil remaining shock cord and wrap it with blue tape • Insert main recovery bundle into upper body tube	• All excess line is securely between the main deployment bag and the E-bay u-bolt • **Connections accurate to**		

		Event Horizon Main Recovery Diagram		
1.5.6 Upper Body Tube Install	• Attach recovery quick link to u-bolt • Connect drogue line to quick links on tendie pins	• No recovery line is sticking out • **Connections accurate to Event Horizon Main Recovery Diagram**		
1.5.7 EBay Connection	• Wrap the kevlar loop around the D bag, running it back through both D links	• Note: Tendie must be packed for this step • **Connections accurate to Eclipse Main Recovery Diagram**		
6 - Upper Body				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.6.1 Secure Upper Body	• Use four #2-56 - ¼” shear pins to secure upper body tube to electronics bay	• Clocking marks correctly line up		
1.6.2 Install Payload	• Install payload into payload ring	• Payload sits flat and within the corners		
1.6.3 Install Nose Cone	• Slide nose cone onto upper body tube, keeping recovery hardware above the payload • Install 4 #2-56 - ¼” nylon shear pins • Ensure nose cone is properly clocked	• Nose cone sits flush on the upper body tube • Camera holes lines up with payload • Shear pins are secured		

2 - Launch Pad Checklist

Things to Bring: 2x Screwdriver, Motor Igniter and Cap, Ladder, Towel for between rail and rocket, safety glasses, Radio at Base

1- Mount Rocket To Rail				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
2.1.1 Install Rocket on Rail	• Slide rocket onto rail • Tilt Launch rail 4 degrees into the wind	• Rocket slides without interference		
2- Flight Computer and GPS Activation				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
2.2.1 Activate Nose Electronics Bay Raven4	• **Before ascending ladder to reach nose cone electronics, ensure people are holding the ladder** • Screw in Raven4 screw switch	• Listen for Raven4 to start beeping		
2.2.2 Check Beep Codes for Continuity	• Listen for Raven4 Beep codes • Count beeps and note high and low tones	• High Beep means Raven4 is on • 4 High beeps for battery voltage • 3 high beeps followed by 1 low for channel connection		
2.2.3 Activate Nose Electronics Bay Easy Mini	• Screw in EasyMini screw switch	• Listen for EasyMini to start beeping		
2.2.4 Check Beep Codes for Continuity	• Listen for EasyMini beep codes	• First set of beeps should have 4, indicating enough		

	• Count beeps	voltage • Second set of beeps should have 3 to indicate main and apo are active		
2.2.5 Activate Nose Electronics Bay GPS	• Screw in GPS screw switch	• Ensure GPS is communicating with the ground station		
2.2.6 Activate Main Electronics Bay Raven4	• Screw in Raven4 Screw switch	• Listen for Raven4 to start beeping		
2.2.7 Check Beep Codes for Continuity	• Listen for Raven4 Beep codes • Count beeps and note high and low tones	• High Beep means Raven4 is on • 4 High beeps for battery voltage • 3 high beeps followed by 1 low for channel connection		
2.2.8 Activate Main Electronics Bay EasyMini	• Screw in EasyMini screw switch	• Listen for EasyMini to start beeping		
2.2.9 Check Beep Codes for Continuity	• Listen for EasyMini beep codes • Count beeps	• First set of beeps should have 4, indicating enough voltage • Second set of beeps should have 3 to indicate main and apo are active		
2.2.10 Activate Main Electronics Bay GPS	• Screw in GPS screw switch	• Ensure GPS is communicating with the ground station		

3 - Motor Igniter Installation				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
2.3.1 Insert Igniter	• Strip leads of igniter • Insert igniter into motor	• Igniter is as far into the rocket as possible • Igniter ends are visible from rocket bottom		
2.3.2 Check Alligator Clips	• Touch alligator clips together	• No spark		
2.3.3 Connect Alligator Clips	• Connect alligator clips to igniter leads	• Ensure clips are freely attached to the leads		
4 - Final Steps				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
2.4.1 Check Igniter Continuity	• Perform continuity check on launch controller	• Launch controller visual confirmation		
2.4.2 Launch	• Ignite motor using igniter	• Motor ignites • Rocket leaves the rail		

3 - Recovery Checklist

1- Extraction				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
3.1.1 Locate rocket	• Locate all portions of rocket	• Do not disturb, but take pictures of everything		
3.1.2 Document Landing	• Photograph and document the state of the rocket on the ground	• Pictures uploaded to the drive		
3.1.3 Determine Success of Parachutes	• Inspect parachutes to ensure they all deployed correctly and fully	• Note all parachute successes and failures • Note why failed parachutes failed		
2 - Shutdown				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
3.2.1 Ensure area is safe	• Ensure there are no dangers posed by rockets, the environment, or wildlife • Tilt tubes to ensure no small wildlife has entered the vehicle	• Visual observation of surroundings • Tilt tubes carefully to dislodge any possible wildlife		
3.2.1 Shut Down All Electronics	• Turn off all electronics, using either a screwdriver	• No beeping is heard • GPS is no longer transmitting to ground station		

3.2.2 Verify Successful Deployment of All Black Powder Charges	• Inspect each black powder charge to see if it has fired • **Observe the deployment from the side, do not stand in front before ensuring the black powder is fully spent**	• No black powder remaining in charge wells, tape is displaced and dog barf is burned		
3.2.3 Return Rocket to Staging Area	• Pick up the rocket, gather recovery, and take it all back to the staging area	• All components are accounted for at the staging area		
3 - Post Launch Disassembly, Data Collection, And Cleaning				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
3.3.1 Separate Rocket Sections	• Unscrew bolts holding sections together • Slide tubes apart	• Each subsection is a separate piece		
3.3.2 Open E-Bay Sections	• Remove jam nuts from the lower ebay bulkhead and remove it • Slide out ebay sled • Unscrew Nose cone tip and remove the bulkhead	• Lower bulkhead and switchband-coupler subassembly are now separate • Nose cone and nose cone bulkhead subassemblies are now separate		
3.3.3 Collect Flight Computer Data	• Connect Raven4 to computer with micro-B USB cable to download flight data • Connect EasyMini to computer with micro-B USB cable to download flight data	• Data is in appropriate folders in the google drive		
3.3.4 Remove Motor	• Unscrew motor casing from	• Lower body and motor		

	threaded rod • Remove motor and motor lining from casing	casing are empty		
3.3.5 Inspect Motor Casing	• Inspect motor remnants and casing	• Ensure motor burn was normal • Ensure casing structure is not compromised		
3.3.6 Clean Motor Casing	• Clean all reusable parts of the casing with white vinegar and shop towels	• Minimal residue remains in reusable components		
3.3.7 Remove Remaining shear Pins	• Unscrew remaining shear pin heads from body tubes • Push remaining threads out of coupler tubes	• All shear pin holes are clear		
3.3.8 Visually Inspect Rocket	• Inspect all tubes, bulkheads, bolts, and rail buttons for damage	• All tubes are structurally sound, no holes or deformation • All bulkheads are structurally sound, no holes, deformation, or epoxy shear • Bolts and rail buttons are undamaged		
3.3.9 Clean off Black Powder Residue	• Clean the inside of tubes, bulkheads, and recovery hardware • Clean Piranhas according to their instructions	• Minimal black powder reside should remain on tubes, bulkheads, or recovery hardware		
3.3.10 Reassemble Rocket for Transport	• Recovery is neatly, but not officially packed	• Rocket is able to neatly fit into vehicles for transport		

	• Subassemblies are loosely put back together			

1 - Disarming Checklist

1- Removal and Preparation				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.1.1 Shutdown	• Use a screwdriver to turn off the nose electronics • Use a screwdriver to turn off the payload and main electronics bay electronics	• No beeping from flight computers • Confirmation of loss of gps packet transfer by base camp		
1.1.2 Igniter removal	• When instructed, remove igniter from motor and replace cap	• Igniter is separate from the rocket		
1.1.3 Removal from rail	• When instructed, move the launch rail to horizontal • Slide the rocket off the launch rail, using a towel between the airframe and rail	• The rocket is separate from the rail		
1.1.4	• Return the rocket and the igniter to the base station	• Return to base		
2- Disassembly				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.2.1 Nose Cone Removal	• Using a 4mm flathead screwdriver, remove the four 2-56 shear pins attaching the nose cone	• Nose cone and payload are separate from the airframe • Payload subteam has payload back		

	• Separate the nose cone and the payload from the airframe			
1.2.2 nose e-Bay Extraction	• Remove the nose e-bay from the nose cone by unscrewing the nose cone tip • Ensure nose e-bay threaded rod doesn't thread out of e-bay	• nose electronics bay is separate from airframe		
1.2.3 nose energetic Separation	• Unscrew the e-matches holding the piranhas and floating charge to the screw terminal • Undo the quick link attaching the nose cone recovery to the eye nut • Set aside the piranhas and floating charges in a safe and labeled area • Shunt the ends of the e-matches	• Piranhas and floating charges are separate from the electronics bay • Energetics are stored in a safe place		
1.2.4 nose electronic Deactivation	• Detach all batteries from their respective electronic components • Remove batteries from mounts	• Batteries are detached and removed from the electronics bay		
1.2.5 Main E-Bay Removal	• Using a 4 mm flathead screwdriver, remove the four 2-56 shear pins attaching the upper body tube • Unscrew the quick links from the u-bolt • Unscrew the bolts attaching	• Main e-bay is separate from the rest of the airframe		

	the electronics bay to the lower body			
1.2.6 Main E-Bay Extraction	• Use wrenches to remove jam nuts on the lower electronics bay bulkhead • Remove the lower bulkhead and coupler	• Main e-bay is removed from coupler		
1.2.7 Main E-Bay Energetic Separation	• Unscrew the e-matches connecting the charge wells and tendie from the screw terminal • Shunt the ends of the e-matches	• All e-matches are visibly shunted		
1.2.8 Main E-Bay Electronics Deactivation	• Detach all batteries from their respective electronic components • Remove batteries from mounts	• Batteries are detached and removed from the electronics bay		

2 - Re-arming Checklist

1- Reassemble Electronics				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
2.1.1 Battery Voltage Check	• Check voltage of all batteries using multimeter	Raven4 Battery Voltage >4.0V EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V nose electronics Bay Batteries: Raven4 Battery Voltage >4.0V		

		EasyMini Battery Voltage >4.0V GPS Battery Voltage > 4.0V		
2.1.2 Return All Batteries	• All batteries are in the correct mounts • **All screw switches are off** • Batteries are connected	• Batteries are visually in the correct location • Battery connections pass tug test (pull by 2+ different members of team independently)		
2.1.3 Main E-Bay Assembly	• Insert upper bulkhead and main e-bay assembly into e-bay coupler, making sure the notches line up correctly • Put on lower e-bay bulkhead, and secure it with 2 ¼ - 20 jam nuts at each thread	• Electronics bay does not rattle when moved • All electronics are off		
2.1.4 Main E-Bay Current Test	• Using a multimeter, check the potential current through the screw terminals • **CURRENT MUST BE BELOW 100 mA**	• All currents read less than 100 mA		
2.1.5 Main E-Bay Reattach E-matches	• Untwist the shunted e-matches • Screw in the exposed ends into the screw terminal	• All e-matches are secured in the correct screw terminal		
2.1.6 Nose Current Test	• Using a multimeter, check the potential current through the screw terminals • **CURRENT MUST BE BELOW 100 mA**	• All currents read less than 100 mA		

2.1.7 Nose Reattach E-matches	• Untwist the shunted e-matches • Screw in the exposed ends into the screw terminal	• All e-matches are secured in the correct screw terminal		
2.1.8 Nose E-Bay Assembly	• Slide the nose e-bay into the nose cone frame • Apply loctite to the top of the threaded rod • Twist on nose cone tip until tight • Wait until loctite sets, approximately 20 minutes	• Electronics bay does not rattle when moved • All electronics are off		
2.1.9 Reintegrate Main E-Bay	• Using four #10-24 0.5” long button head bolts, screw the e-bay into the lower body	• Main e-bay is firmly attached, with the clocking marks lining up		
2.1.10 Reintegrate Upper Body Tube	• Wrap the kevlar loop around the deployment bag, running it back through both D links • Use four #2-56 shear pins to secure upper body tube to electronics bay	• Note: Tendie must be packed for this step • Connections accurate to Main Recovery Diagram • Clocking marks correctly line up		
2.1.11 Reintegrate Payload and Nose Cone	• Install payload into payload bulkhead • Payload sits within rails • Slide nose cone onto upper body tube, keeping recovery hardware above the payload • Install four #2-56 shear pins • Ensure nose cone is properly clocked	• Nose cone sits flush on the upper body tube • Camera holes lines up with payload • Shear pins are secured		

1 - Pre-Launch Checklist

1 - Pre Launch Inspection & Testing				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.1.1 Structural Check	• Check frame for debris and cracks • Check fasteners tightness	• Frame is structurally sound • All fasteners are tightened and cannot be loosed by hand		

1.1.2 Battery Checks	• Check for nominal battery voltage	• Electronics Bay
		  ○ GPS (4.2 V)
		  ○ Raven4 (4.2 V)
		  ○ Raven4 (8.4 V)
		  ○ Arduino Nano(8.4 V)
		  ○ Runcam (8.4 V)
		  ○ Servo Motors (8.4 V)		

1.1.3 Shield Checks	• Check shields for debris and cracks • Check shields for cleanliness	• All shields have no cracks and no debris • All shields are transparent and clean		

1.1.4 Flight Computer Programming	• Program Raven4
	• Program Raven4
	• Consult with McKenzie on Arduino Nano programming
		• Raven4 Redundancy:
		  ○ Apo: Output Disabled
		  ○ Main: Flight Time > TVal time, Height Above Pad < AGL1, Pressure Increasing
		  ○ 3rd: Output Disabled
		  ○ 4th: Output Disabled
		  ○ TVal: 35
		  ○ AGL1: 150
		• Arduino Nano programming verified by McKenzie
		• Raven4 connected to Arduino Nano
		  ○ Apo: Output Disabled
		  ○ Main: Flight Time > TVal time, Height Above Pad < AGL1, Pressure Increasing
		  ○ 3rd: Latched, Height Above Pad < AGL1
		  ○ 4th: Latched, Liftoff
		  ○ TVal: 35
		  ○ AGL1: 150		

1.1.5	• Inspect both cubesat	• No components are damaged		

Electronic Sled check	components	• All connectors are securely attached to wires		
2 - Recovery Testing				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.2.1 Recovery Hardware Inspection	• Inspect the parafoil • Inspect all connection lines • Inspect the drogue parachute	• Parafoil has no tears or loose threads and no lines are tangled • Pins have no cracks and nylon goes through holes • No connection lines are frayed or untied • No tears or flaws are found in the drogue		
1.2.2 Parafoil Deployment Test	• Fold and Pack the parafoil • Ensure cutting line is looped through NiCr cutters	• Follow steps in the document to properly pack the parafoil • Inspect and shake the cubesat • Verify that drogue connection to NiCr cutter is restored after test. • Ensure velcro cover removed with drogue release		
1.2.3 Nichrome Cord Cutter Test	• Test Nichrome Cord Cutter 1 activation via Arduino Nano test • Test Nichrome Cord Cutter 2 via Raven Test	• Both nichrome wires glow with full intensity		
3 - Recovery Installation				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.3.1 Drogue Connection	• Connect and verify the drogue parachute • Drogue attached to velcro cover • Drogue release line is properly connected to NiCr cutters and drogue	• Drogue is connected to the top of the parafoil and the connection is secure • When drogue pulled on, it is stopped before extracting parafoil		
1.3.2 Recovery Bulkhead Connection	• Connect the last lines of the parafoil to the hardpoints with a quicklink • Control lines fed through pass through hole	• Quicklink connection is tightened and secure • No obstructions impinging parafoil movement		

1.3.3 Parafoil Packing	• Fold and pack the parafoil by following steps in document • Verify parafoil is secure in top of recovery bay • Velcro cover attached over top of parafoil	• Parafoil is tightly packed according to the document • Inspect and shake the recovery bay to ensure the parafoil pack is secure		
1.3.4 Nichrome Cord Cutter Connection	• Connect the Drogue Parachute release line to the nichrome cord cutter mechanism with a loop of nylon	• Drogue parachute recovery line is secured to the nylon and loop, accurate to recovery packing diagram • Drogue parachute recovery line is long enough so that line to velcro cover is not under tension • Nylon loop is pressed against nichrome wires		
1.3.5 Final Recovery Inspection	• Inspect the recovery set up	• Connections and packing are accurate to Payload Recovery Layout		
4 - Electronics				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.4.1 Electronics sled set up and secure	• Servo control lines connected to Supernova • Runcams have Micro SD cards installed • Screw switches temporarily removed • Power cables run down to bottom • All wires secure	• Visual confirmation of all items • Tug tests on wires when applicable.		
1.4.2 NiCr power set up	• NiCr power lines clear of obstructions	• Visual confirmation of all items • Tug tests on wires when applicable		
1.4.3 Battery sled set up and secure	• All circuit board connections are secure. • All batteries connected to appropriate connections on circuit board • Battery voltages confirmed • Battery covers installed • Antenna installed and line is free	• Visual confirmation of items • Use multimeter to confirm voltages across various points along the circuit boards		
1.4.4		• Visual confirmation of all		

Electronics sled instillation	• Run Raven power JST to appropriate location on battery sled board • Run NiCr 1 to Raven terminals according to wiring diagram • Connect Nicr to Supernova • Connect Arduino Nano & Raven4 battery to Supernova • Connect RunCam battery to Supernova • Connect Featherweight to battery • Connect Runcams to Supernova • Connect Arduino Nano power to Supernova • Connect Arduino Nano RunCams control to Supernova • Connect Arduino Nano control to servo on Supernova • Connect Arduino Nano NiCr fire control to Supernova • Run control lines into bottom of servo drums • Place servo drum cover on drums • Slide sled into frame • Screw sled into place • Screw servo cover into place • Reinstall screws into screw switches	connections by at least two people Pull test on all connections • Verify all seven screws are in place • Varifty no wires snagged in poor locations to prevent the mechanism from moving.		
1.4.5 Electrictronics continuity test	• Confirm Raven is powered and operating • Perform Arduino Nano preflight checks	• Tests conclusive		
5 - Frame Plate Installation				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.6.1 Install 2U Frame	• Install all 4 frame plate • Ensure camera shields are	• All 4 frame plates are properly installed with appropriate fasteners/		

Plates	free of obstructions.	• Screw switches holes are lined up • Clear view to cameras		
1.6.2 Install 1U Frame Plates	• Install all 4 frame plates • Ensure shields in front of cameras are free of obstructions	• All four shields installed with appropriate fasteners • Screw switch hole lined up • Clear view to camera.		
6 - Final Systems Check				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.7.1 Final confirmation of Cubesat prep	• Confirm all Crosswind systems are assembled. • Check 1U Featherweight GPS connection	• No sounds of loose components when cubesat shaken • All three screw switches reachable • GPS communication test positive • The Raven4 powers on and indicates proper continuity		

2 - Launchpad Checklist

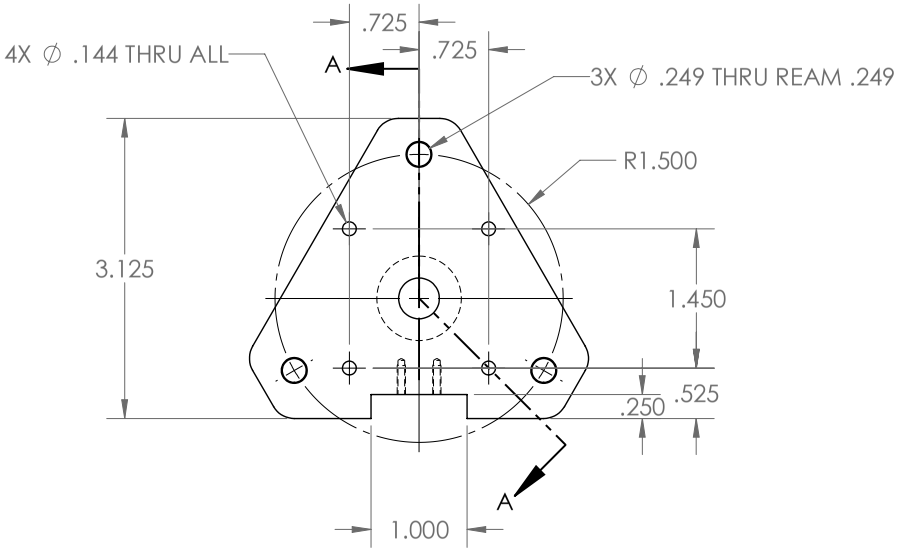
1 - Launchpad Steps				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
1.1.1 Hand off the Payload	• Integrate Payload into Rocket	• Payload is secured in payload retention ring inside Rocket		
1.1.2 Power up systems	• Screw down Raven4 switch • Screw down Arduino Nano switch • Screw down GPS switch	• Arduino Nano communication test positive and Raven4 indicates continuity • The Raven4 powers on and indicates proper continuity • GPS communication active		

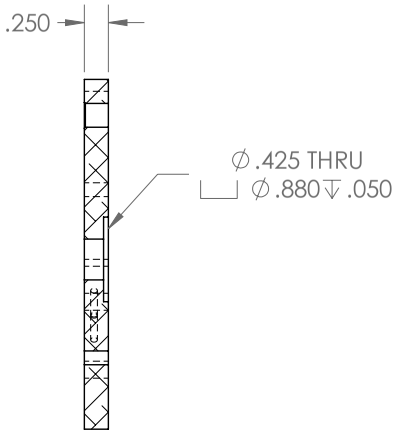
3 - Recovery Checklist

1 - Extraction				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
3.1.1 Locate Payload	• Locate payload and all recovery hardware	• Do not disturb until all components are found and pictures are taken		
3.1.2 Document with Pictures	• Document every component on payload on the ground	• Upload all photos to Google Drive		
3.1.3 Determine Success of Recovery	• Inspect each recovery component to see if it deployed fully and correctly	• Note all successful recovery • Note any failed recovery and how they failed		
2 - Shutdown				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
3.2.1 Electronics Power down	• Unscrew screw switches	• All LEDs should be off, and no beeps should be heard		
3.2.2 Return Payload to staging area	• Gather payload and recovery components and bring to the staging area of the launch site	• All components Singularity should be accounted for		

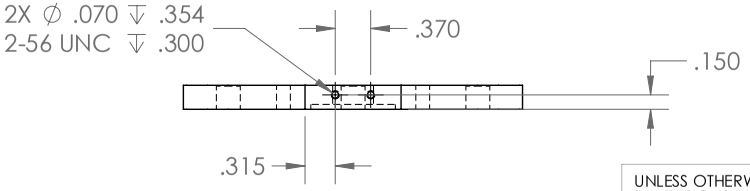
	• Partially fold parafoil into cubesat to prevent deployment from wind			
3 - Post Launch Operations				
Task	**Required Steps**	**Verification Method**	**Team Member**	**Sign Off**
3.3.1 Disassembly	• Remove frame plates and Disconnect all batteries • Disconnect all electronics • Remove upper electronics sled	• All batteries are disconnected and removed. • Flight computer connection ports are accessible • SD cards are removed from RunCams		
3.3.2 Collect Flight Data	• Download data from Raven4 • Download data from GPS • Remove SD cards from Runcams and back up flight footage	• Upload all data files to Google Drive		
3.3.3 Visual Inspection	• Inspect all sections of the Payload	• Frame is structurally sound • No components are damaged • Payload is ready for return transport		

F. Engineering Drawings Appendix





SECTION A-A



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TOLERANCES:
.XX ±.01 .XXX ±.005
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ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

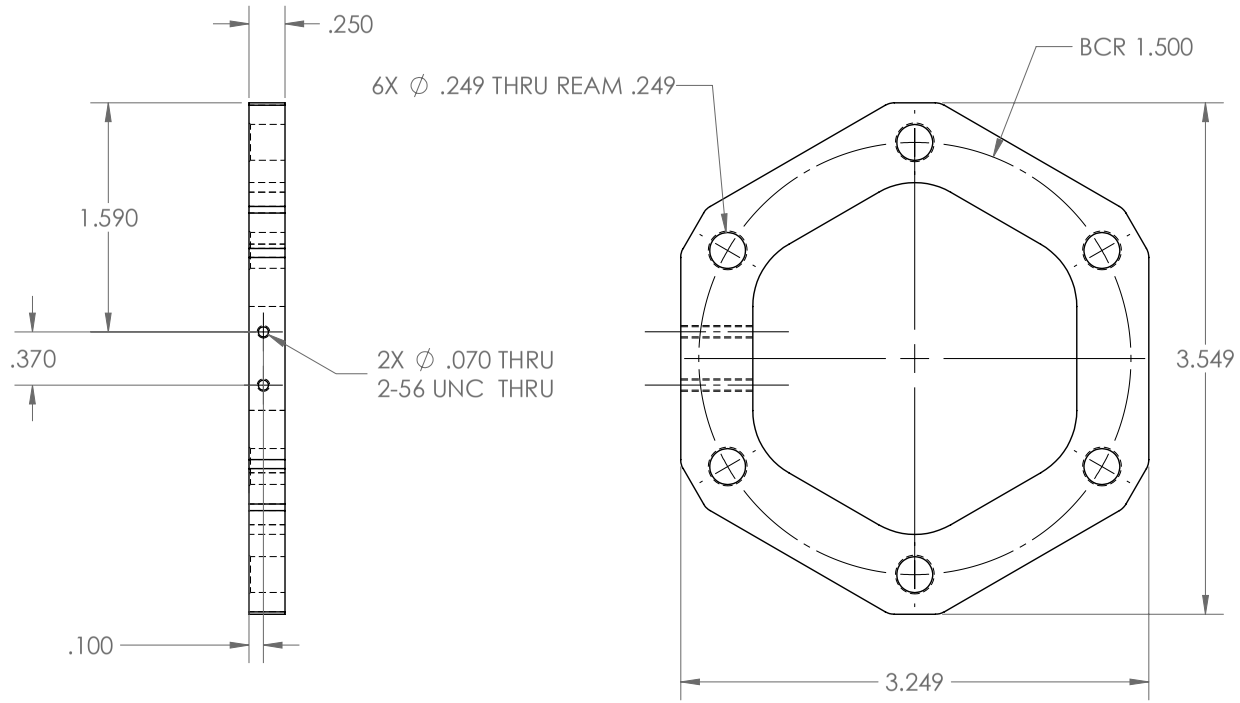
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CASE ROCKET TEAM

Case Western Reserve University

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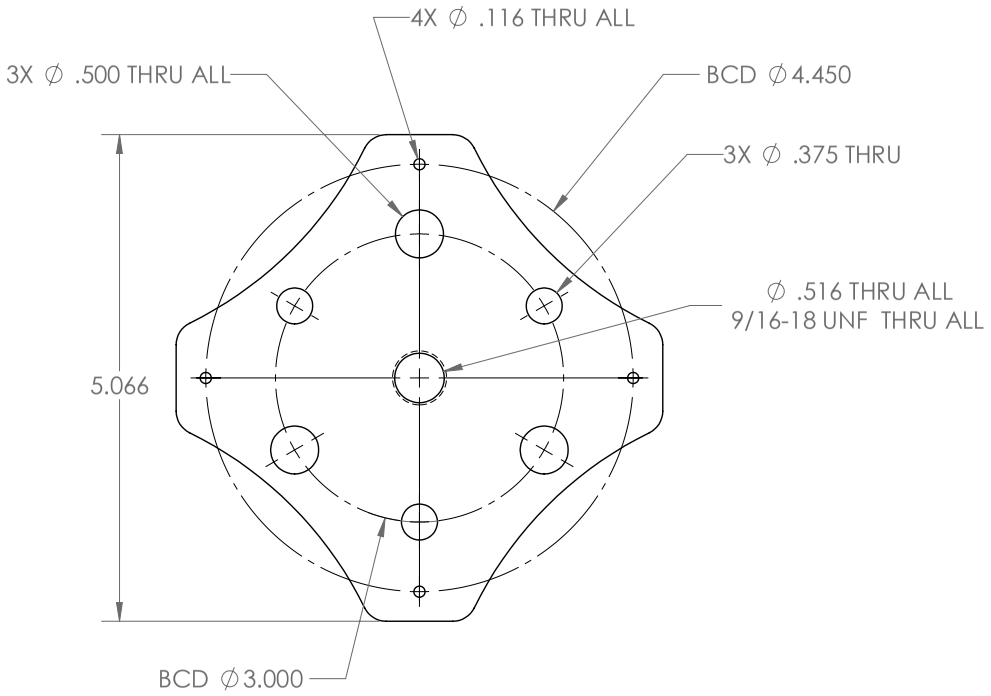
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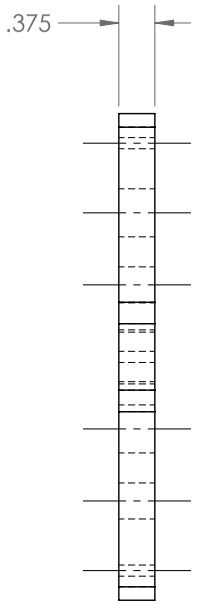
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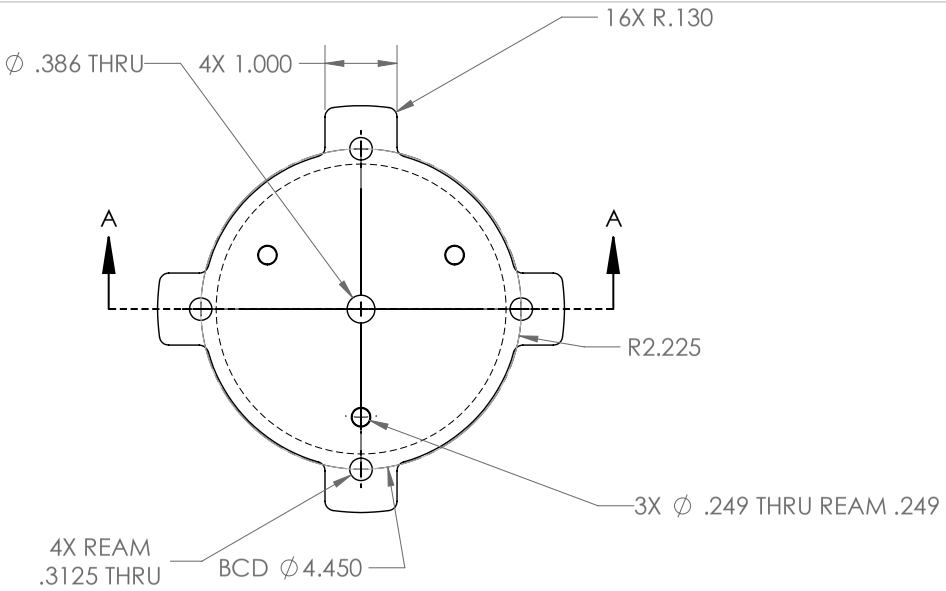
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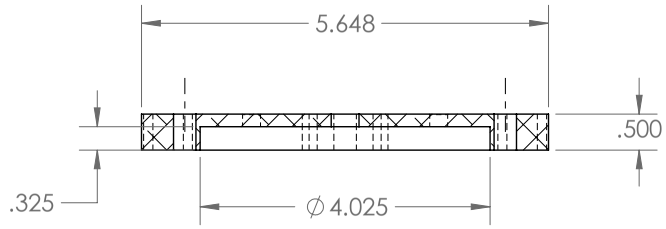
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SECTION A-A

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BREAK ALL EDGES .030

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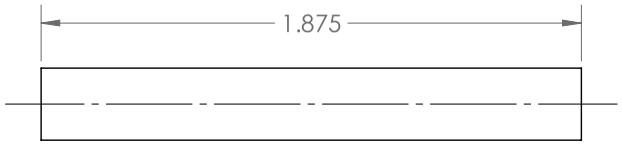
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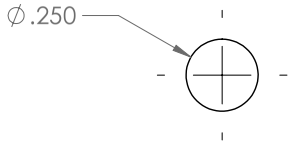
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BREAK ALL EDGES .030

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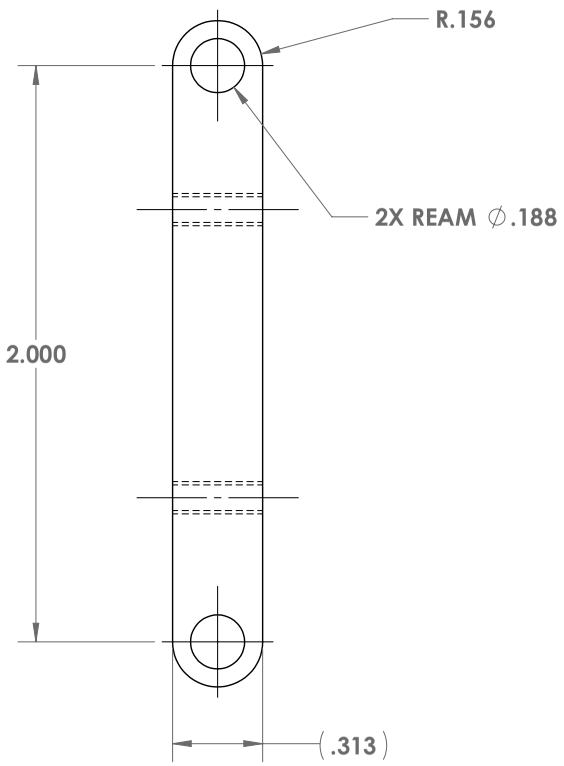
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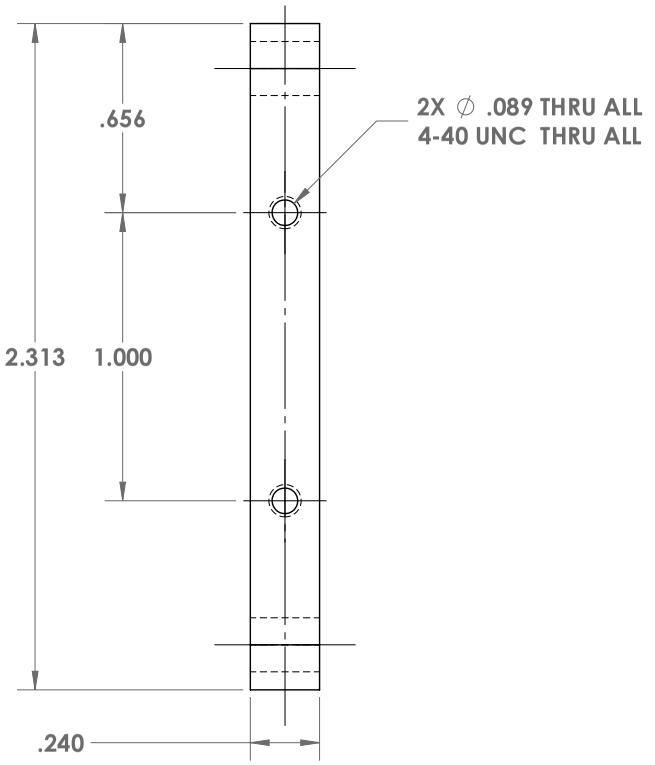
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BREAK ALL EDGES .030

DO NOT SCALE

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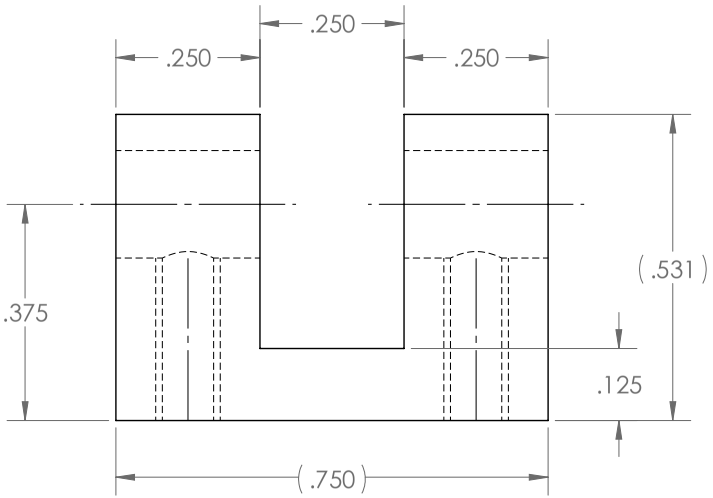
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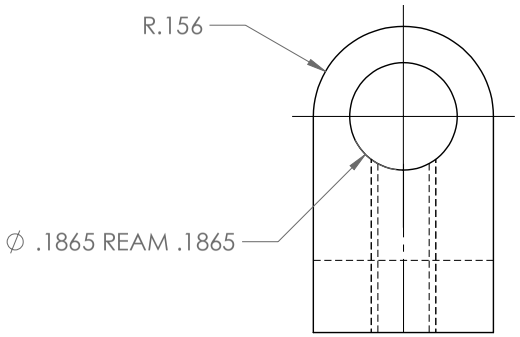
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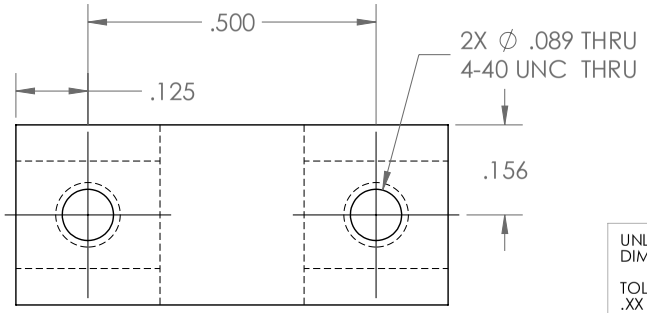
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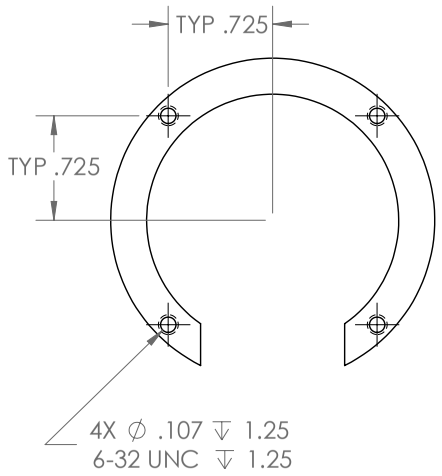
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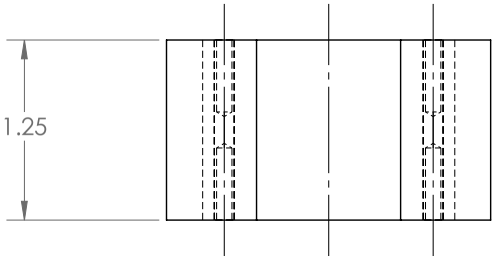
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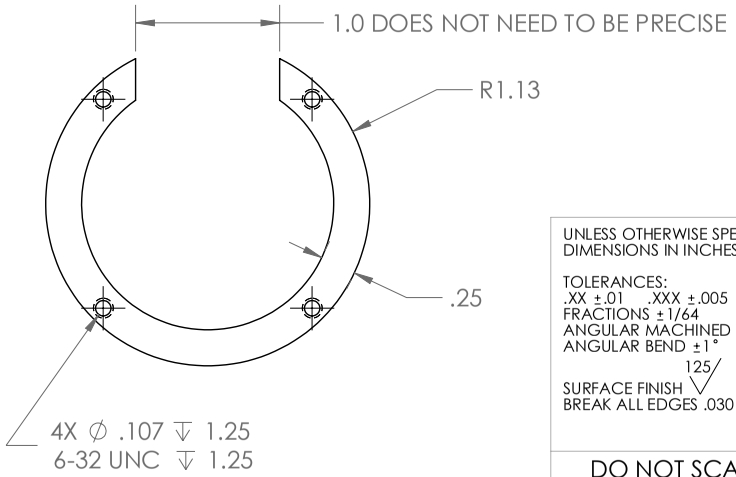
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ANGULAR MACHINED ±.5°
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SHEET 1 OF 1

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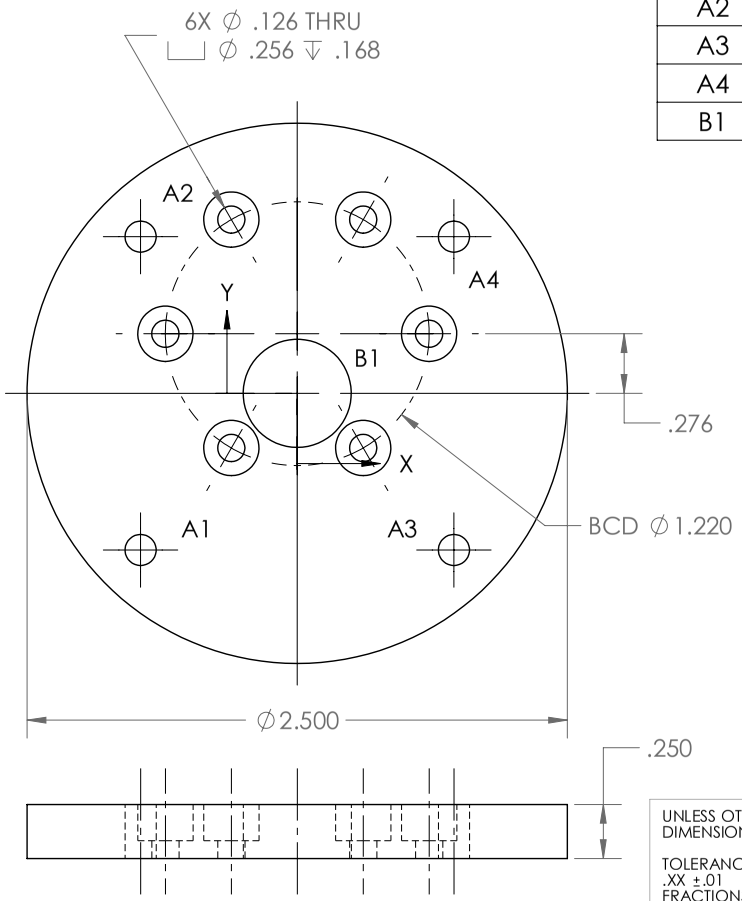
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B1	-.000	-.000	∅ .500 THRU



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DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
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ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

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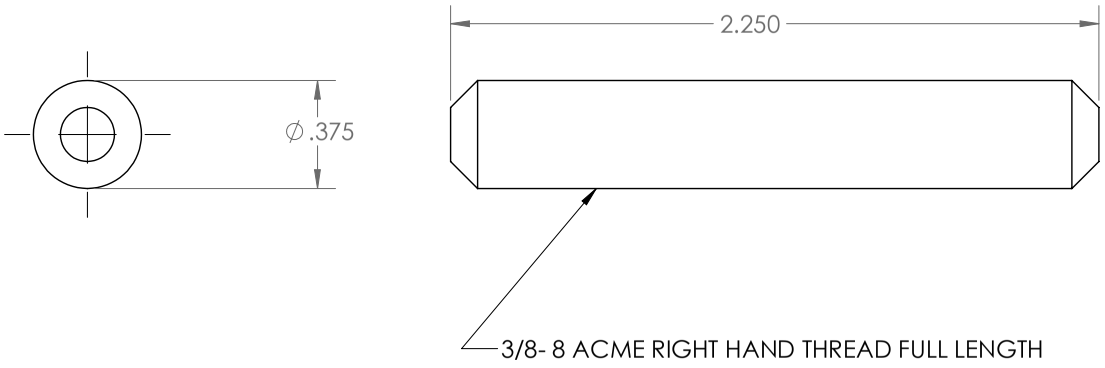
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DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

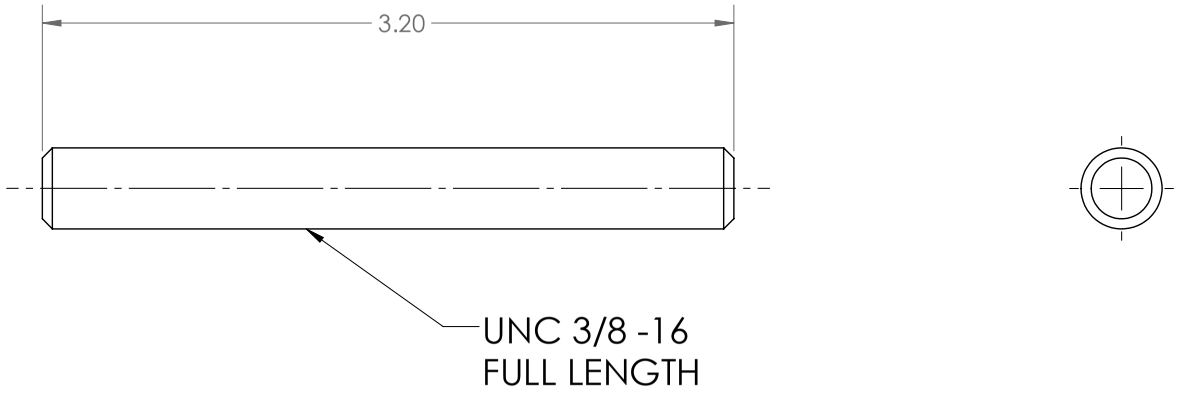
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TITLE:
1018 CARBON STEEL PRECISION ACME LEAD SCREW

SIZE:	DATE:	DRAWN BY:
A	3/18/2024	JMT231

MATERIAL:	PART #:	REV:
1018 CARBON STEEL	24A05012	A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

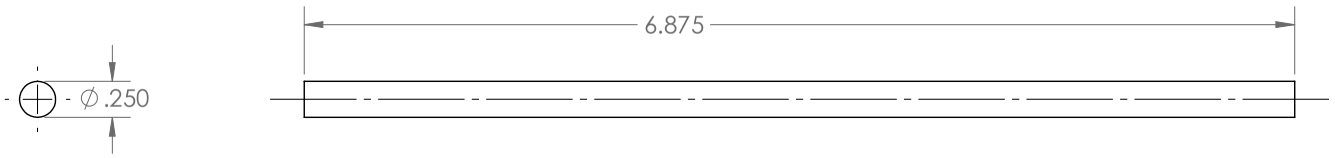
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: MOTOR RETENTION THREAD ROD

SIZE:	DATE:	DRAWN BY:	
A	2/15/2024	MSM268	
MATERIAL:		PART #:	REV:
STEEL		24A10018	B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

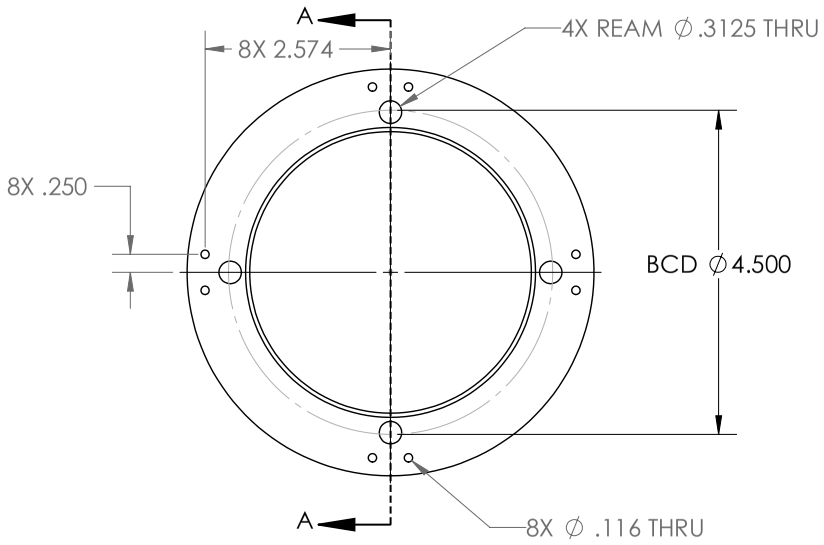
CASE WESTERN RESERVE UNIVERSITY

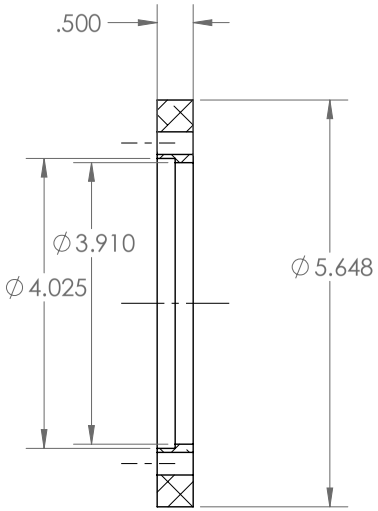
TITLE: STRUCTURAL RAIL

SIZE:	DATE:	DRAWN BY:
A	3/18/2024	JMT231

MATERIAL:	PART #:	REV:
304 STAINLESS STEEL	24A05019	A

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SECTION A-A

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

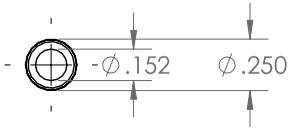
CASE ROCKET TEAM

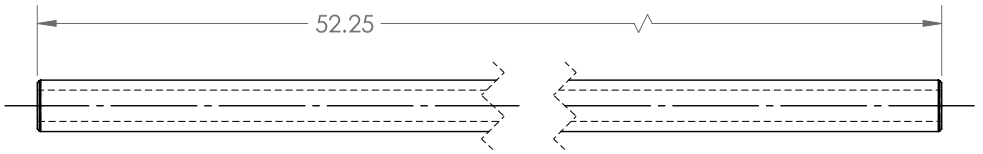
CASE WESTERN RESERVE UNIVERSITY

TITLE: ACTUATION MOUNT BULKHEAD

SIZE:	DATE:	DRAWN BY:	
A	2/12/2024	GXM331	
MATERIAL:		PART #:	REV:
6061-T6		24A05022	C

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

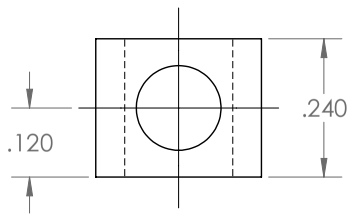
CASE ROCKET TEAM

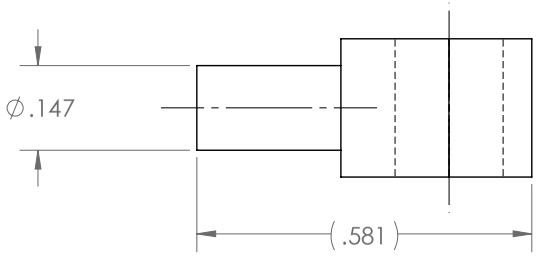
CASE WESTERN RESERVE UNIVERSITY

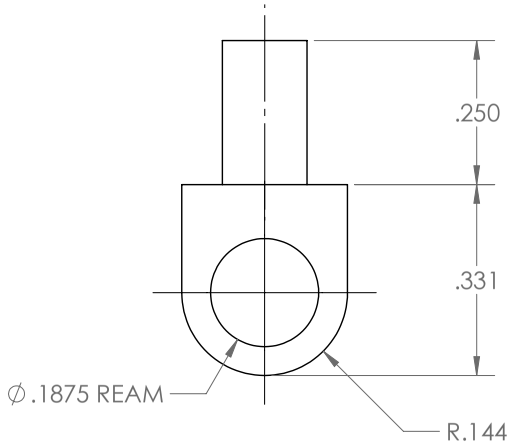
TITLE: ACTUATION TUBE

SIZE:	DATE:	DRAWN BY:	
A	3/18/2024	JMT231	
MATERIAL:		PART #:	REV:
7075 ALUMINUM		24A05023	A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

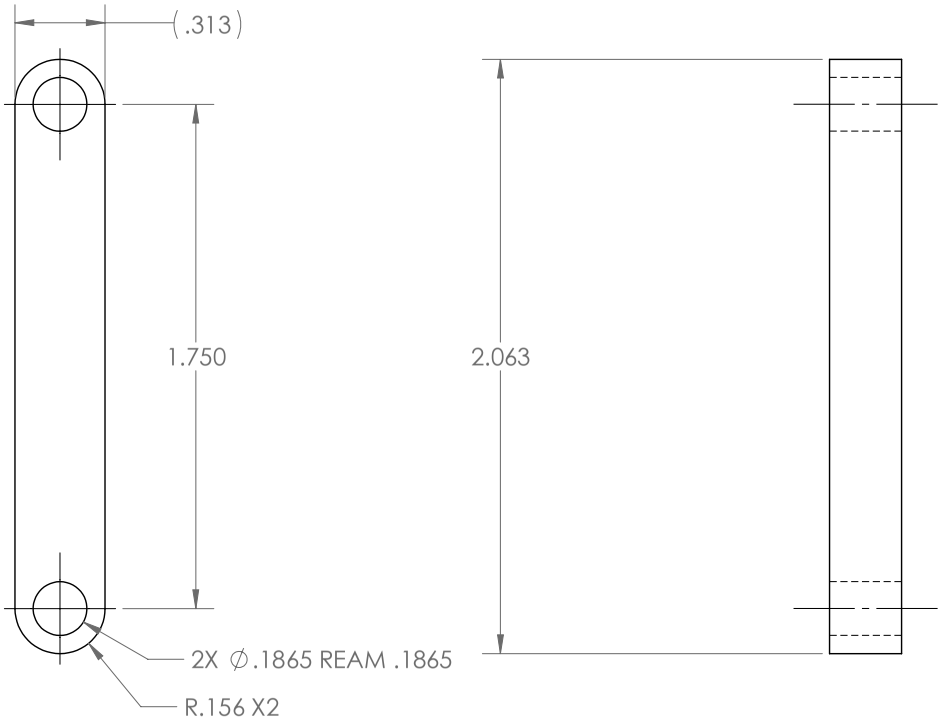
SHEET 1 OF 1

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE:
ACTUATION TUBE LINKAGE CONNECTOR

SIZE:	DATE:	DRAWN BY:	
A	3/19/2024	MSM268	
MATERIAL:		PART #:	REV:
PLAIN CARBON STEEL		24A05024	D

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

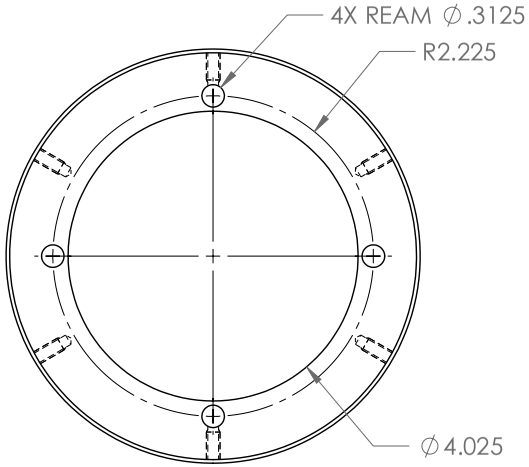
CASE ROCKET TEAM

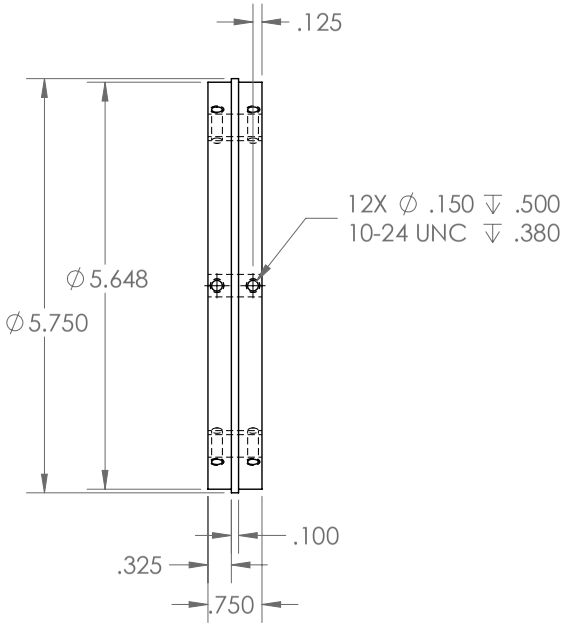
Case Western Reserve University

TITLE: Actuation Linkage

SIZE:	DATE:	DRAWN BY:	
A	1/30/24	JDG151	
MATERIAL:		PART #:	REV:
6061-T6		24A05027	B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

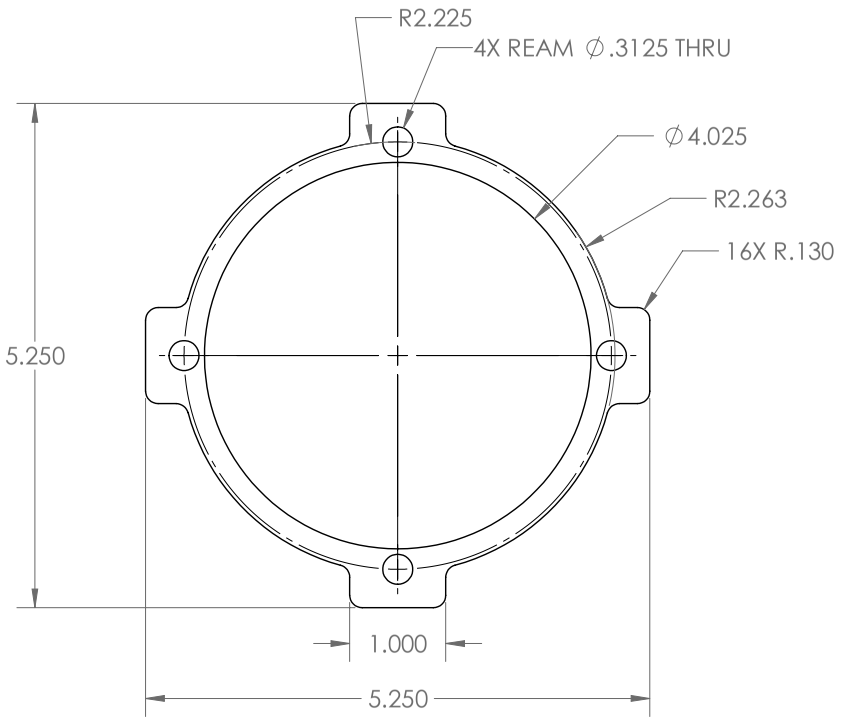
CASE ROCKET TEAM

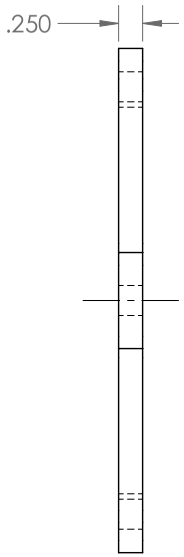
CASE WESTERN RESERVE UNIVERSITY

TITLE:
ACTUATION TUBE STABILIZER BULKHEAD

SIZE:	DATE:	DRAWN BY:	
A	2/12/2024	GXM331	
MATERIAL:		PART #:	REV:
6061-T6		24A05028	D

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

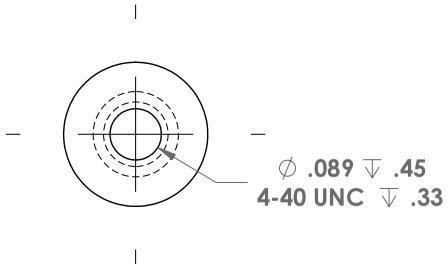
CASE ROCKET TEAM

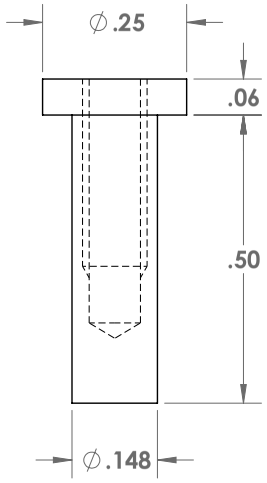
Case Western Reserve University

TITLE: CENTERING RING

SIZE:	DATE:	DRAWN BY:	
A	2/1/2024	GXM331	
MATERIAL:		PART #:	REV:
6061-T6		24A05029	D

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

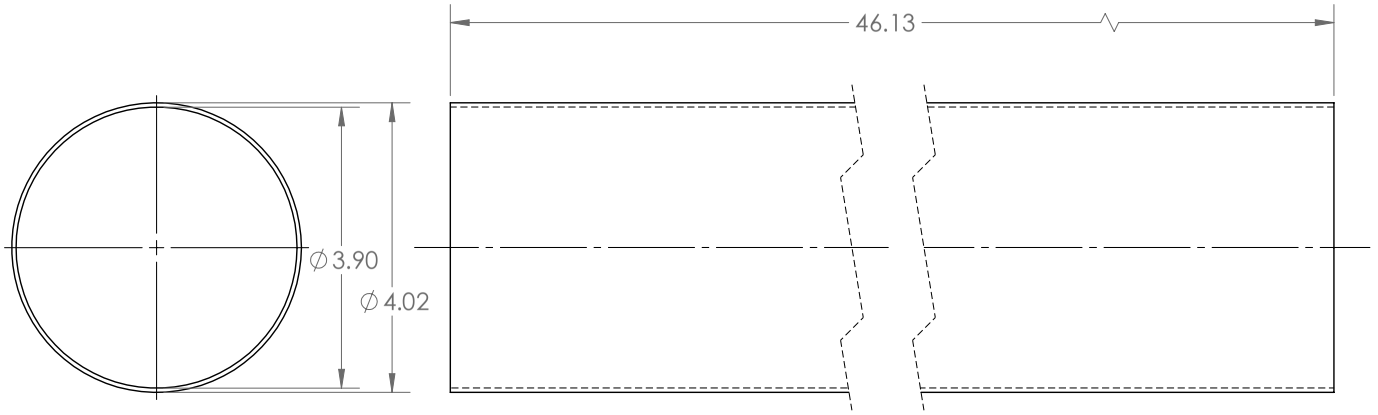
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE:
ACTUATION TUBE SCREW CONNECTOR

SIZE:	DATE:	DRAWN BY:	
A	2/29/2024	GXM331	
MATERIAL:		PART #:	REV:
6061-T6 (SS)		24A05030	B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

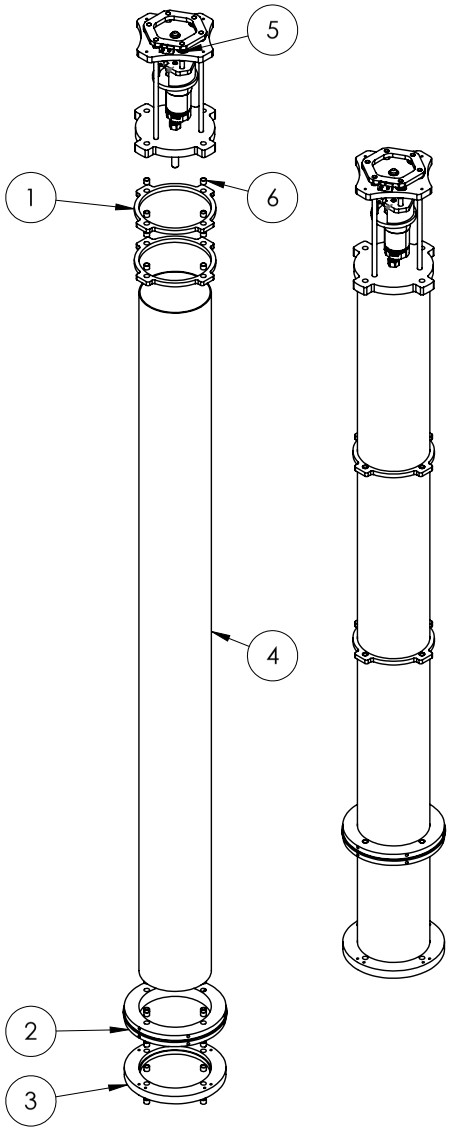
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

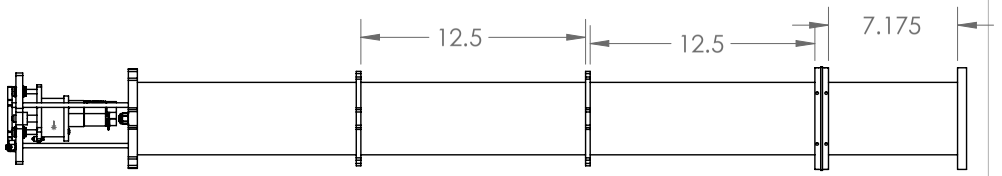
TITLE: MOTOR TUBE

SIZE:	DATE:	DRAWN BY:	
A	5/10/2024	JMT231	
MATERIAL:		PART #:	REV:
G12		24A05026	A

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ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A05029	Centering Ring	2
2	24A05028	Actuation Tube Stabilizer Bulkhead	1
3	24A05022	Actuation Mount Bulkhead	1
4	24A05026	Motor Tube	1
5	24A05032	Upper Mechanism	1
6	24A05025	Oil-Embedded Bronze Sleeve Bearing	20



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

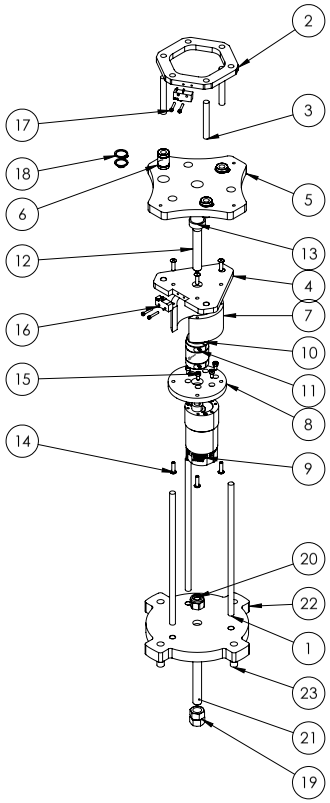
CASE WESTERN RESERVE UNIVERSITY

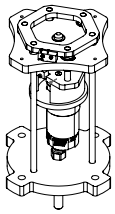
TITLE: SUPERSTRUCTURE

SIZE:	DATE:	DRAWN BY:
A	5/10/2024	GXM331

MATERIAL:	PART #:	REV:
	24A05031	A

SOLIDWORKS Educational Product. For Instructional Use Only.





ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A05019	Structural Rail	3
2	24A05002	Upper Plate	1
3	24A05005	Linear Rail	3
4	24A05001	Main Bulkhead	1
5	24A05003	Moving Plate	1
6	24A05014	Linear Bearing	3
7	24A05010	Motor Mount Tube	1
8	24A05011	Motor Mount Plate	1
9	24A05020	Electric Motor	1
10	24A05015	High-Load Dry-Running Thrust Bearing	1
11	24A05016	Clamping Precision Flexible Shaft Coupling	1
12	24A05012	1018 Carbon Steel Precision Acme Lead Screw	1
13	24A05014	Precision Acme Externally Threaded Nut	1
14	24A98031	6-32 Button Head 1/2" Bolt	8
15	24A98049	M3 6mm Socket Head Cap Screw	6
16	24A05021	Subminiature Snap-Acting Switch	2
17	24A98050	2-56 1/2" Socket Head Screw	4
18	24A05018	External Retaining Ring	6
19	24A98020	18-8 Stainless Steel Hex Nut	2
20	24A98041	Medium-Strength Steel Nylon-Insert Locknut	1
21	24A10018	Motor Retention Thread Rod	1
22	24A05004	Motor Retainer Mount	1
23	24A05025	Oil-Embedded Bronze Sleeve Bearing	4

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

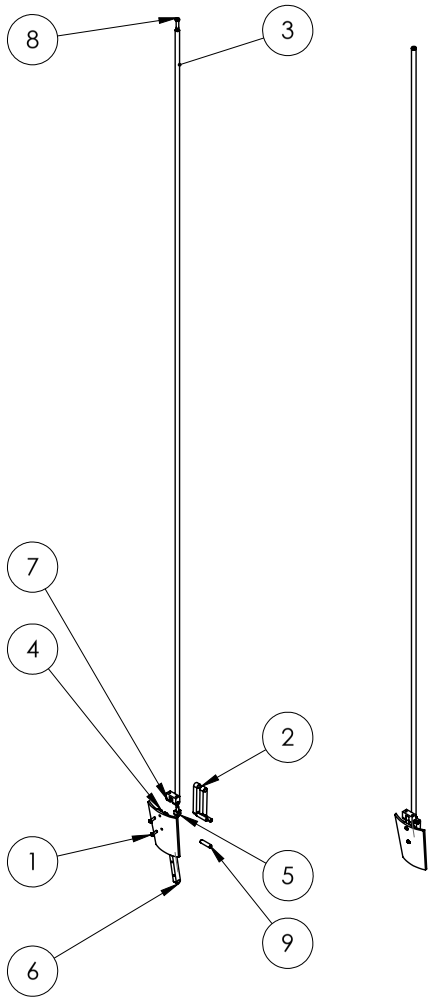
CASE WESTERN RESERVE UNIVERSITY

TITLE: Upper Mechanism

SIZE:	DATE:	DRAWN BY:
B	5/10/2024	GXM331

MATERIAL:	PART #:	REV:
		A

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ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A98028	4-40 Button Head 3/8" Bolt	2
2	24A05027	Actuation Linkage	2
3	24A05023	Actuation Tube	1
4	24A05006	Flap	1
5	24A05024	Actuation Tube Linkage Connector	1
6	24A05007	Flap Linkage	1
7	24A05008	Flap Mount	1
8	24A05030	Actuation Tube Screw Connector	1
9	24A05009	Dowel Pin	3

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

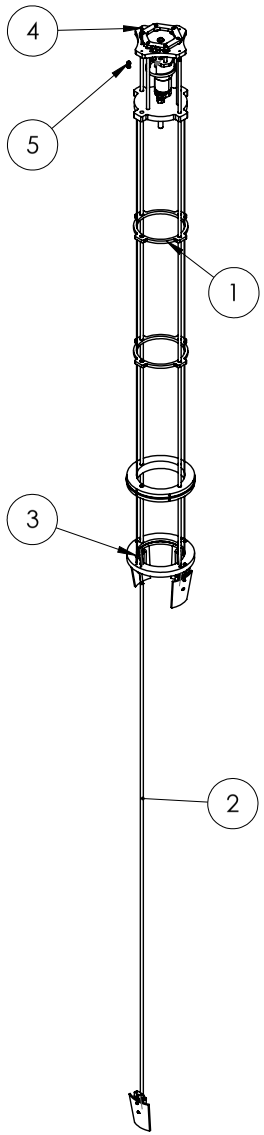
CASE WESTERN RESERVE UNIVERSITY

TITLE: LOWER MECHANISM

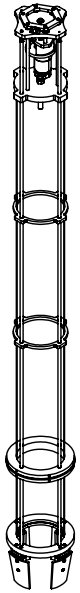
SIZE:	DATE:	DRAWN BY:
A	5/10/2024	GXM331

MATERIAL:	PART #:	REV:
	24A05033	A

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ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A05031	AIRBRAKES SUPERSTRUCTURE	1
2	24A05033	LOWER MECHANISM	4
3	24A98027	4-40 BUTTON HEAD 5/8" BOLT	8
4	24A98066	4-40 SOCKET HEAD 1.5" BOLT	1
5	24A98009	4-40 SS HEX NUT	3



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

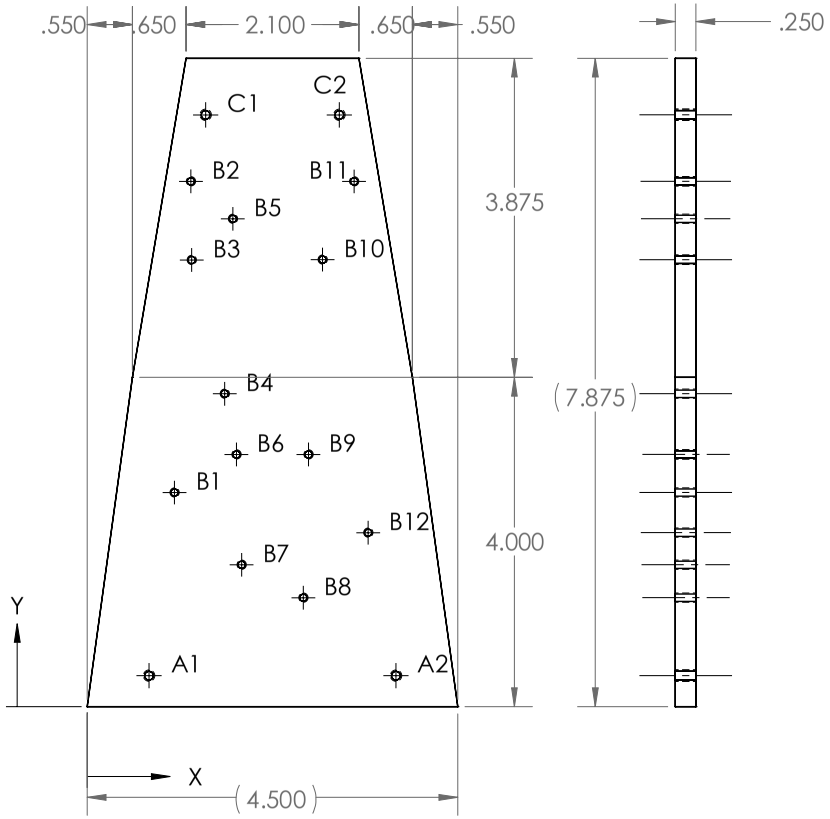
TITLE: AIRBRAKES ASSEMBLY

SIZE:	DATE:	DRAWN BY:
A	2/13/2024	GXM331

MATERIAL:	PART #:	REV:
	24A00005	A

SOLIDWORKS Educational Product. For Instructional Use Only.

TAG	X LOC	Y LOC	SIZE
A1	.750	.375	∅ .107 THRU 6-32 UNC THRU
A2	3.750	.375	∅ .107 THRU 6-32 UNC THRU
B1	1.060	2.600	∅ .089 THRU 4-40 UNC THRU
B2	1.259	6.380	∅ .089 THRU 4-40 UNC THRU
B3	1.269	5.425	∅ .089 THRU 4-40 UNC THRU
B4	1.670	3.800	∅ .089 THRU 4-40 UNC THRU
B5	1.769	5.925	∅ .089 THRU 4-40 UNC THRU
B6	1.813	3.063	∅ .089 THRU 4-40 UNC THRU
B7	1.875	1.723	∅ .089 THRU 4-40 UNC THRU
B8	2.625	1.323	∅ .089 THRU 4-40 UNC THRU
B9	2.688	3.063	∅ .089 THRU 4-40 UNC THRU
B10	2.859	5.430	∅ .089 THRU 4-40 UNC THRU
B11	3.242	6.380	∅ .089 THRU 4-40 UNC THRU
B12	3.413	2.113	∅ .089 THRU 4-40 UNC THRU
C1	1.438	7.188	∅ .107 THRU 6-32 UNC THRU
C2	3.063	7.188	∅ .107 THRU 6-32 UNC THRU



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

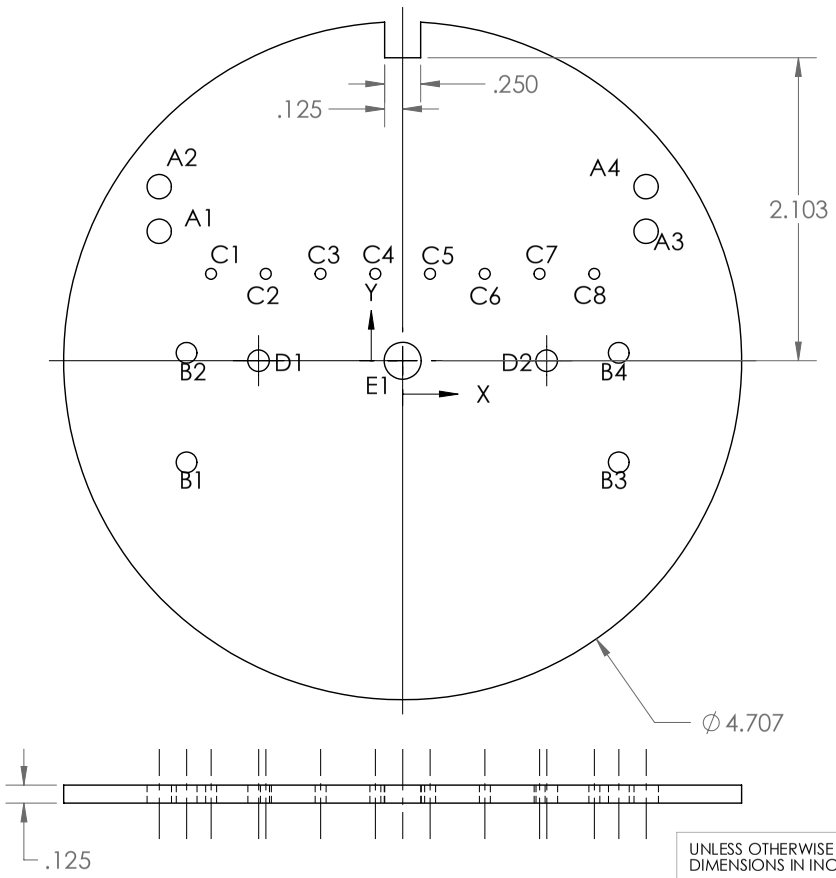
CASE WESTERN RESERVE UNIVERSITY

TITLE: NOSE CONE EBAY SLED

SIZE:	DATE:	DRAWN BY:
A	11/28/2023	KWW33

MATERIAL:	PART #:	REV:
PC HIGH VISCOSITY	24A07003	B

SOLIDWORKS Educational Product. For Instructional Use Only.



TAG	X LOC	Y LOC	SIZE
A1	-1.690	.898	∅ .170 THRU ALL
A2	-1.690	1.208	∅ .170 THRU ALL
A3	1.690	.898	∅ .170 THRU ALL
A4	1.690	1.208	∅ .170 THRU ALL
B1	-1.500	-.705	∅ .144 THRU ALL
B2	-1.500	.055	∅ .144 THRU ALL
B3	1.500	-.705	∅ .144 THRU ALL
B4	1.500	.055	∅ .144 THRU ALL
C1	-1.330	.603	∅ .076 THRU ALL
C2	-.950	.603	∅ .076 THRU ALL
C3	-.570	.603	∅ .076 THRU ALL
C4	-.190	.603	∅ .076 THRU ALL
C5	.190	.603	∅ .076 THRU ALL
C6	.570	.603	∅ .076 THRU ALL
C7	.950	.603	∅ .076 THRU ALL
C8	1.330	.603	∅ .076 THRU ALL
D1	-1.000	.000	∅.150 THRU ALL
D2	1.000	.000	∅.150 THRU ALL
E1	.000	.000	∅ .257 THRU ALL

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

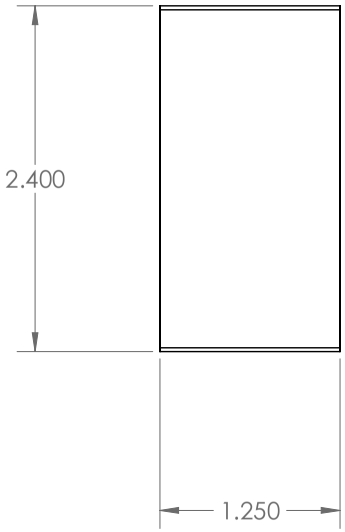
CASE ROCKET TEAM

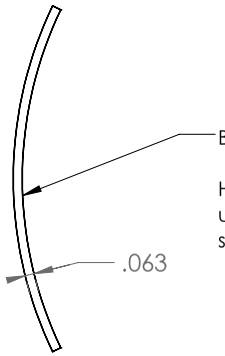
CASE WESTERN RESERVE UNIVERSITY

TITLE:
NOSE CONE BULKHEAD

SIZE:	DATE:	DRAWN BY:	
A	11/2/2023	DXS1075	
MATERIAL:		PART #:	REV:
G10		24A07004	B

SOLIDWORKS Educational Product. For Instructional Use Only.





Bend Instructions:

Heat the acrylic sheet with heat gun on highest setting until pilable. Mold the heated sheet on the piece of coupler section of the nose cone and hold until it hardens.

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

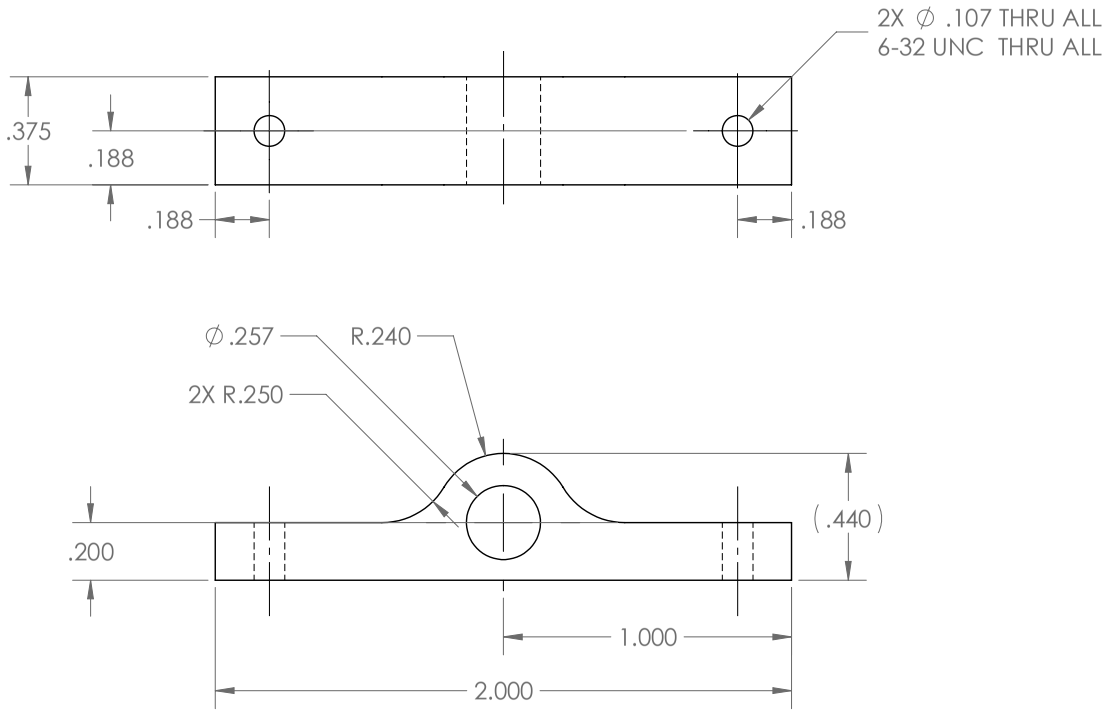
SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: CAMERA SHIELD			
SIZE: A	DATE: 2/15/2024	DRAWN BY: MSM268	
MATERIAL: ACRYLIC (MEDIUM-HIGH IMPACT)		PART #: 24A07006	REV: A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

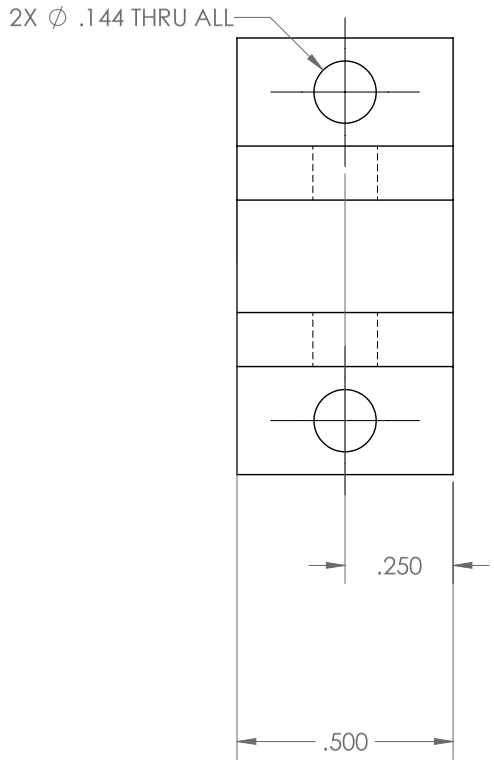
CASE ROCKET TEAM

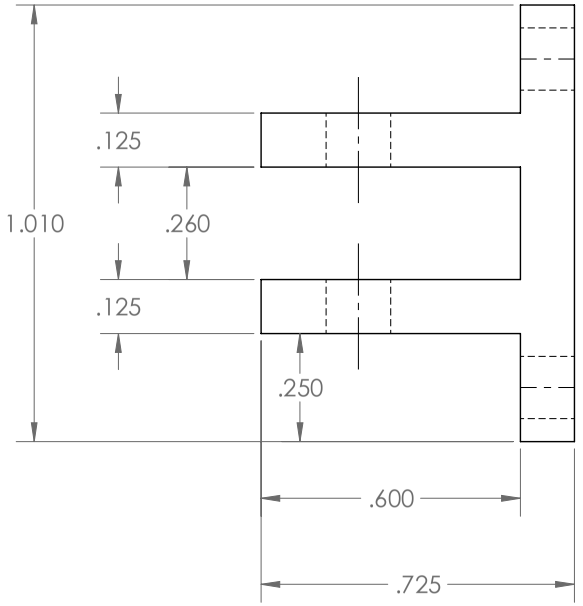
Case Western Reserve University

TITLE:
NOSE CONE SLED TO ROD BRACKET

SIZE:	DATE:	DRAWN BY:	
A	11/7/2023	JDG151	
MATERIAL:		PART #:	REV:
6061-T6		24A07007	D

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

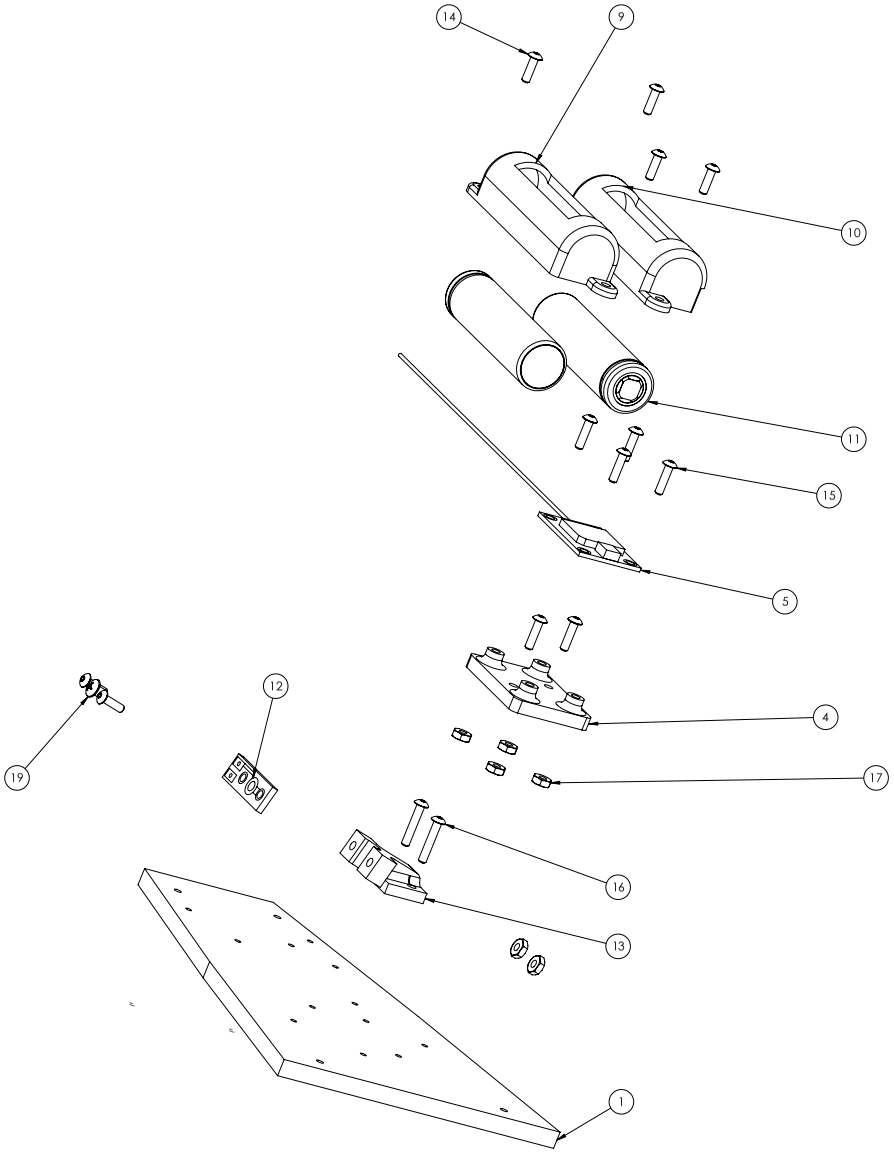
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE:
NOSE CONE SLED TO BULKHEAD CHANNEL

SIZE:	DATE:	DRAWN BY:	
A	11/2/2023	FAR41	
MATERIAL:		PART #:	REV:
6061-T6		24A07009	B

SOLIDWORKS Educational Product. For Instructional Use Only.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A07003	NOSE CONE EBAY SLED	1
4	24A07013	TELEGPS MOUNT NOSE	1
5	24A98003	TELEGPS	1
9	24A07022	NEW BATTERY MOUNT (DEFAULT)	1
10	24A07022	NEW BATTERY MOUNT (OPPOSITE)	1
11	24A98016	USE18650 BATTERY	3
12	24A98012	SCREW SWITCH	3
13	24A07023	SCREW SWITCH MOUNT (NOSE)	3
14	24A98028	4-40 BUTTON HEAD 3/8" BOLT	12
15	24A98026	4-40 BUTTON HEAD 7/16" BOLT	17
16	24A98027	4-40 BUTTON HEAD 5/8" BOLT	4
17	24A98009	4-40 SS HEX NUT	21
19	24A98013	PASSIVATED 18-8 STAINLESS STEEL PAN HEAD PHILLIPS SCREW	3

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

CASE ROCKET TEAM

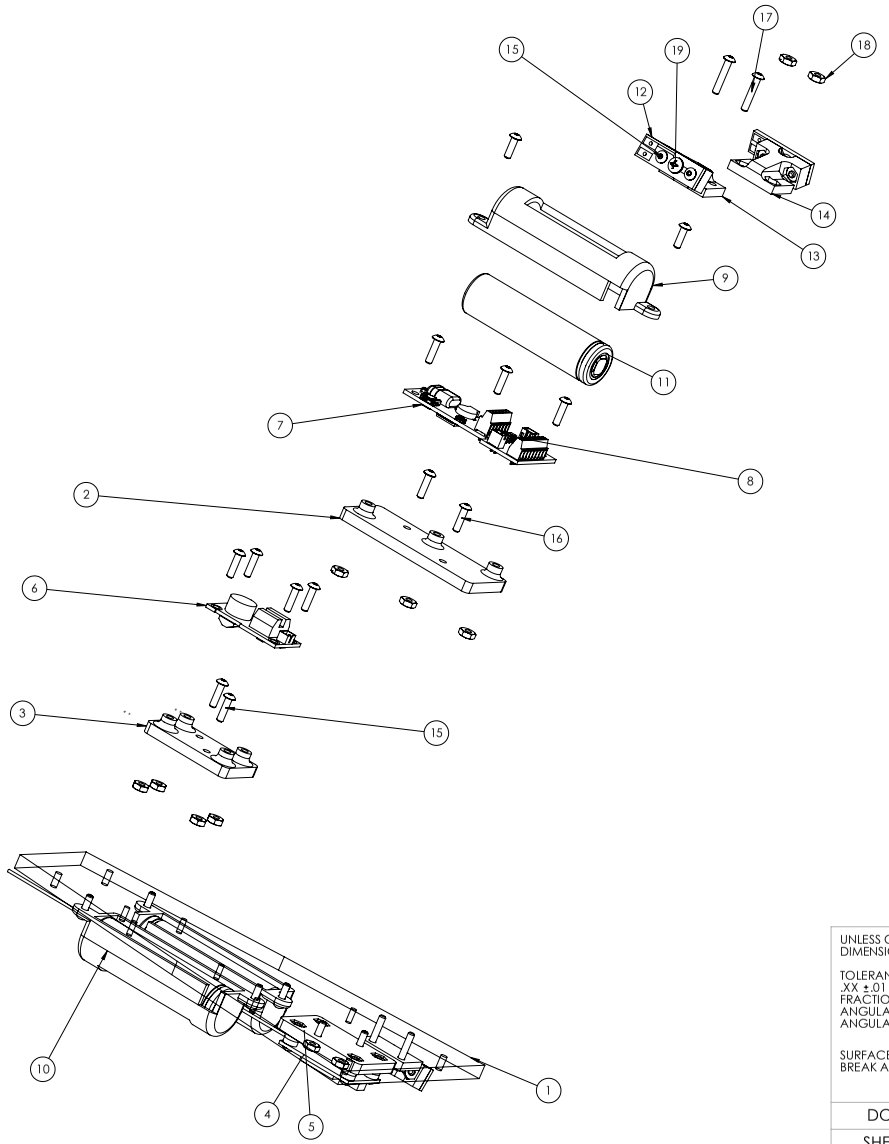
CASE WESTERN RESERVE UNIVERSITY

TITLE: Nose Cone E-Bay Sled Subassembly

SIZE:	DATE:	DRAWN BY:
C	11/30/2023	RJP132

MATERIAL:	PART #:	REV:
	24A07010	A

SOLIDWORKS Educational Product. For Instructional Use Only.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A07003	NOSE CONE EBAY SLED	1
2	24A07011	RAVEN4 MOUNT	1
3	24A07012	EASYMINI MOUNT	1
4	24A07013	TELEGPS MOUNT	1
5	24A98003	TELEGPS	1
6	24A98004	EASY MINI	1
7	24A98002	RAVEN4 ALTIMETER	1
8	24A98011	RAVEN4 BREAKOUT	1
9	24A07022	NEW BATTERY MOUNT (DEFAULT)	2
10	24A07022	NEW BATTERY MOUNT (OPPOSITE)	1
11	24A98016	USE18650 BATTERY	3
12	24A98012	SCREW SWITCH	3
13	24A07023	SCREW SWITCH MOUNT(DEFAULT)	2
14	24A07023	SCREW SWITCH MOUNT(NUT CARRIER)	1
15	24A98028	4-40 BUTTON HEAD 3/8" BOLT	12
16	24A98026	4-40 BUTTON HEAD 7/16" BOLT	17
17	24A98027	4-40 BUTTON HEAD 5/8" BOLT	4
18	24A98009	4-40 SS HEX NUT	21
19	24A98013	PASSIVATED 18-8 STAINLESS STEEL PAN HEAD PHILLIPS SCREW	3

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 2

CASE ROCKET TEAM

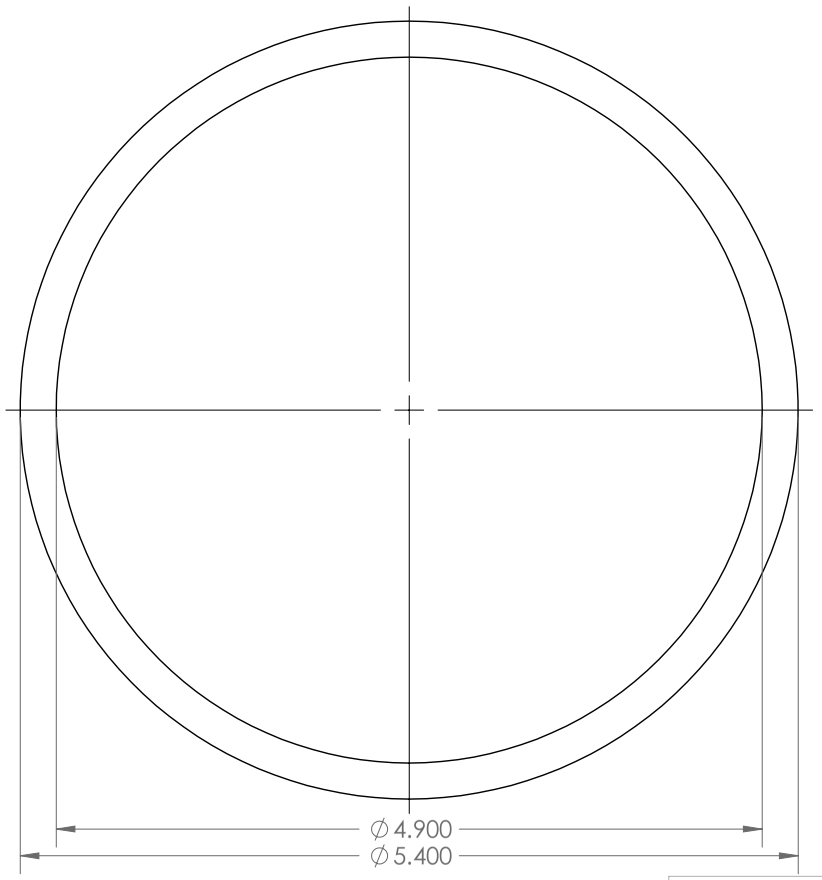
CASE WESTERN RESERVE UNIVERSITY

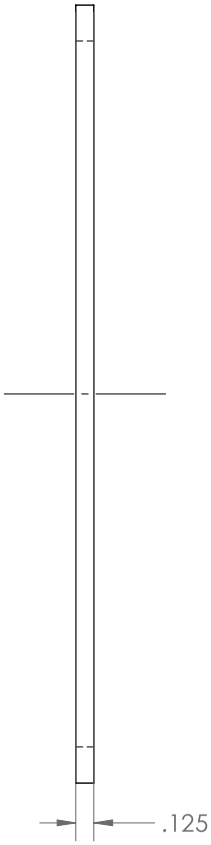
TITLE: Nose Cone E-Bay Sled Subassembly

SIZE:	DATE:	DRAWN BY:
C	11/30/2023	RJP132

MATERIAL:	PART #:	REV:
	24A07010	A

SOLIDWORKS Educational Product. For Instructional Use Only.





UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

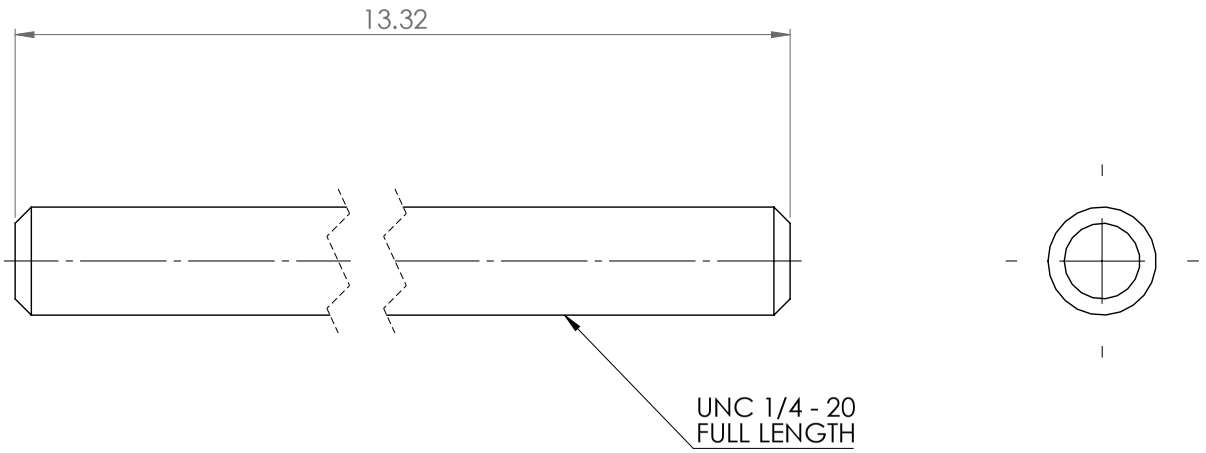
Case Western Reserve University

TITLE:

UPPER PAYLOAD RETENTION RING

SIZE:	DATE:	DRAWN BY:	
A	11/7/2023	EBK48	
MATERIAL:		PART #:	REV:
G10		24A07015	B

SOLIDWORKS Educational Product. For Instructional Use Only.



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

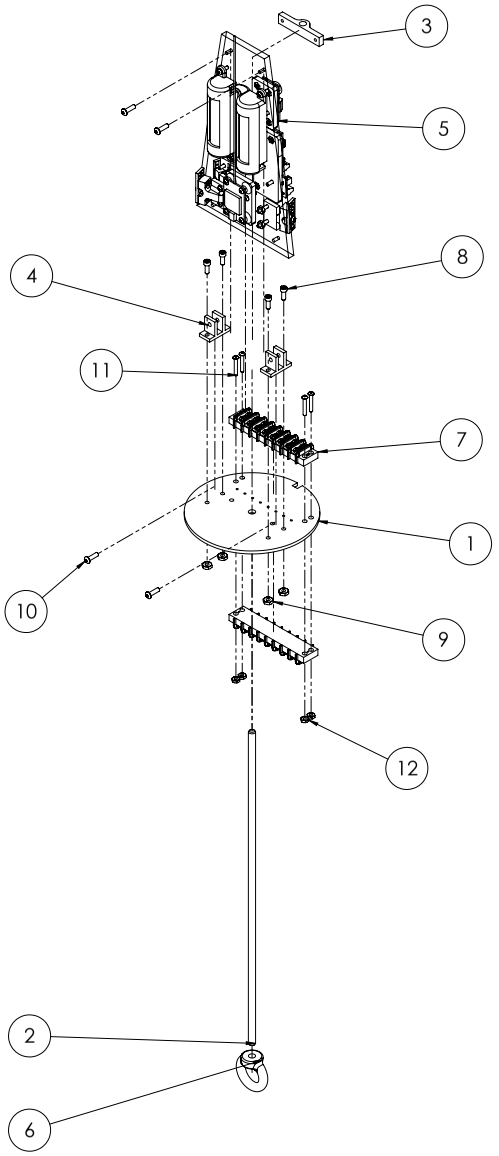
CASE ROCKET TEAM

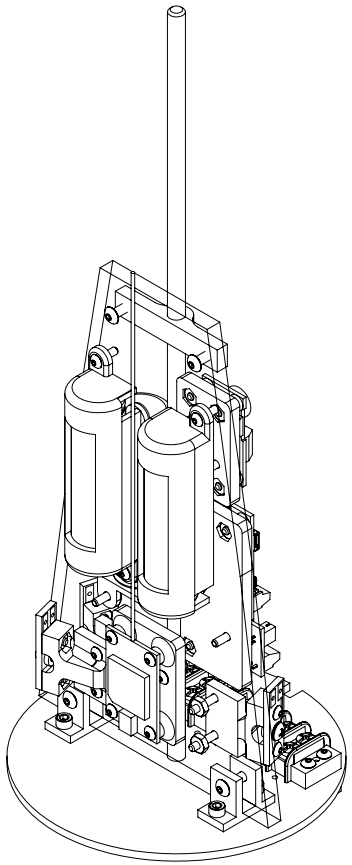
CASE WESTERN RESERVE UNIVERSITY

TITLE: NOSE CONE THREADED ROD

SIZE:	DATE:	DRAWN BY:	
A	11-7-2023	DXS1075	
MATERIAL:		PART #:	REV:
B7 MEDIUM STEEL		24A07018	F

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ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A07004	NOSE CONE BULKHEAD	1
2	24A07018	GRADE B7 MEDIUM-STRENGTH STEEL THREADED ROD	1
3	24A07007	SLED TO ROD BRACKET	1
4	24A07009	NOSE CONE SLED TO BULKHEAD CHANNEL	2
5	24A07010	NOSE CONE E-BAY SLED SUBASSEMBLY	1
6	24A98007	ZINC-PLATED STEEL ROUND EYE NUT - FOR LIFTING	1
7	24A98008	300V AC/300V DC TERMINAL BLOCK	2
8	24A98036	6-32 SOCKET HEAD 3/8" BOLT	4
9	24A98029	6-32 STAINLESS STEEL HEX NUT	4
10	24A98031	6-32 BUTTON HEAD 1/2" BOLT	4
11	24A98025	4-40 BUTTON HEAD 3/4" BOLT	4
12	24A98009	4-40 SS HEX NUT	4

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

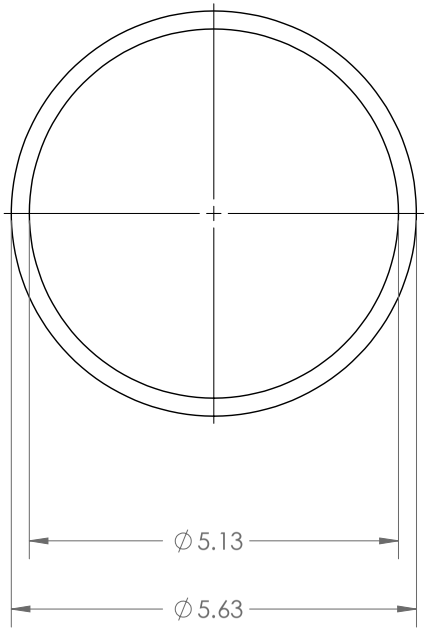
SHEET 1 OF 1

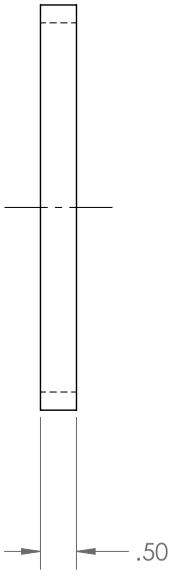
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: Nose Cone Subassembly			
SIZE: C	DATE: 12/5/2023	DRAWN BY: RJP132	
MATERIAL:		PART #: 24A07021	REV: A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

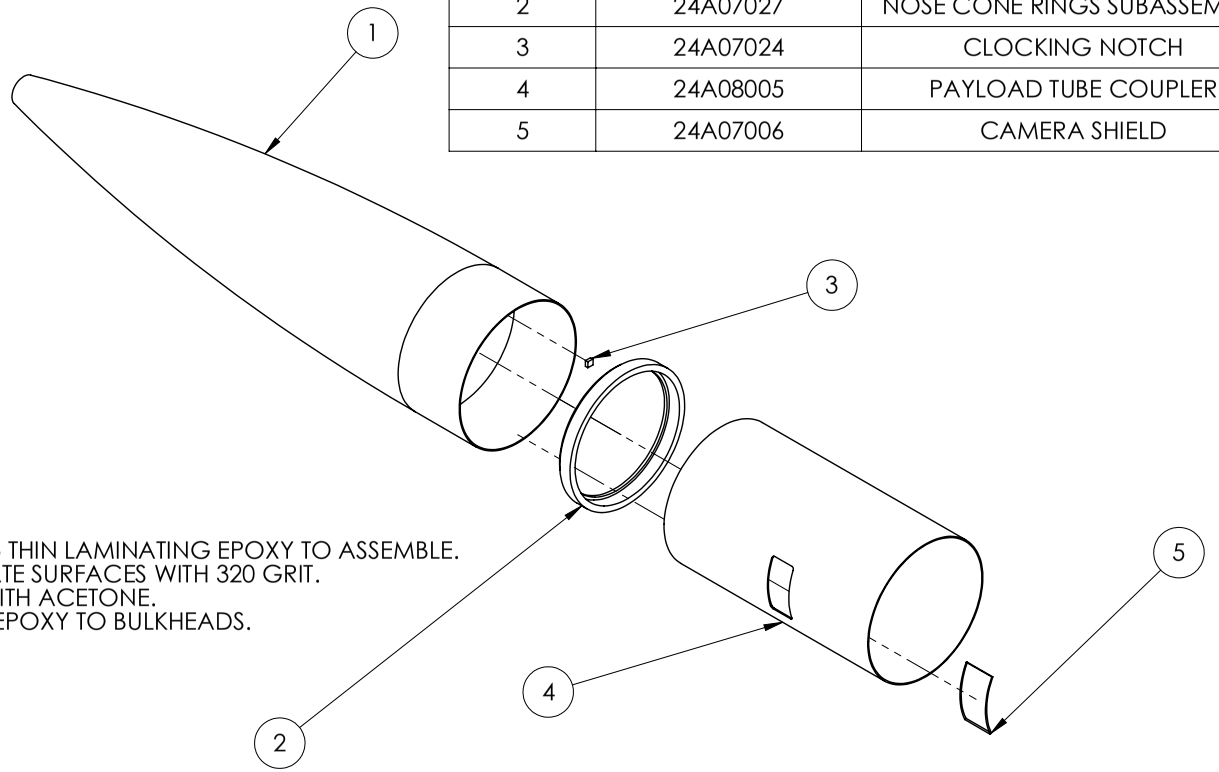
CASE WESTERN RESERVE UNIVERSITY

TITLE:
NOSE CONE PAYLOAD FOAM RING

SIZE:	DATE:	DRAWN BY:	
A	2/21/2024	RJP132	
MATERIAL:		PART #:	REV:
POLYURETHANE FOAM RIGID		24A07025	A

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A07002	NOSE CONE	1
2	24A07027	NOSE CONE RINGS SUBASSEMBLY	1
3	24A07024	CLOCKING NOTCH	1
4	24A08005	PAYLOAD TUBE COUPLER	1
5	24A07006	CAMERA SHIELD	1



USE 635 THIN LAMINATING EPOXY TO ASSEMBLE.
ACTIVATE SURFACES WITH 320 GRIT.
WIPE WITH ACETONE.
APPLY EPOXY TO BULKHEADS.

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

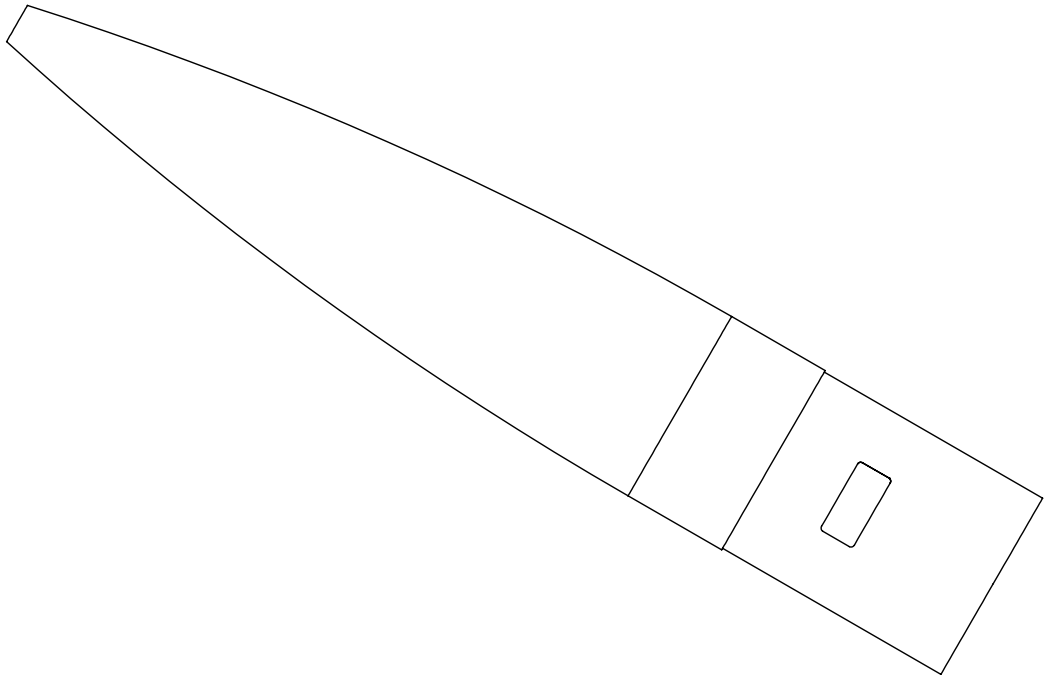
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE:
NOSE CONE EPOXY SUBASSEMBLY

SIZE:	DATE:	DRAWN BY:	
A	2/15/2024	MSM268	
MATERIAL:		PART #: 24A07026	REV: B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 2

CASE ROCKET TEAM

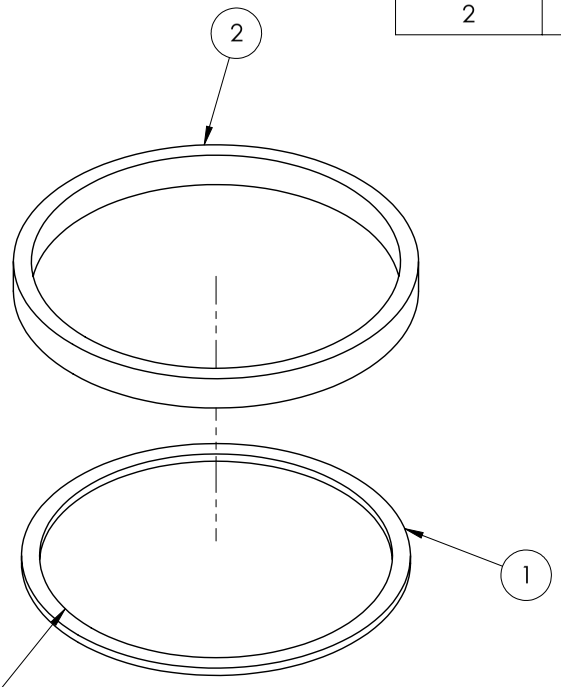
CASE WESTERN RESERVE UNIVERSITY

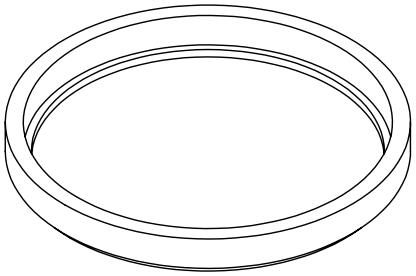
TITLE: NOSE CONE EPOXY SUBASSEMBLY

SIZE:	DATE:	DRAWN BY:	
A	2/15/2024	MSM268	
MATERIAL:		PART #: 24A07026	REV: A

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ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A07015	NOSECONE PAYLOAD RETENTION TOP	1
2	24A07025	NOSECONE PAYLOAD FOAM RING	1





USE 635 THIN LAMINATING EPOXY TO ASSEMBLE.
ACTIVATE SURFACES WITH 320 GRIT.
WIPE WITH ACETONE.
APPLY EPOXY TO RING.

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

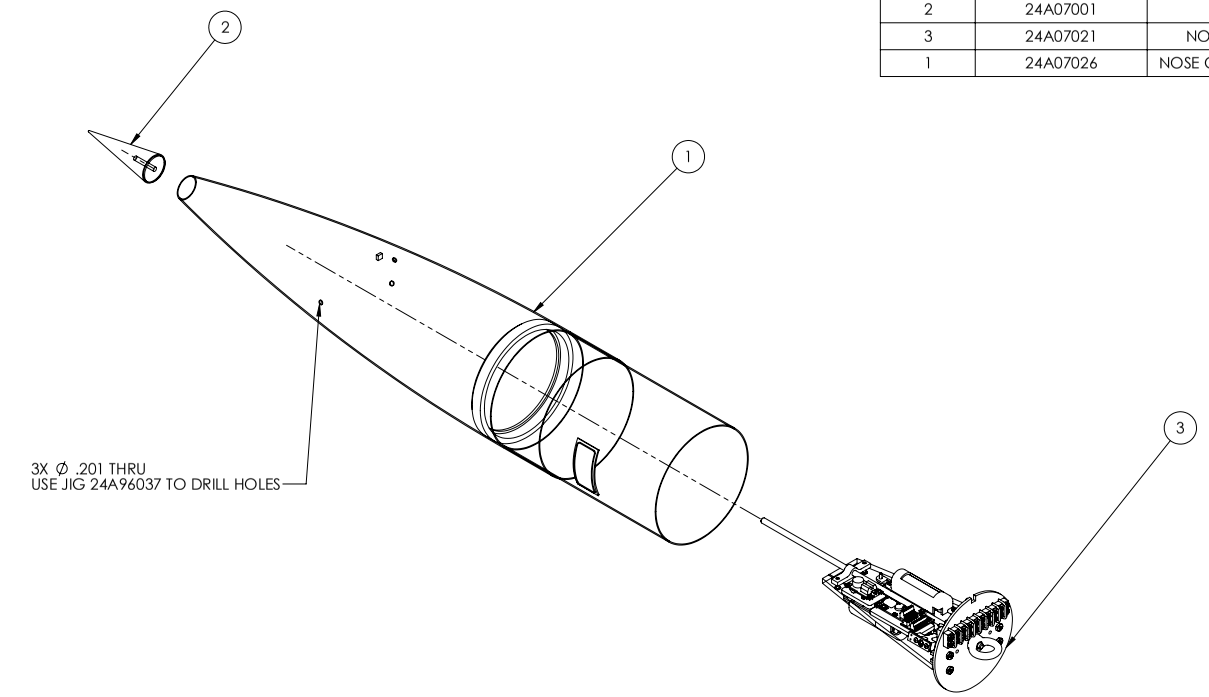
TITLE:
NOSE CONE RINGS SUBASSEMBLY

SIZE:	DATE:	DRAWN BY:
A	2/15/2024	MSM268

MATERIAL:	PART #:	REV:
	24A07027	A

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ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
2	24A07001	NOSE CONE TIP	1
3	24A07021	NOSE CONE SUBASSEMBLY	1
1	24A07026	NOSE CONE EPOXY SUBASSEMBLY	1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

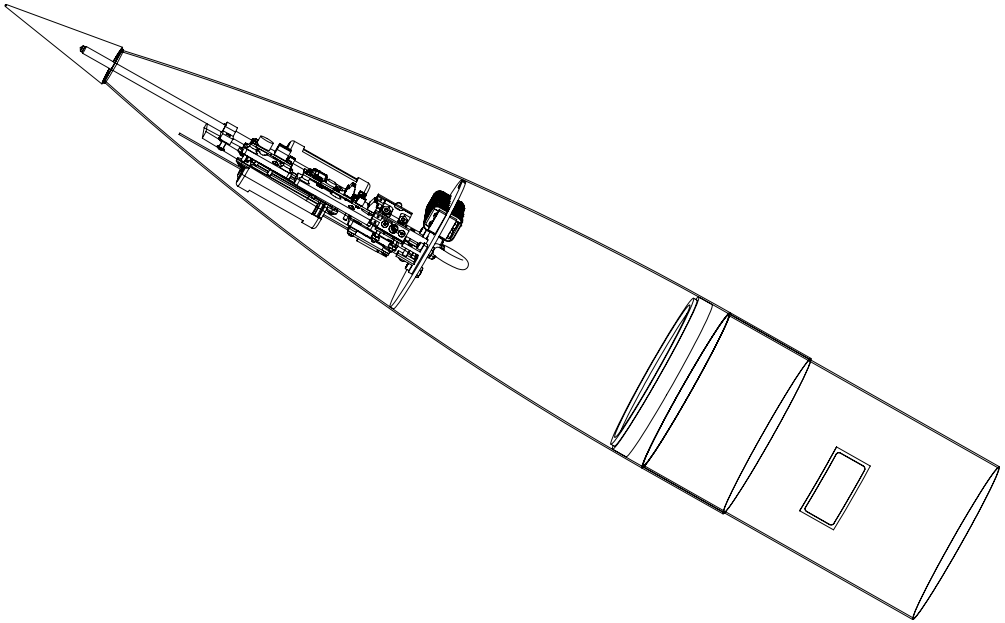
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: Nose Cone Assembly

SIZE:	DATE:	DRAWN BY:	
B	12/5/2023	LCS113	
MATERIAL:		PART #: 24A00007	REV: B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 2

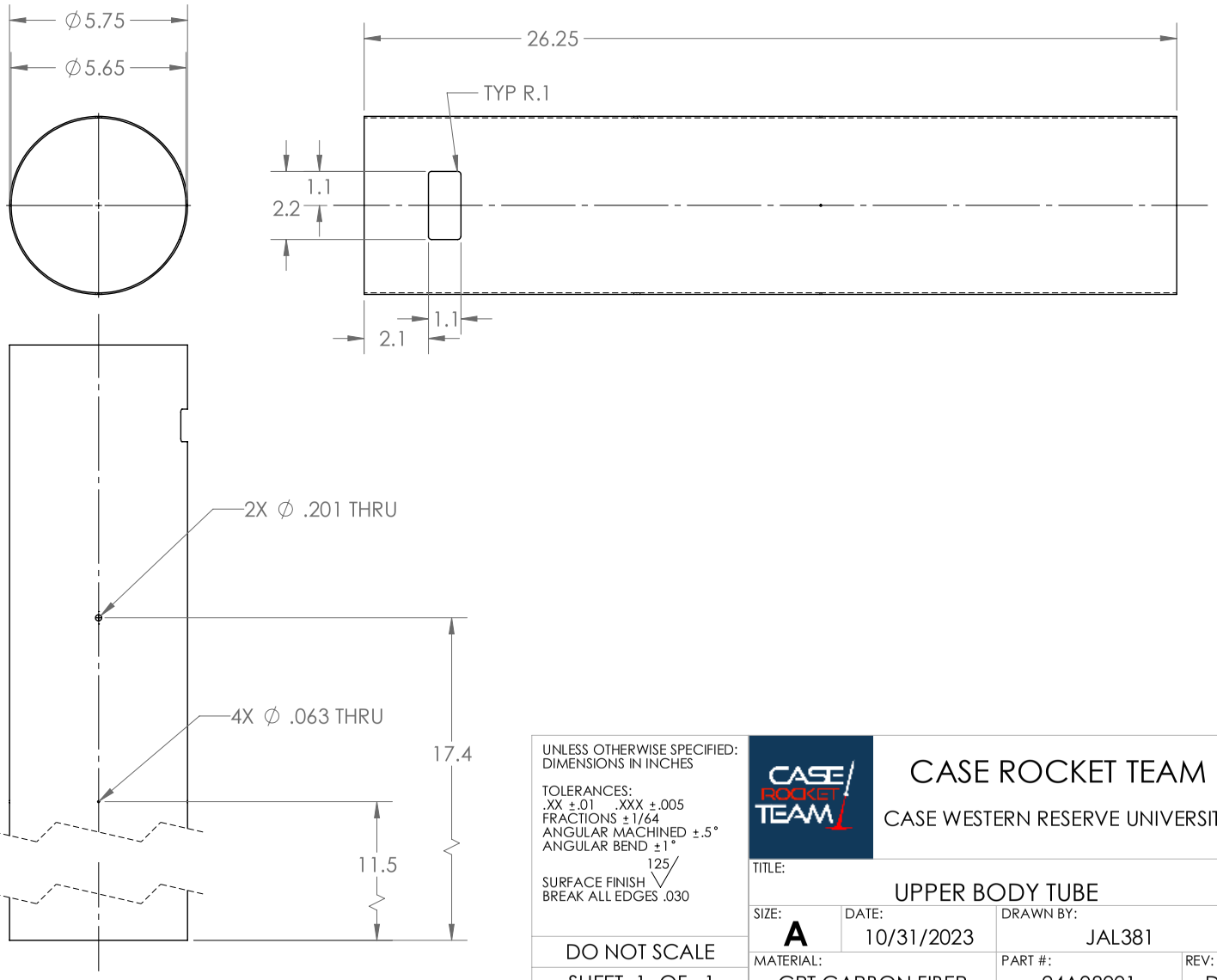
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: Nose Cone Assembly

SIZE:	DATE:	DRAWN BY:	
B	12/5/2023	RJP132	
MATERIAL:		PART #: 24A00010	REV: B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

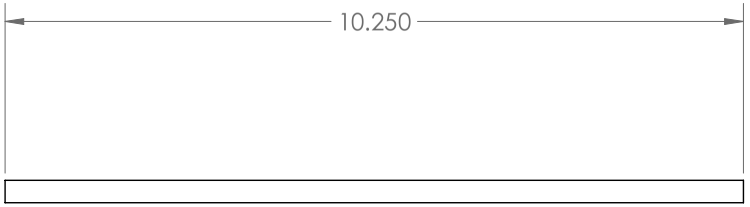
CASE WESTERN RESERVE UNIVERSITY

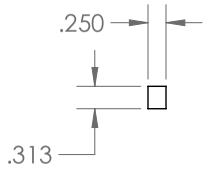
TITLE: UPPER BODY TUBE

SIZE:	DATE:	DRAWN BY:
A	10/31/2023	JAL381

MATERIAL:	PART #:	REV:
CRT CARBON FIBER	24A08001	D

SOLIDWORKS Educational Product. For Instructional Use Only.





UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

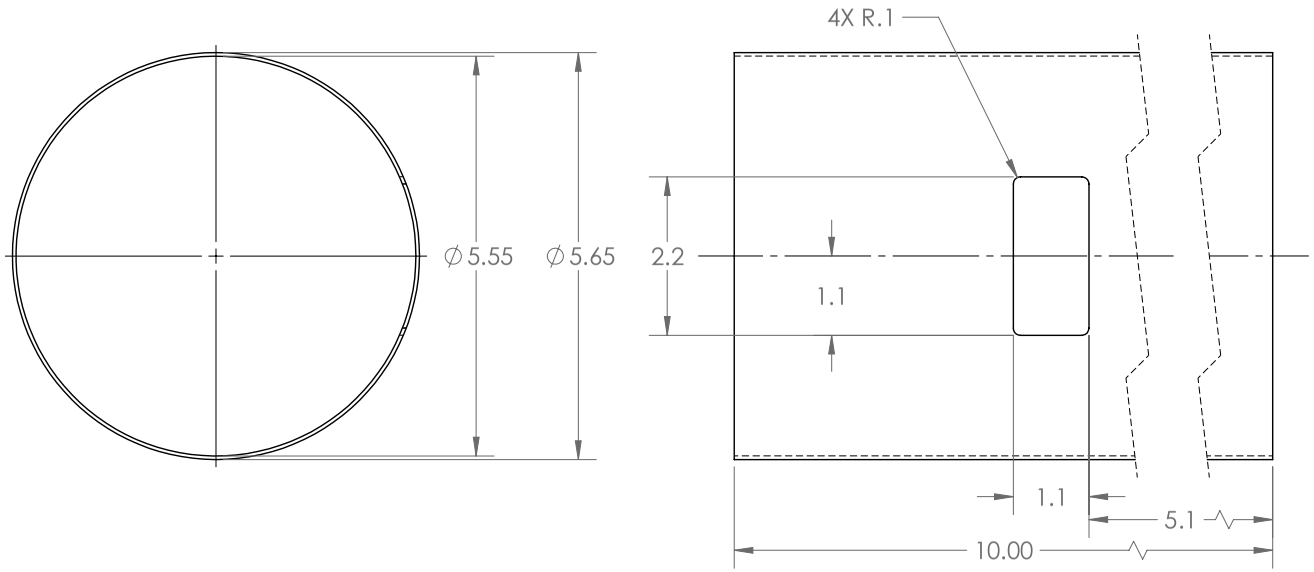
SHEET 1 OF 1

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: PAYLOAD RETENTION RAIL

SIZE:	DATE:	DRAWN BY:	
A	3/7/2024	MSM268	
MATERIAL:		PART #:	REV:
DELRIN		24A08004	0

SOLIDWORKS Educational Product. For Instructional Use Only.



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

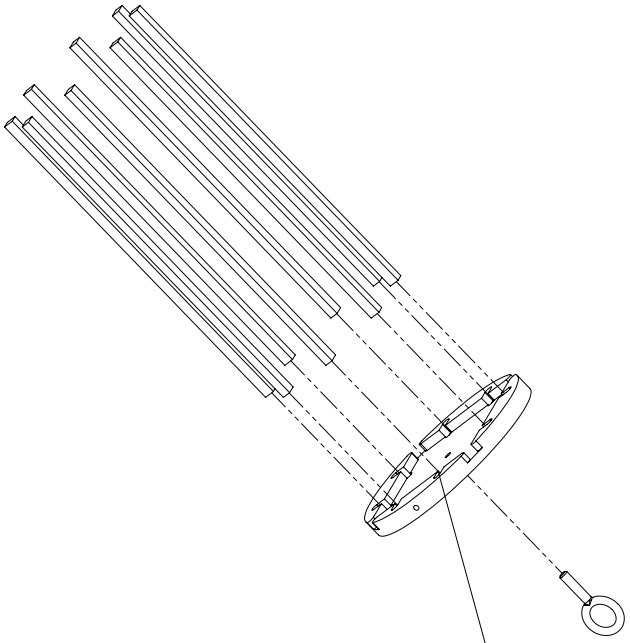
CASE WESTERN RESERVE UNIVERSITY

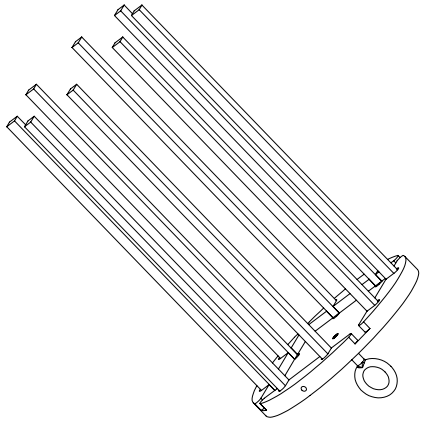
TITLE: PAYLOAD TUBE COUPLER

SIZE:	DATE:	DRAWN BY:	
A	10/31/2023	MSM268	
MATERIAL:		PART #:	REV:
CRT CARBON FIBER		24A08005	C

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A08004	PAYLOAD RETENTION RAIL	8
2	24A08010	LOWER PAYLOAD RETENTION BULKHEAD	1
3	24A98055	EYE BOLT DROGUE PARACHUTE	1





USE STRUCTUAL EPOXY TO ASSEMBLE.
ACTIVATE SURFACES WITH 320 GRIT.
WIPE WITH ACETONE.
APPLY EPOXY TO SURFACE

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

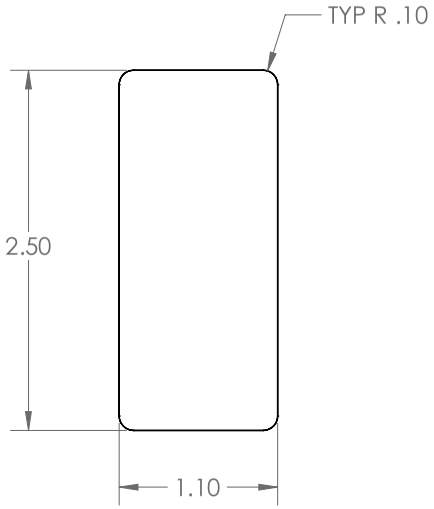
CASE ROCKET TEAM

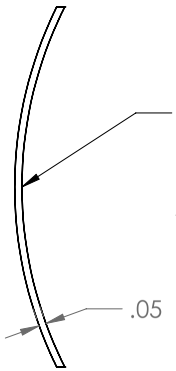
CASE WESTERN RESERVE UNIVERSITY

TITLE: PAYLOAD RETENTION SUBASSEMBLY

SIZE:	DATE:	DRAWN BY:	
B	11/7/2023	KKW34	
MATERIAL:		PART #: 24A08006	REV: B

SOLIDWORKS Educational Product. For Instructional Use Only.





Bend Instructions:

Heat the acrylic sheet with heat gun on highest setting until pilable. Mold the heated sheet on the piece of coupler section of the nose cone and hold until it hardens.

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

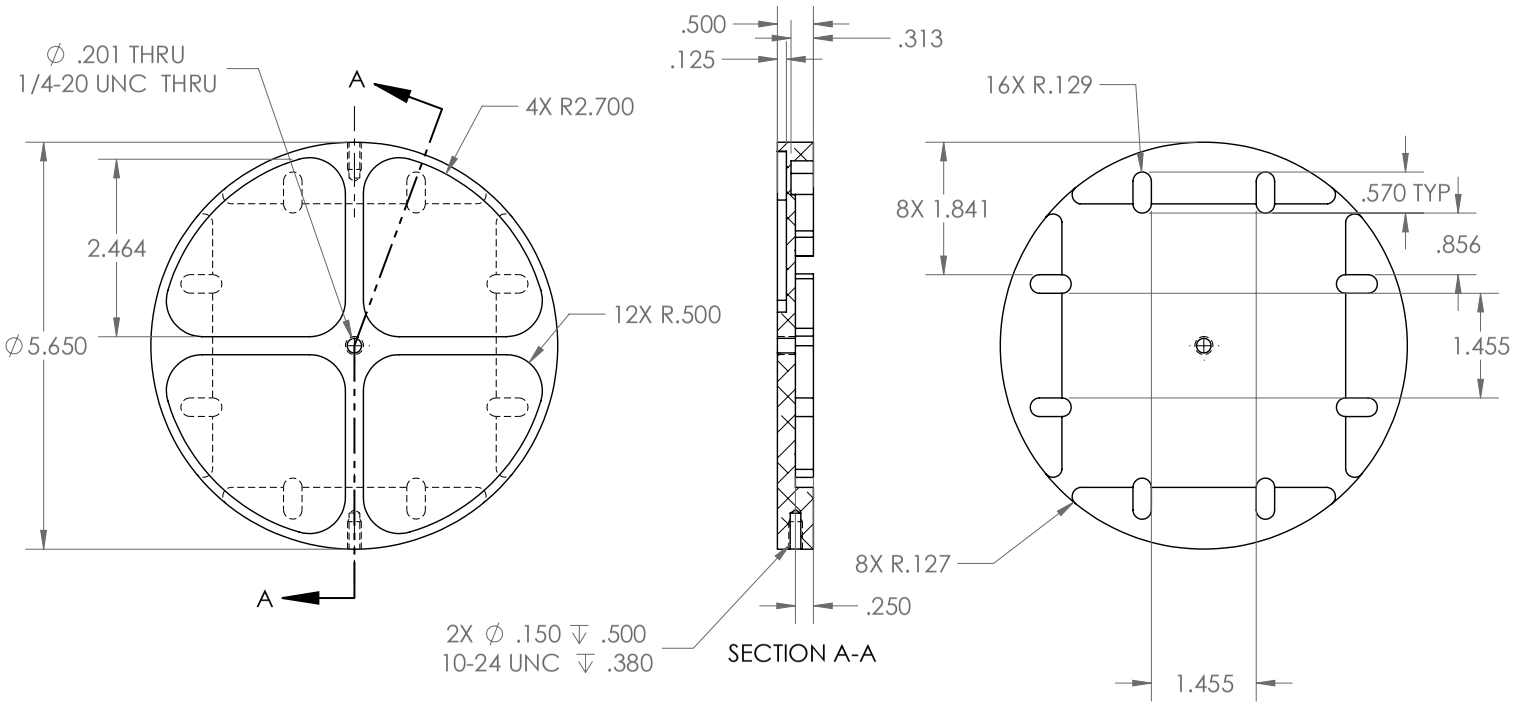
SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: CAMERA SHIELD V2			
SIZE: A	DATE: 11/16/2023	DRAWN BY: LCS113	
MATERIAL: ACRYLIC (MEDIUM-HIGH IMPACT)		PART #: 24A08009	REV: B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

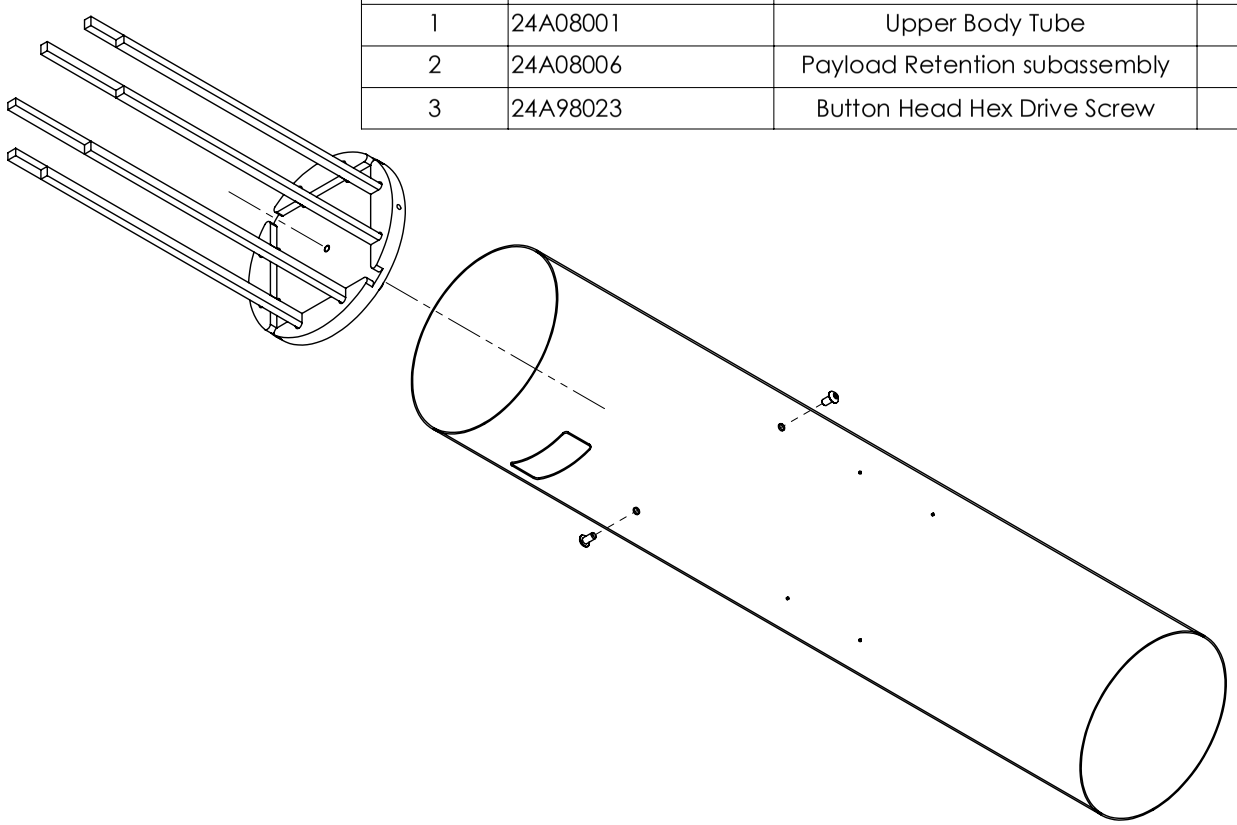
CASE WESTERN RESERVE UNIVERSITY

TITLE:
LOWER PAYLOAD RETENTION BULKHEAD

SIZE:	DATE:	DRAWN BY:	
A	2/13/2024	MSM268	
MATERIAL:		PART #:	REV:
6061-T6		24A08010	B

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A08001	Upper Body Tube	1
2	24A08006	Payload Retention subassembly	1
3	24A98023	Button Head Hex Drive Screw	2



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

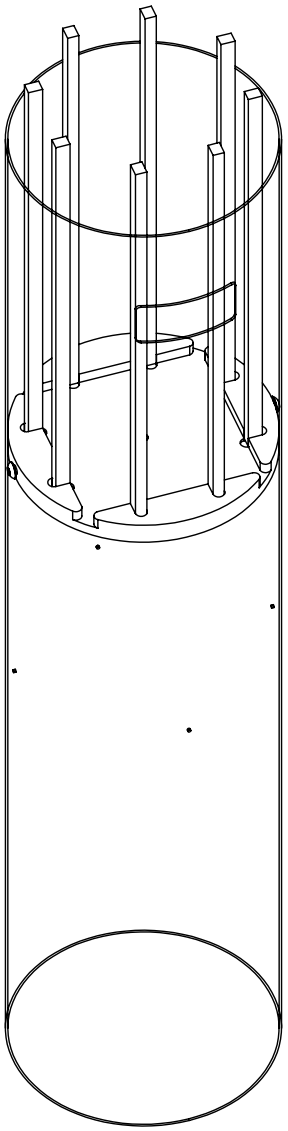
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: PAYLOAD SUBASSEMBLY

SIZE:	DATE:	DRAWN BY:	
A	11/8/2023	MSM268	
MATERIAL:		PART #:	REV:
N/A		24A00008	B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 2

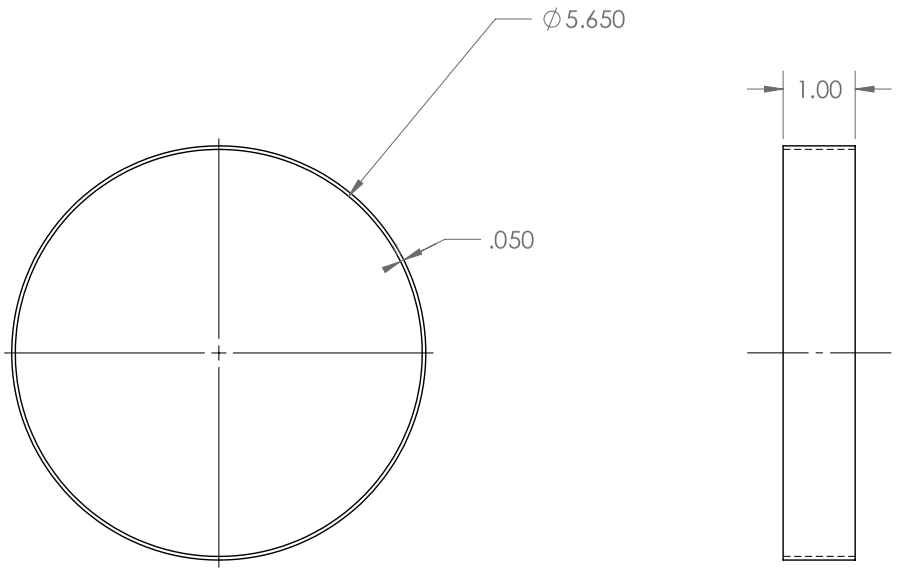
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: PAYLOAD SUBASSEMBLY

SIZE:	DATE:	DRAWN BY:	
A	11/8/2023	MSM268	
MATERIAL:		PART #:	REV:
N/A		24A00008	B

SOLIDWORKS Educational Product. For Instructional Use Only.



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

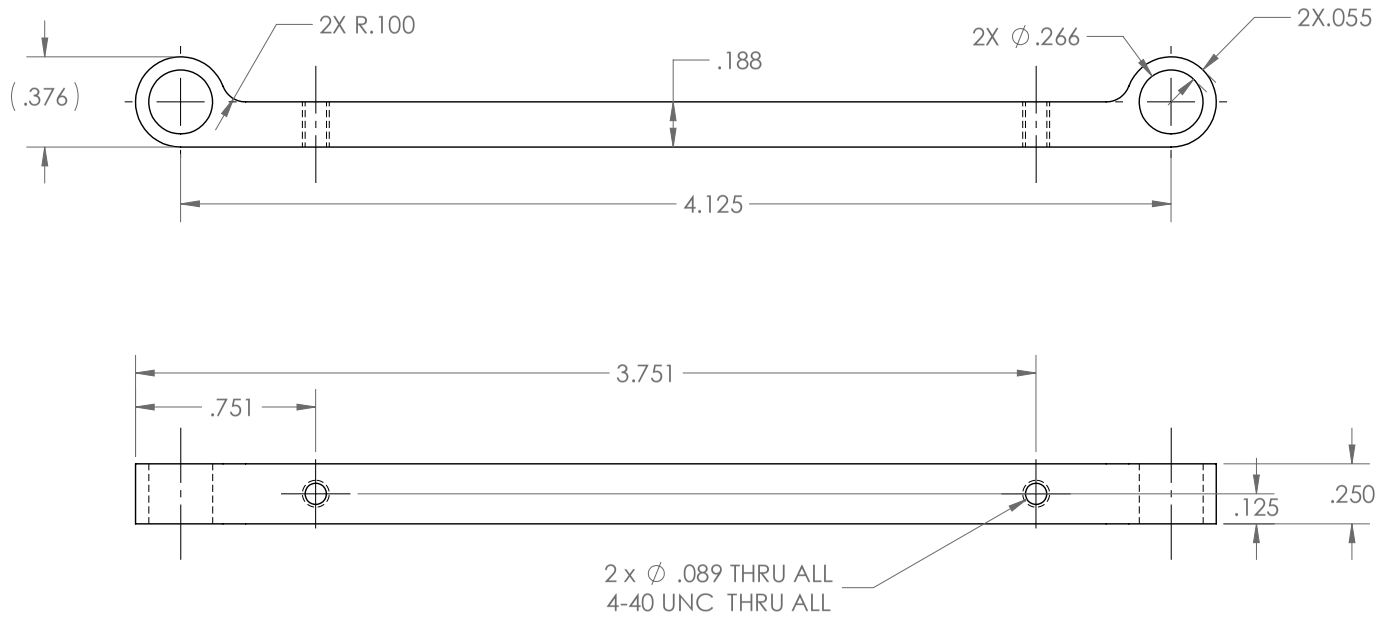
SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: SWITCHBAND			
SIZE: A	DATE: 11/30/2023	DRAWN BY: DCF69	
MATERIAL: CRT CARBON FIBER		PART #: 24A09001	REV: B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

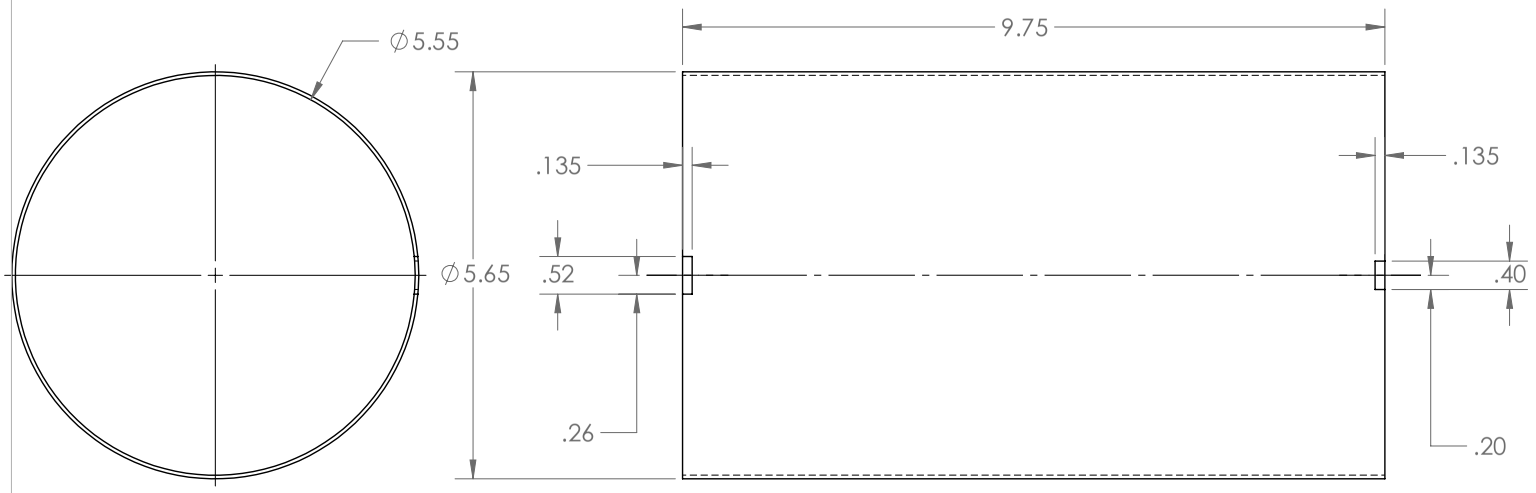
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: E-BAY SLED BRACKET

SIZE:	DATE:	DRAWN BY:	
A	11-7-2023	DXS1075	
MATERIAL:		PART #:	REV:
6061-T6		24A09002	D

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

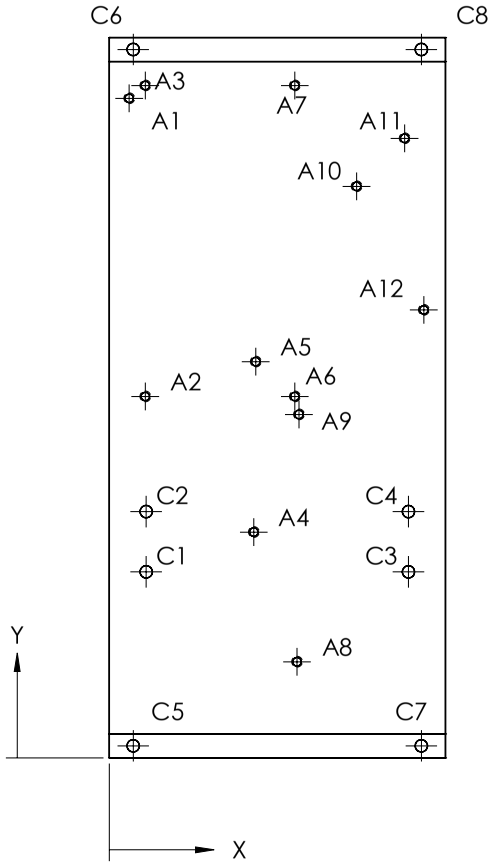
CASE ROCKET TEAM

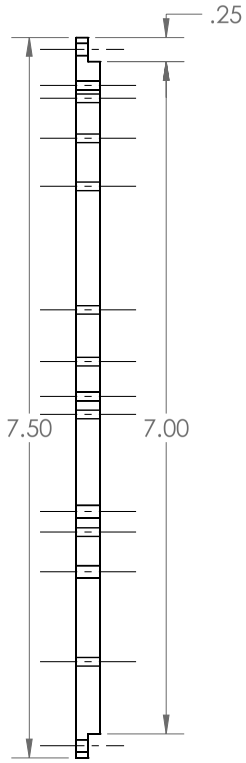
CASE WESTERN RESERVE UNIVERSITY

TITLE: E-BAY COUPLER

SIZE:	DATE:	DRAWN BY:	
A	11/07/23	DXS1075	
MATERIAL:		PART #:	REV:
CRT CARBON FIBER		24A09003	D

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TAG	X LOC	Y LOC	SIZE
A1	.208	6.866	Ø .089 THRU 4-40 UNC THRU
A2	.375	3.762	Ø .089 THRU 4-40 UNC THRU
A3	.375	7.000	Ø .089 THRU 4-40 UNC THRU
A4	1.505	2.350	Ø .089 THRU 4-40 UNC THRU
A5	1.525	4.125	Ø .089 THRU 4-40 UNC THRU
A6	1.932	3.762	Ø .089 THRU 4-40 UNC THRU
A7	1.932	7.000	Ø .089 THRU 4-40 UNC THRU
A8	1.955	1.000	Ø .089 THRU 4-40 UNC THRU
A9	1.975	3.575	Ø .089 THRU 4-40 UNC THRU
A10	2.575	5.950	Ø .089 THRU 4-40 UNC THRU
A11	3.075	6.450	Ø .089 THRU 4-40 UNC THRU
A12	3.275	4.663	Ø .089 THRU 4-40 UNC THRU
C1	.384	1.936	Ø .129 THRU
C2	.384	2.564	Ø .129 THRU
C3	3.116	1.936	Ø .129 THRU
C4	3.116	2.564	Ø .129 THRU
C5	.250	.125	Ø .129 THRU
C6	.250	7.375	Ø .129 THRU
C7	3.250	.125	Ø .129 THRU
C8	3.250	7.375	Ø .129 THRU

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

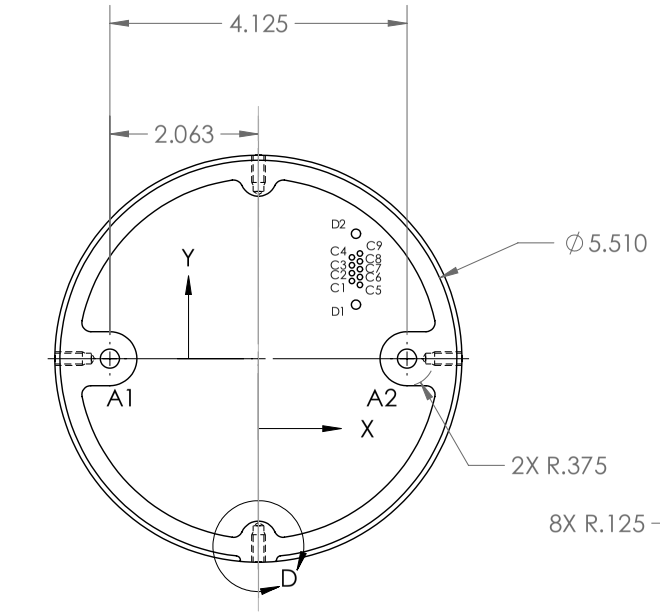
CASE WESTERN RESERVE UNIVERSITY

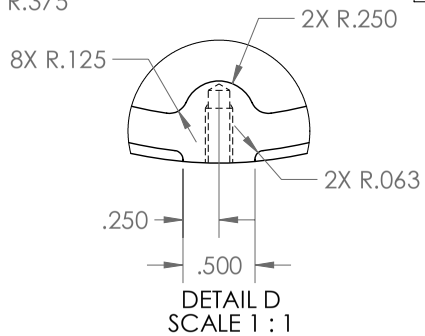
TITLE: E-BAY SLED

SIZE:	DATE:	DRAWN BY:
A	2/8/2024	DXS1075

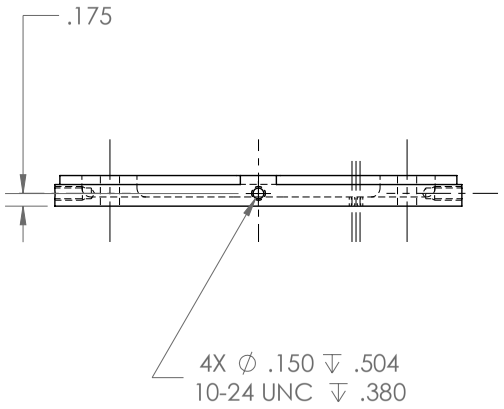
MATERIAL:	PART #:	REV:
PC HIGH VISCOSITY	24A09004	A

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DETAIL D
SCALE 1 : 1



TAG	X LOC	Y LOC	SIZE
A1	-2.063	.000	∅ .266 THRU
A2	2.063	.000	∅ .266 THRU
C1	1.298	1.079	∅ .076 THRU
C2	1.298	1.188	∅ .076 THRU
C3	1.298	1.297	∅ .076 THRU
C4	1.298	1.406	∅ .076 THRU
C5	1.410	1.024	∅ .076 THRU
C6	1.410	1.133	∅ .076 THRU
C7	1.410	1.242	∅ .076 THRU
C8	1.410	1.351	∅ .076 THRU
C9	1.410	1.460	∅ .076 THRU
D1	1.354	.750	∅ .129 THRU
D2	1.354	1.734	∅ .129 THRU

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

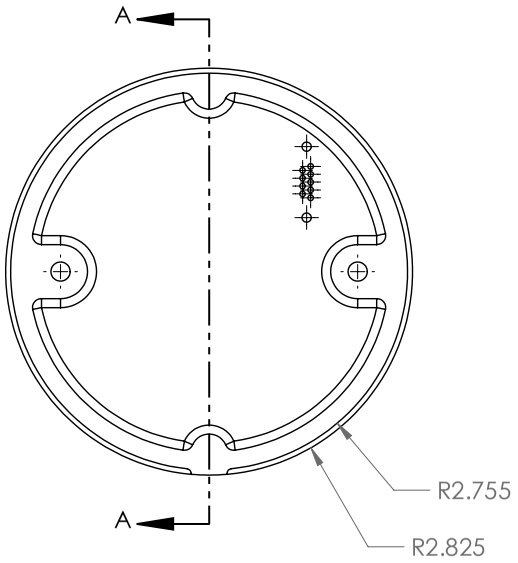
CASE ROCKET TEAM

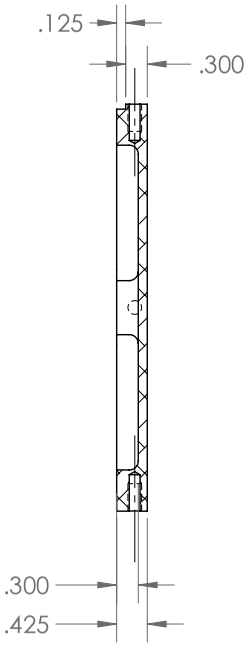
CASE WESTERN RESERVE UNIVERSITY

TITLE: LOWER E-BAY BULKHEAD

SIZE:	DATE:	DRAWN BY:	
A	11/28/2023	RJP132	
MATERIAL:		PART #:	REV:
7075-T6 (SN)		24A09005	B

SOLIDWORKS Educational Product. For Instructional Use Only.





SECTION A-A

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 2

CASE ROCKET TEAM

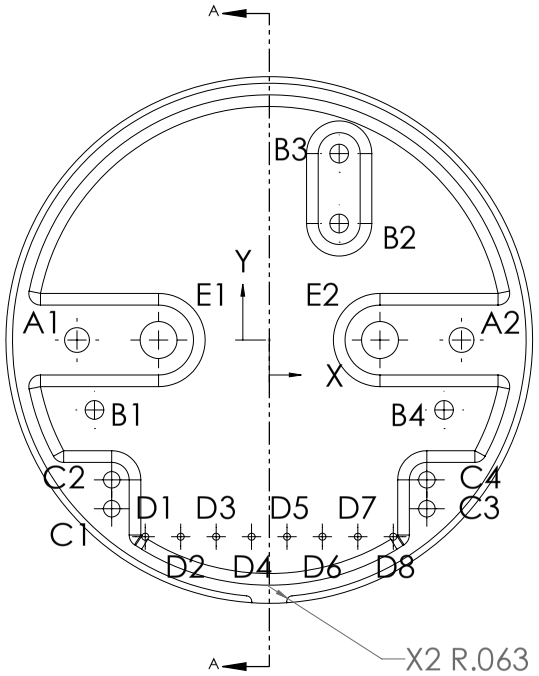
CASE WESTERN RESERVE UNIVERSITY

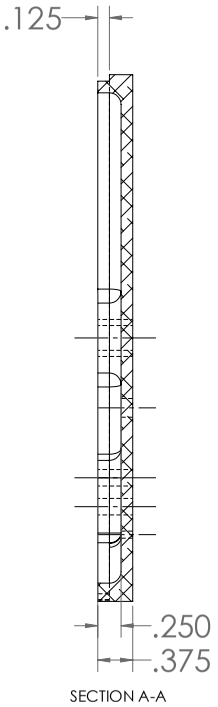
TITLE: LOWER E-BAY BULKHEAD

SIZE:	DATE:	DRAWN BY:
A	11/28/2023	RJP132

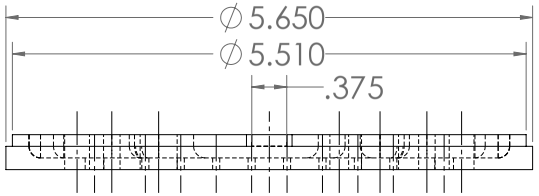
MATERIAL:	PART #:	REV:
7075-T6 (SN)	24A09005	A

SOLIDWORKS Educational Product. For Instructional Use Only.





SECTION A-A



Hole Table			
TAG	X LOC	Y LOC	SIZE
A1	-2.063	.000	∅ .266 THRU
A2	2.063	.000	∅ .266 THRU
B1	-1.875	-.750	∅ .201 THRU
B2	.750	1.250	∅ .201 THRU
B3	.750	2.000	∅ .201 THRU
B4	1.875	-.750	∅ .201 THRU
C1	-1.690	-1.810	∅ .177 THRU
C2	-1.690	-1.500	∅ .177 THRU
C3	1.690	-1.810	∅ .177 THRU
C4	1.690	-1.500	∅ .177 THRU
D1	-1.330	-2.110	∅ .076 THRU
D2	-.950	-2.110	∅ .076 THRU
D3	-.570	-2.110	∅ .076 THRU
D4	-.190	-2.110	∅ .076 THRU
D5	.190	-2.110	∅ .076 THRU
D6	.570	-2.110	∅ .076 THRU
D7	.950	-2.110	∅ .076 THRU
D8	1.330	-2.110	∅ .076 THRU
E1	-1.188	.000	∅ .397 THRU
E2	1.188	.000	∅ .397 THRU

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

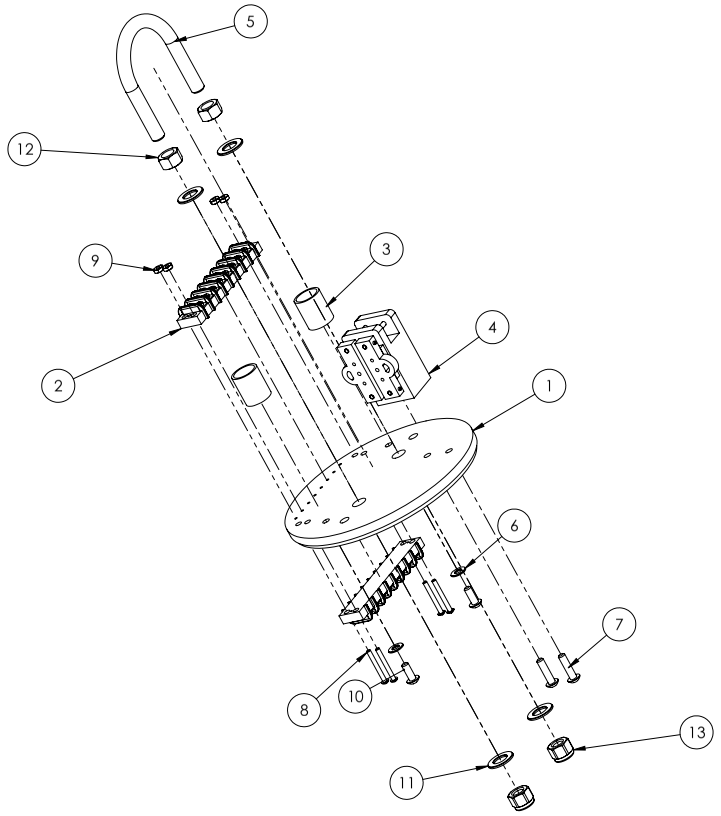
CASE ROCKET TEAM
CASE WESTERN RESERVE UNIVERSITY

TITLE: Upper E-Bay Bulkhead

SIZE:	DATE:	DRAWN BY:
B	11/2/2023	FAR41

MATERIAL:	PART #:	REV:
6061-T6	24A09012	B

SOLIDWORKS Educational Product. For Instructional Use Only.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A09012	UPPER E-BAY BULKHEAD	1
2	24A98001	300V AC/300V DC TERMINAL BLOCK	2
3	24A09020	CHARGE WELL	2
4	24A89001	TENDIE MAIN ASSEMBLY	1
5	24A98015	3/8" - 16 U-BOLT	1
6	24A98038	STAINLESS STEEL WASHER	4
7	24A98037	10-24 BUTTON HEAD 3/4" BOLT	2
8	24A98039	4-40 BUTTON HEAD 1" BOLT	4
9	24A98009	4-40 SS HEX NUT	4
10	24A98040	1/2" 10-24 BUTTON HEAD BOLT	2
11	24A98021	STAINLESS STEEL WASHER	4
12	24A98020	3/8-16 SS HEX NUT	2
13	24A98041	3/8-16 SS NYLOCK NUT	2

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

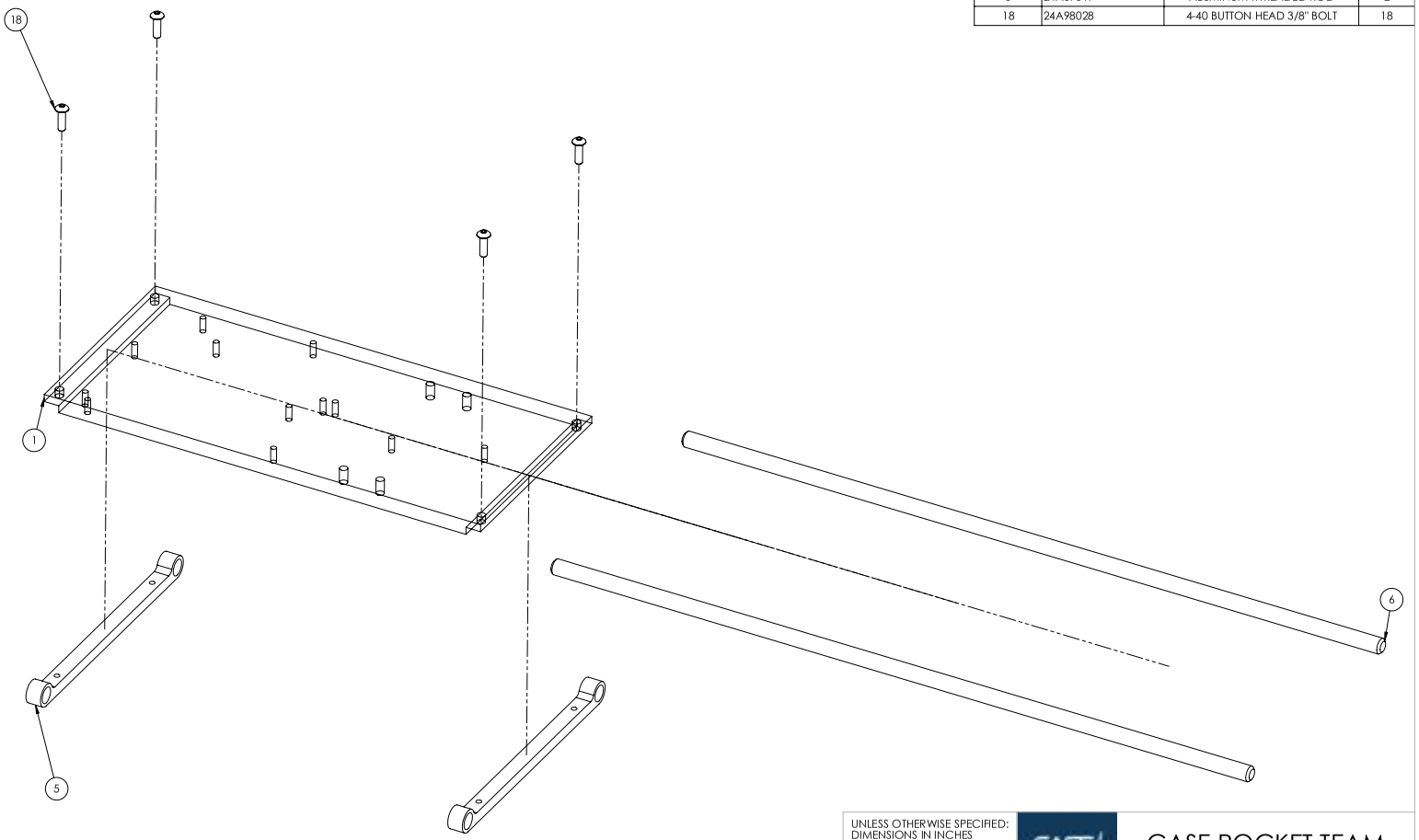
TITLE:
UPPER E-BAY BULKHEAD SUBASSEMBLY

SIZE:	DATE:	DRAWN BY:
B	11/7/2023	RJP132

MATERIAL:	PART #:	REV:
	24A09015	A

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A09004	E-BAY SLED	1
5	24A09002	E-BAY SLED BRACKET	2
6	24A09019	ALUMINUM THREADED ROD	2
18	24A98028	4-40 BUTTON HEAD 3/8" BOLT	18



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

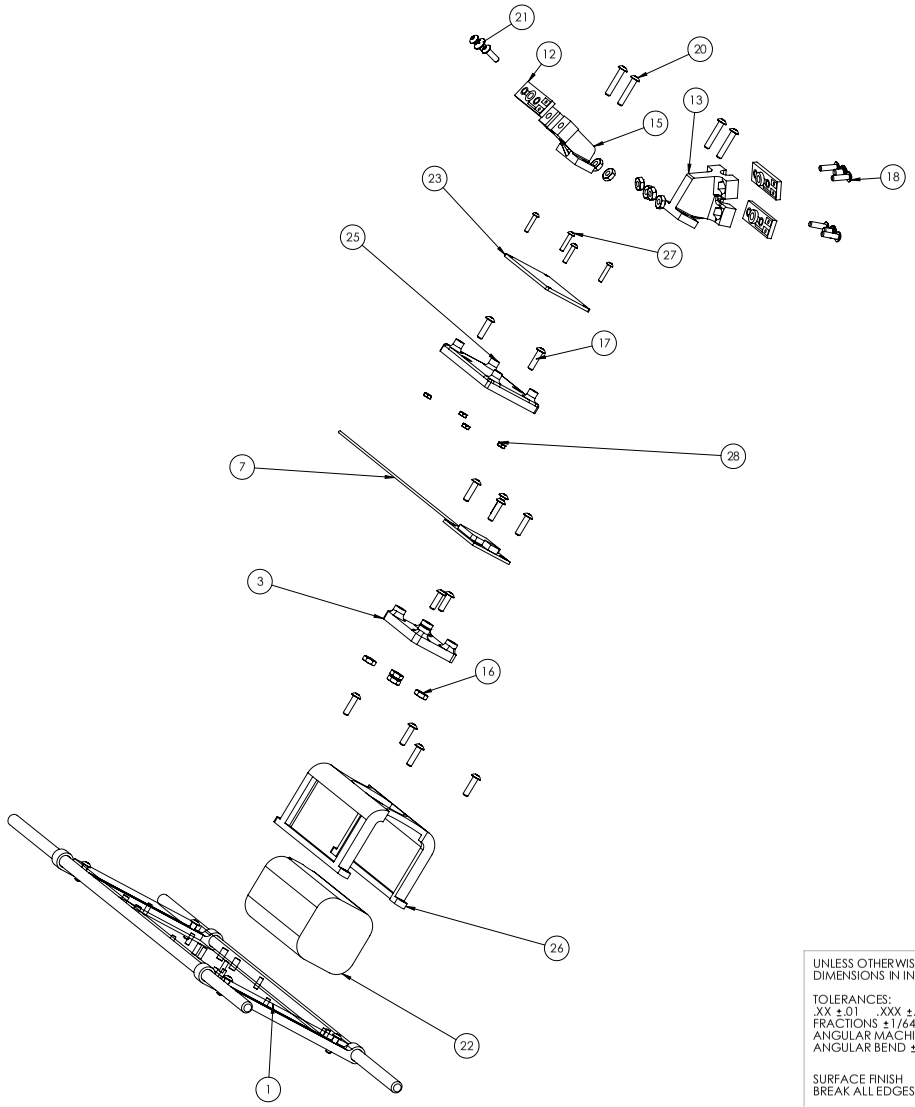
SHEET 1 OF 4

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: Ebay Sled Subassemly			
SIZE: C	DATE: 1/25/2024	DRAWN BY: RJP132	
MATERIAL:		PART #: 24A09017	REV: A

SOLIDWORKS Educational Product. For Instructional Use Only.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A09004	E-BAY SLED	1
3	24A09008	TELEGPS MOUNT	1
7	24A98003	TELEGPS	1
12	24A98012	SCREW SWITCH	5
13	24A09022	DOUBLE SCREW SWITCH MOUNT	1
15	24A09022	SCREW SWITCH MOUNT	1
16	24A98009	4-40 SS HEX NUT	25
17	24A98026	4-40 BUTTON HEAD 7/16" BOLT	21
18	24A98028	4-40 BUTTON HEAD 3/8" BOLT	18
20	24A98027	4-40 BUTTON HEAD 5/8" BOLT	4
21	24A98042	6-32 3/16" BUTTON HEAD SCREW	5
22	24A98054	4S LI-ION BATTERY	1
23	24A09024	SIRIN	1
25	24A09025	SIRIN MOUNT	1
26	24A09027	AIRBRAKES BATTERY MOUNT	1
27	24A98057	10mm M2X0.40 BOLT	4
28	24A98058	M2X0.40 NUT	4

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 4

CASE ROCKET TEAM

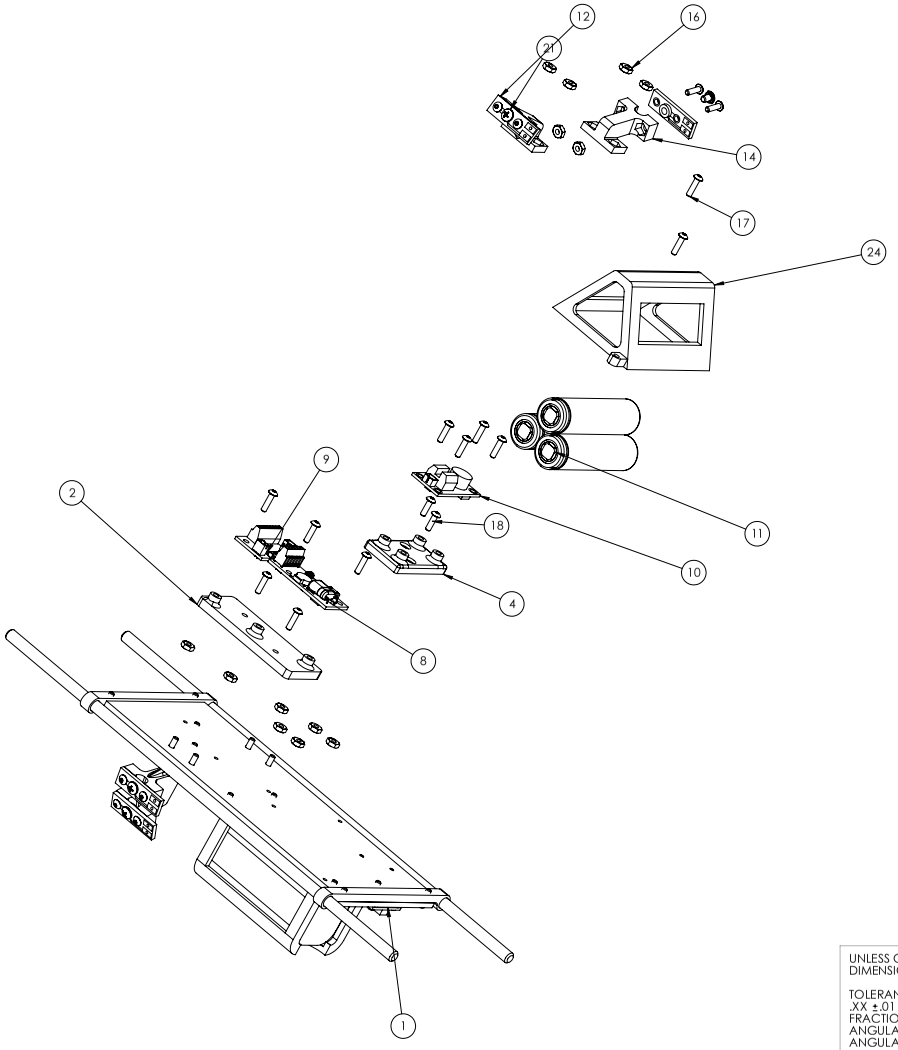
CASE WESTERN RESERVE UNIVERSITY

TITLE: Ebay Sled Subassemly

SIZE:	DATE:	DRAWN BY:
C	1/25/2024	RJP132

MATERIAL:	PART #:	REV:
	24A09017	A

SOLIDWORKS Educational Product. For Instructional Use Only.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A09004	E-BAY SLED	1
2	24A09009	RAVEN4 MOUNT	1
4	24A09007	EASYMINI MOUNT	1
8	24A98002	RAVEN4 ALTIMETER	1
9	24A98011	RAVEN4 BREAKOUT	1
10	24A98004	EASYMINI	1
11	24A98016	USE18650 BATTERY	3
12	24A98012	SCREW SWITCH	5
14	24A09022	SCREW SWITCH MOUNT NUT CARRIER	2
16	24A98009	4-40 SS HEX NUT	25
17	24A98026	4-40 BUTTON HEAD 7/16" BOLT	21
18	24A98028	4-40 BUTTON HEAD 3/8" BOLT	18
21	24A98042	6-32 3/16" BUTTON HEAD SCREW	5
24	24A09026	TRIPLE 18650 BATTERY MOUNT	1

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 3 OF 4

CASE ROCKET TEAM

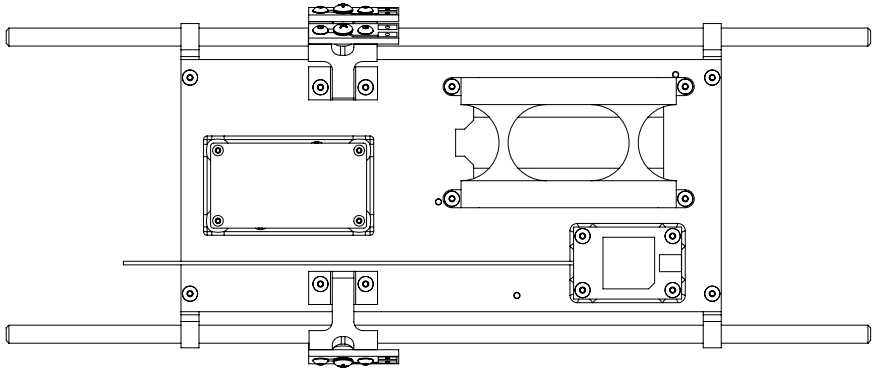
CASE WESTERN RESERVE UNIVERSITY

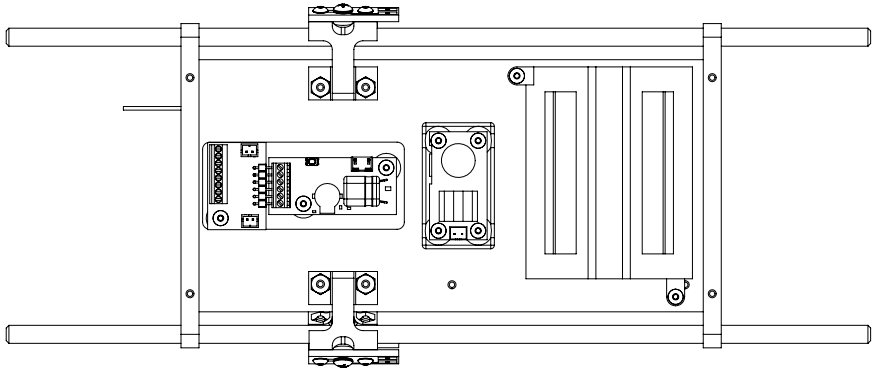
TITLE: Ebay Sled Subassemly

SIZE:	DATE:	DRAWN BY:
C	1/25/2024	RJP132

MATERIAL:	PART #:	REV:
	24A09017	A

SOLIDWORKS Educational Product. For Instructional Use Only.





UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

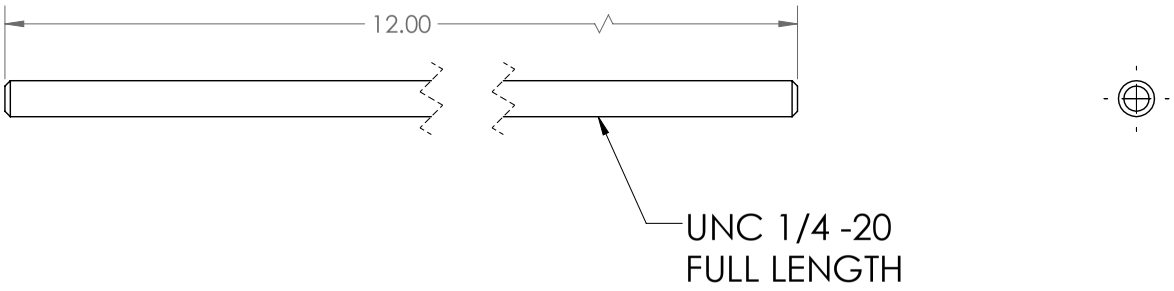
SHEET 4 OF 4

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: Ebay Sled Subassemly			
SIZE: C	DATE: 1/25/2024	DRAWN BY: RJP132	
MATERIAL:		PART #: 24A09017	REV: A

SOLIDWORKS Educational Product. For Instructional Use Only.



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

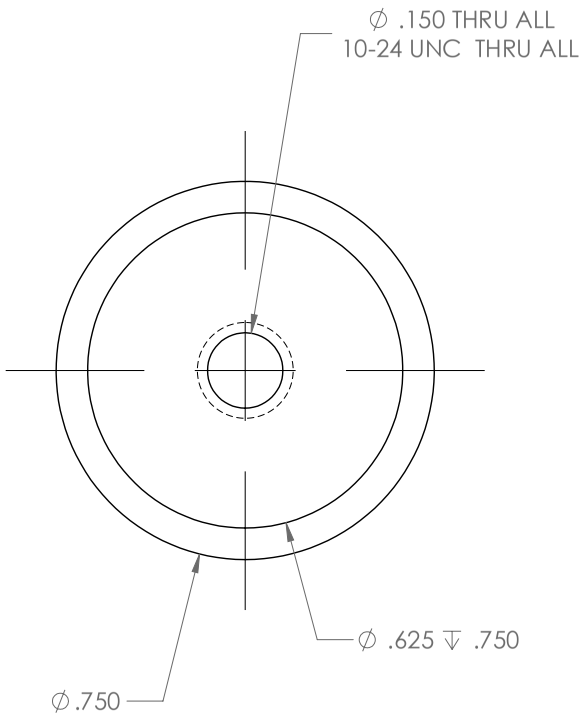
Case Western Reserve University

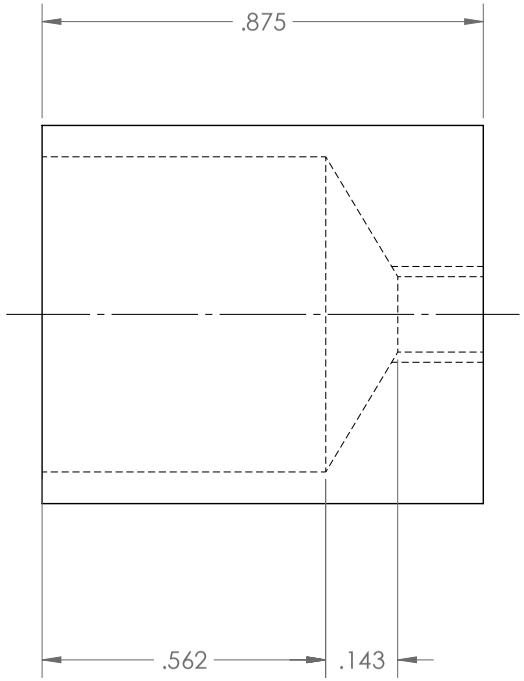
TITLE: THREADED ROD V2

SIZE:	DATE:	DRAWN BY:
A	11/7/2023	EBK48

MATERIAL:	PART #:	REV:
MEDIUM STRENGTH GRADE B7 STEEL	24A09019	C

SOLIDWORKS Educational Product. For Instructional Use Only.





UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

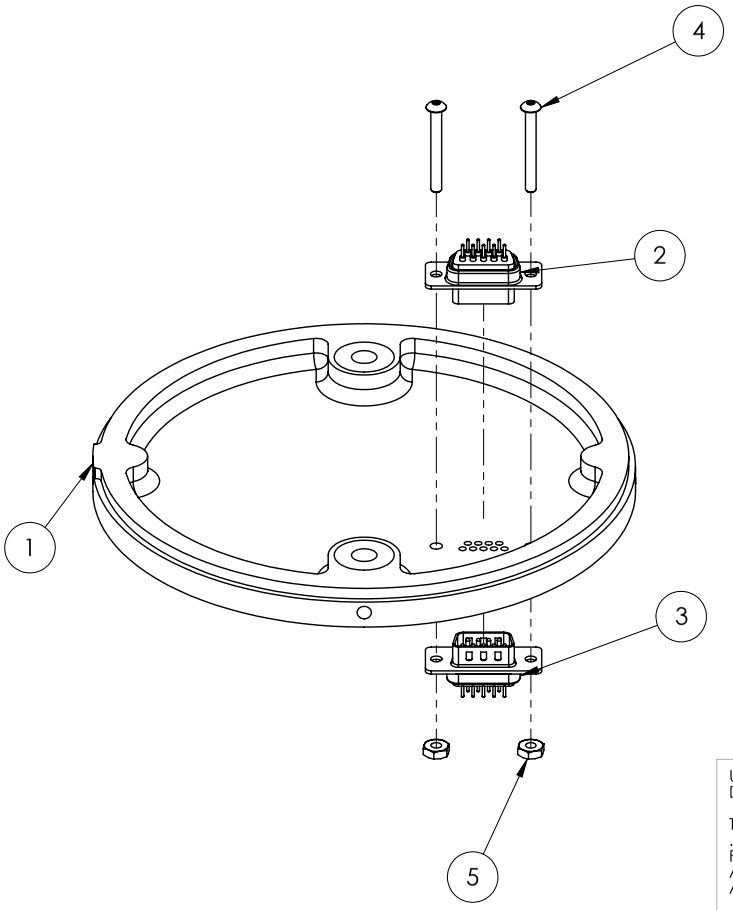
CASE ROCKET TEAM

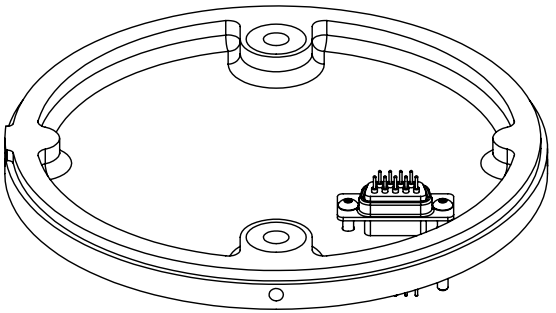
CASE WESTERN RESERVE UNIVERSITY

TITLE:			
CHARGE WELL			
SIZE:	DATE:	DRAWN BY:	
A	10/31/2023	KKW34	
MATERIAL:		PART #:	REV:
6061-T6		24A09020	C

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A09005	LOWER E-BAY BULKHEAD	1
2	24A98060	CIRCUIT BOARD D-SUB SOCKET	1
3	24A98061	CIRCUIT BOARD D-SUB PLUG	1
4	24A98039	4-40 SOCKET HEAD 1" BOLT	2
5	24A98009	4-40 SS HEX NUT	2





UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

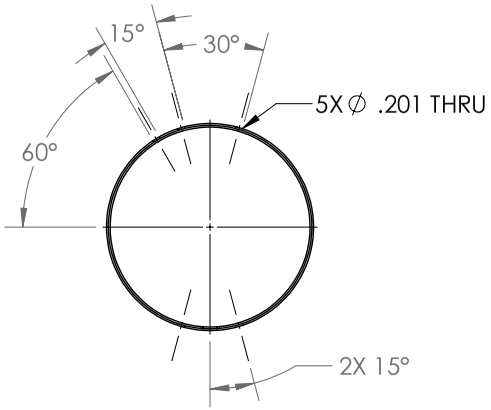
CASE ROCKET TEAM

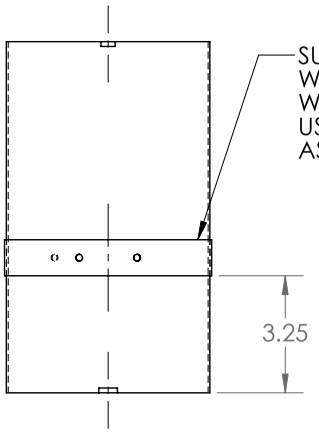
CASE WESTERN RESERVE UNIVERSITY

TITLE:
LOWER E-BAY BULKHEAD SUBASSEMBLY

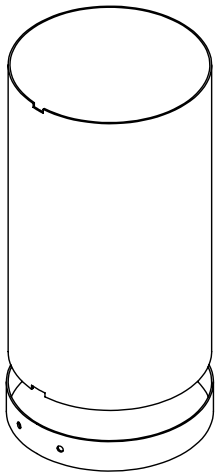
SIZE:	DATE:	DRAWN BY:	
A	2/19/2024	RJP132	
MATERIAL:		PART #: 24A09029	REV: A

SOLIDWORKS Educational Product. For Instructional Use Only.





SURFACE PREP ALL SURFACES
WITH 320 GRIT SAND PAPER
WIPE SURFACES WITH ACETONE
USE LAMINATING EPOXY TO
ASSEMBLE



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

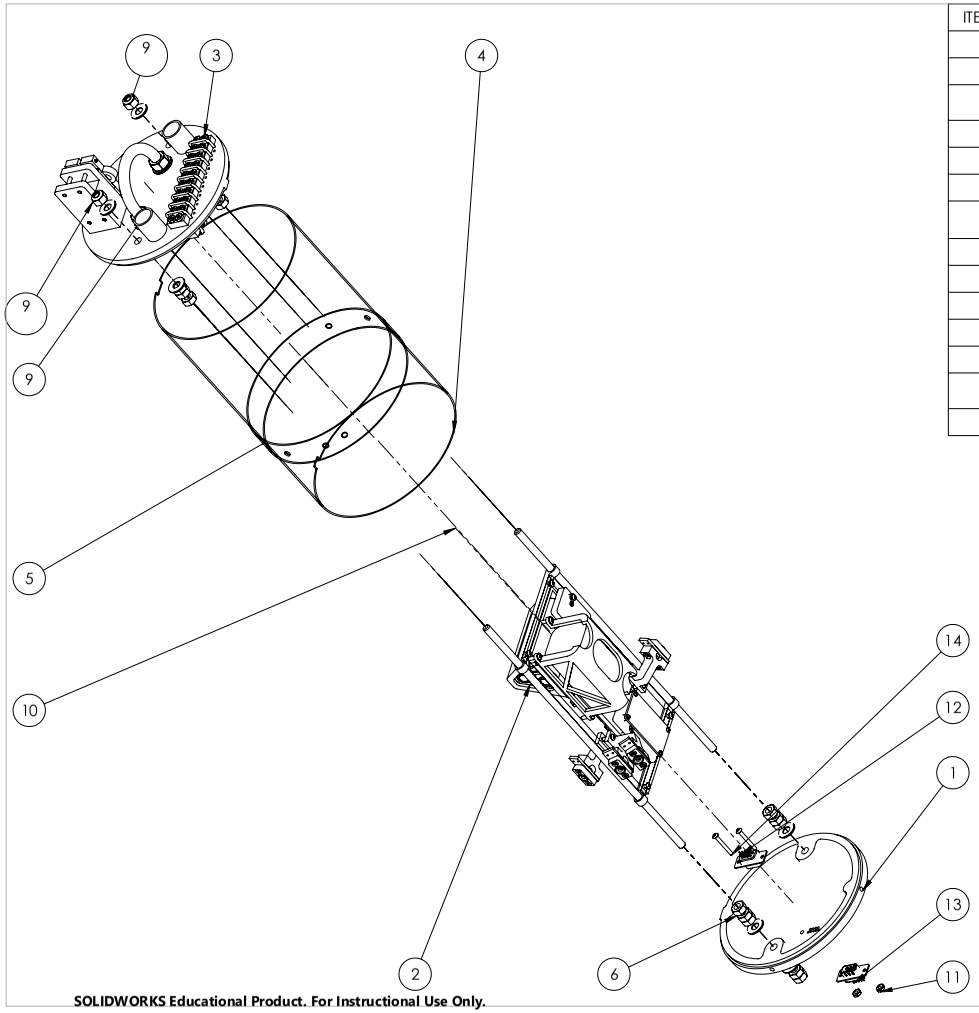
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE:
COUPLER-SWITCHBAND SUBASSEMBLY

SIZE:	DATE:	DRAWN BY:	
A	5/7/2024	JMT231	
MATERIAL:		PART #: 24A09032	REV: A

SOLIDWORKS Educational Product. For Instructional Use Only.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A09005	Lower E-Bay Bulkhead	1
2	24A09017	Ebay Sled Subassemly	1
3	24A09015	UPPER E-BAY BULKHEAD SUBASSEMBLY	1
4	24A09003	E-Bay Coupler	1
5	24A09001	Switchband	1
6	24A98017	18-8 Stainless Steel Hex Nut	16
9	24A98019	18-8 Stainless Steel Nylon-Insert Locknut	10
8	24A98020	18-8 Stainless Steel Hex Nut	4
9	24A98021	316 Stainless Steel Washer	4
11	24A98009	4-40 SS Hex Nut	2
12	24A98060	Circuit Board D-Sub Socket	1
13	24A98061	Circuit Board D-Sub Plug	1
14	24A98039	18-8 Stainless Steel Button Head Hex Drive Screw	2
15	24A09030	Screw Switch Guide	2

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

CASE ROCKET TEAM

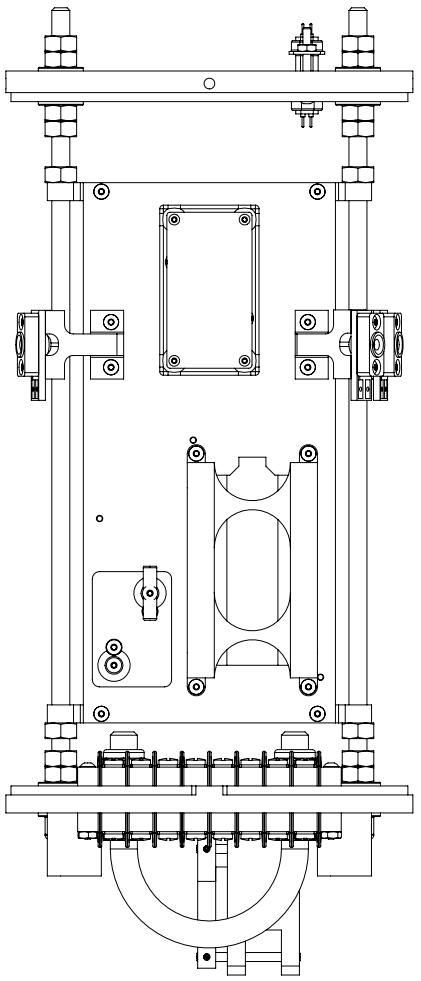
CASE WESTERN RESERVE UNIVERSITY

TITLE: E-Bay Assembly

SIZE:	DATE:	DRAWN BY:
B	1/25/2024	wmc31

MATERIAL:	PART #:	REV:
		A

SOLIDWORKS Educational Product. For Instructional Use Only.



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

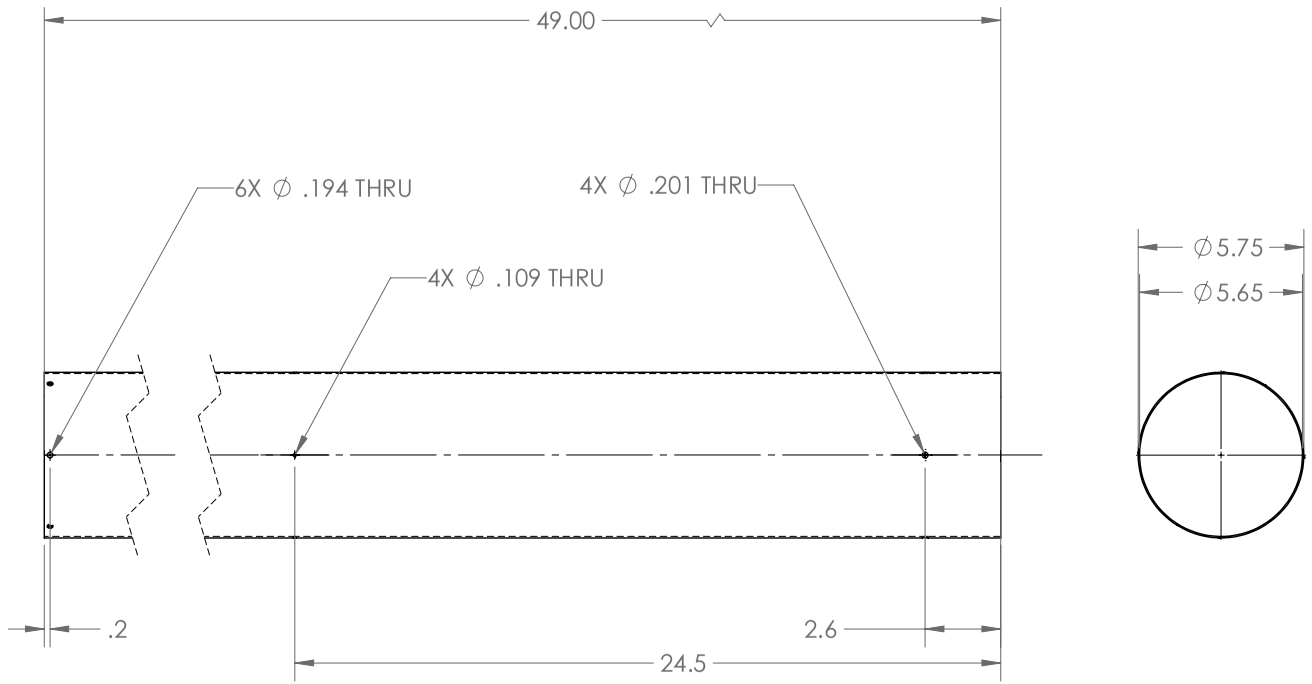
SHEET 2 OF 2

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE:			
E-Bay Assembly			
SIZE:	DATE:	DRAWN BY:	
C	1/25/2024	wcm31	
MATERIAL:		PART #:	REV:
			A

SOLIDWORKS Educational Product. For Instructional Use Only.



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

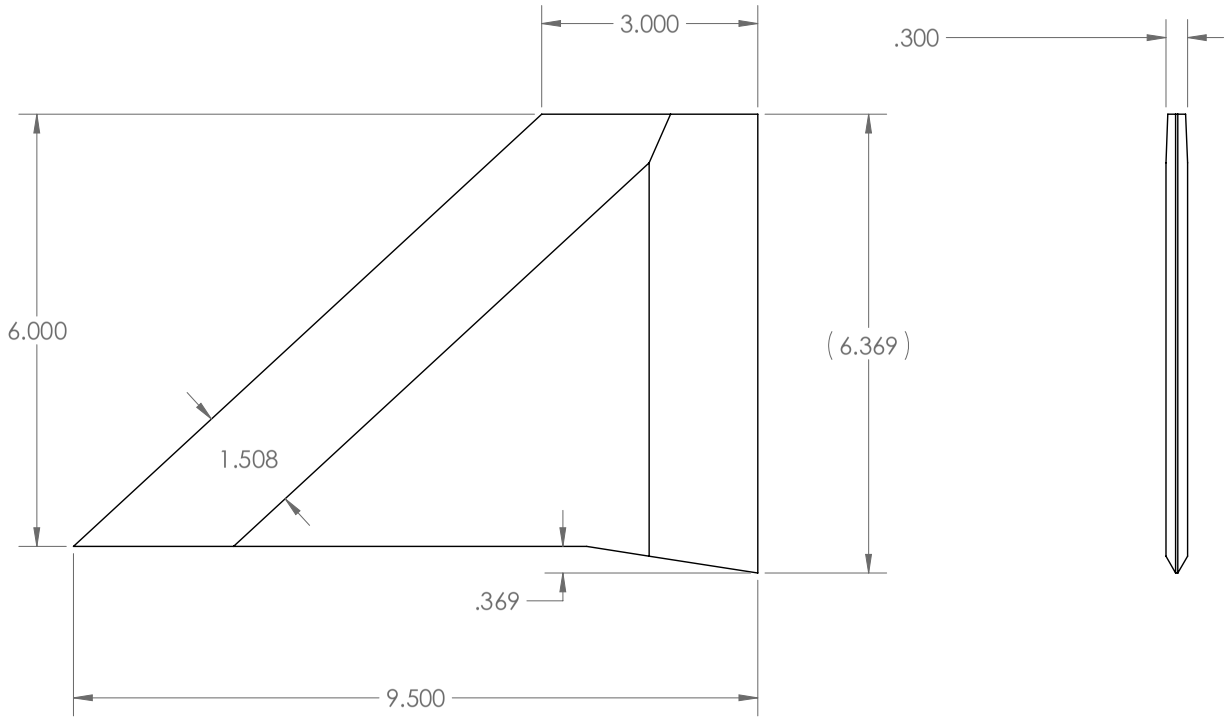
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: LOWER BODY TUBE

SIZE:	DATE:	DRAWN BY:	
A	2/6/2024	DCF69	
MATERIAL:		PART #:	REV:
CRT LAYUP CARBON FIBER		24A10005	B

SOLIDWORKS Educational Product. For Instructional Use Only.



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

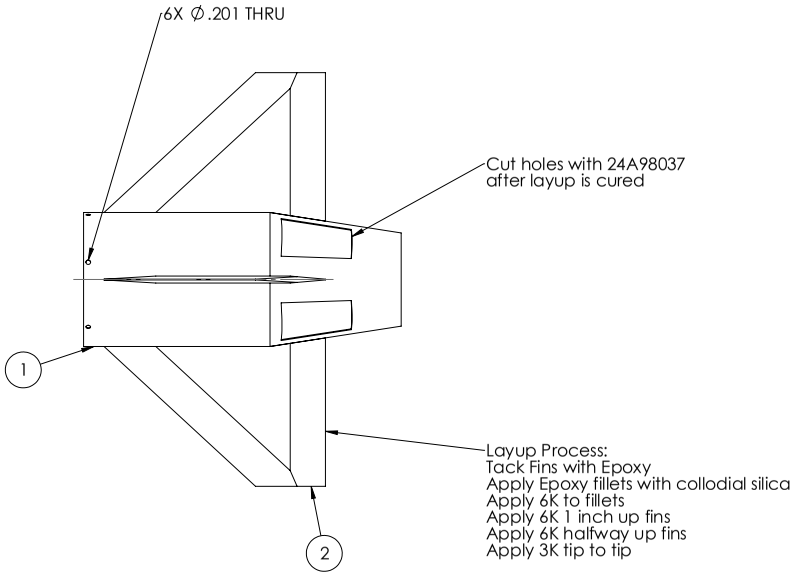
CASE ROCKET TEAM

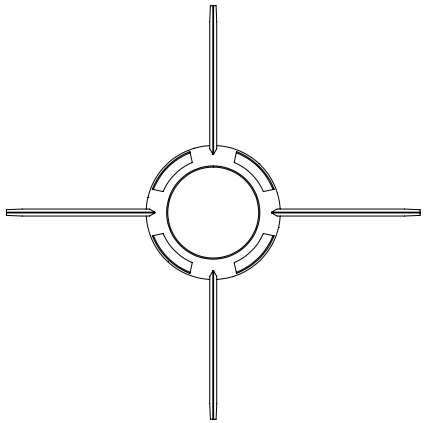
CASE WESTERN RESERVE UNIVERSITY

TITLE: FIN			
SIZE: A	DATE: 2/6/2024	DRAWN BY: SAF122	
MATERIAL: G10		PART #: 24A10006	REV: A

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A10003	FIN CAN	1
2	24A10006	FIN	4





UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

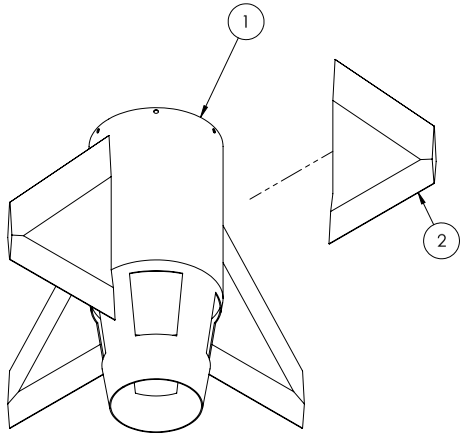
TITLE: Fin Can Epoxy Subassembly

SIZE:	DATE:	DRAWN BY:
B	2/10/2024	RJP132

MATERIAL:	PART #:	REV:
	24A10009	A

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A10003	FIN CAN	1
2	24A10006	FIN	4



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 2

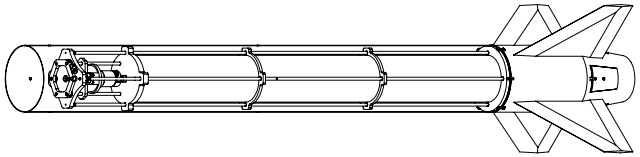
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: Fin Can Epoxy Subassembly

SIZE:	DATE:	DRAWN BY:	
B	2/10/2024	RJP132	
MATERIAL:		PART #: 24A10009	REV: A

SOLIDWORKS Educational Product. For Instructional Use Only.



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

CASE ROCKET TEAM

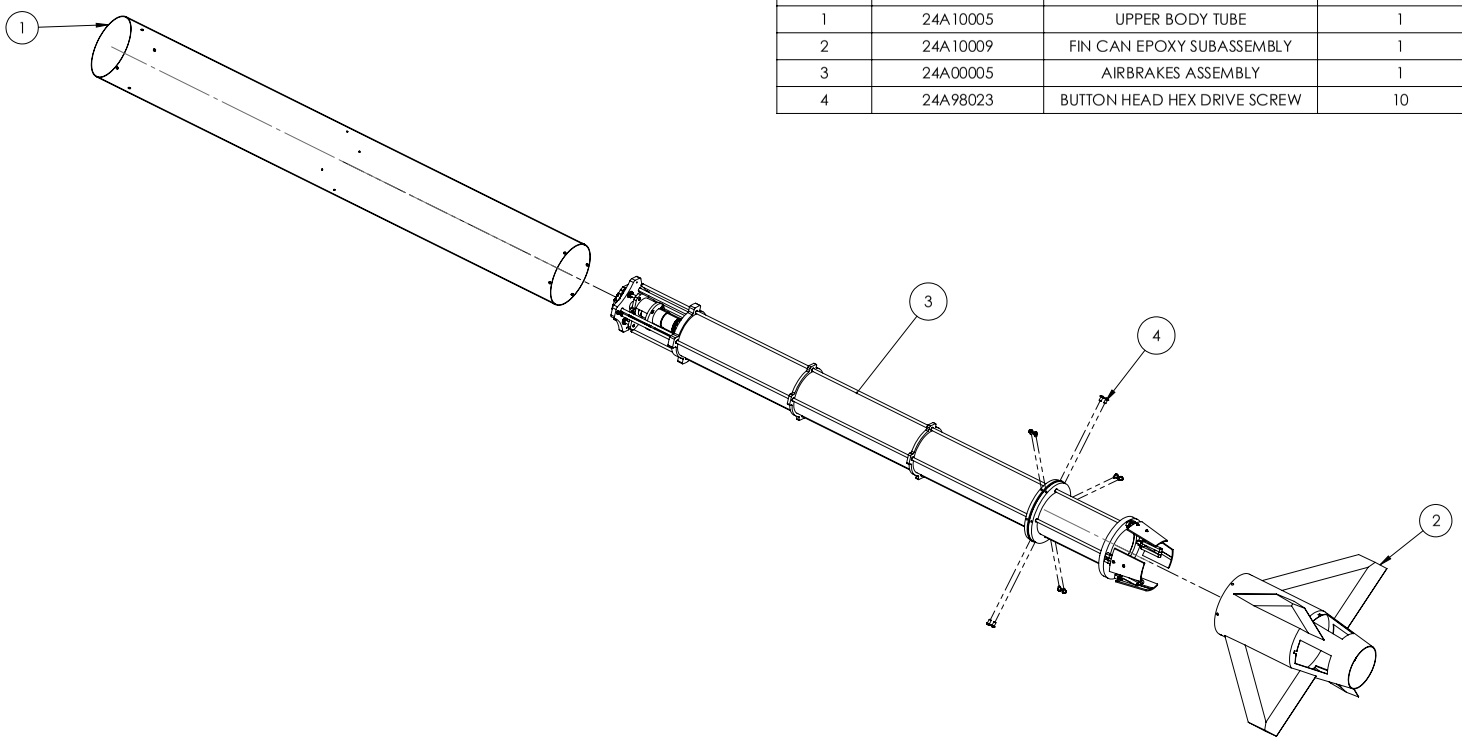
CASE WESTERN RESERVE UNIVERSITY

TITLE: Lower Body Assembly

SIZE:	DATE:	DRAWN BY:	
B	2/8/2024	DCF69	
MATERIAL:		PART #:	REV:
N/A		24A00010	A

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A10005	UPPER BODY TUBE	1
2	24A10009	FIN CAN EPOXY SUBASSEMBLY	1
3	24A00005	AIRBRAKES ASSEMBLY	1
4	24A98023	BUTTON HEAD HEX DRIVE SCREW	10



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 2

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

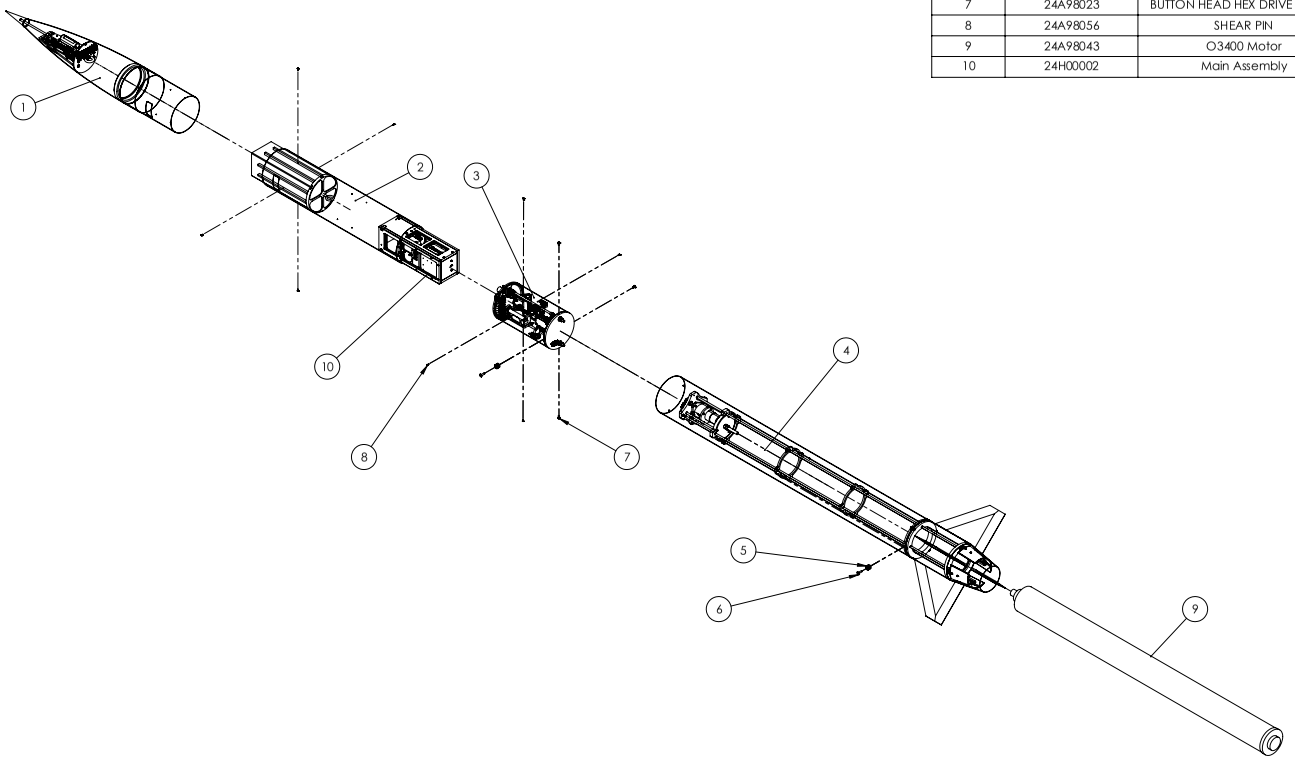
TITLE: Lower Body Assembly

SIZE:	DATE:	DRAWN BY:
B	2/8/2024	DCF69

MATERIAL:	PART #:	REV:
N/A	24A10000	A

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A00007	NOSE CONE SUBASSSEMBLY	1
2	24A00008	PAYLOAD SUBASSEMBLY	1
3	24A00009	E-BAY SUBASSEMBLY	1
4	24A00010	LOWER BODY SUBASSEMBLY	1
5	24A10004	1515 RAIL BUTTONS	2
6	24A98046	#10-24 3/4" FLAT HEAD BOLT	2
7	24A98023	BUTTON HEAD HEX DRIVE SCREW	3
8	24A98056	SHEAR PIN	8
9	24A98043	O3400 Motor	1
10	24H00002	Main Assembly	1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

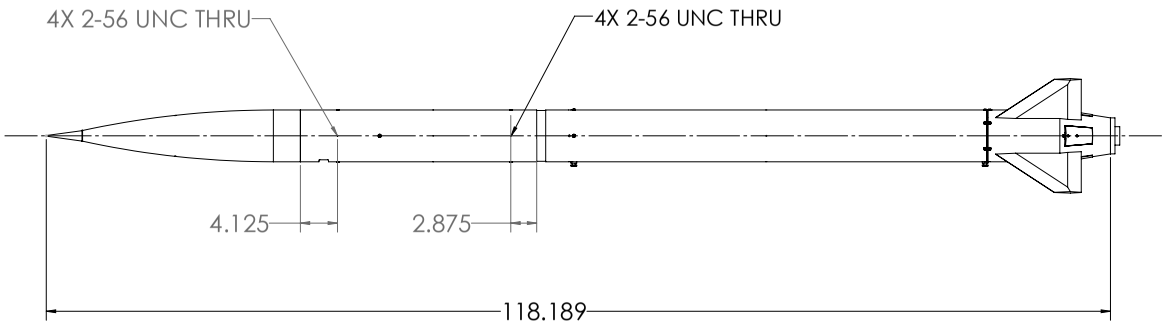
CASE ROCKET TEAM

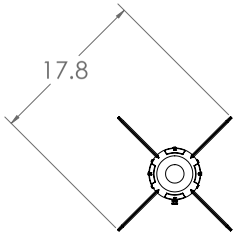
CASE WESTERN RESERVE UNIVERSITY

TITLE:			
MAIN ASSEMBLY			
SIZE:	DATE:	DRAWN BY:	
C	2/12/2024	DCF69	
MATERIAL:		PART #:	REV:
N/A		24A00000	A

SOLIDWORKS Educational Product. For Instructional Use Only.

NOTE: DRILL #2-56 TAP SIZED HOLE THRU
BOTH UPPER BODY TUBE AND COUPLER. REMOVE
BODY TUBE, DRILL 0.096 HOLE THRU COUPLERS.
TAP HOLES IN BODY TUBE.





UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 2

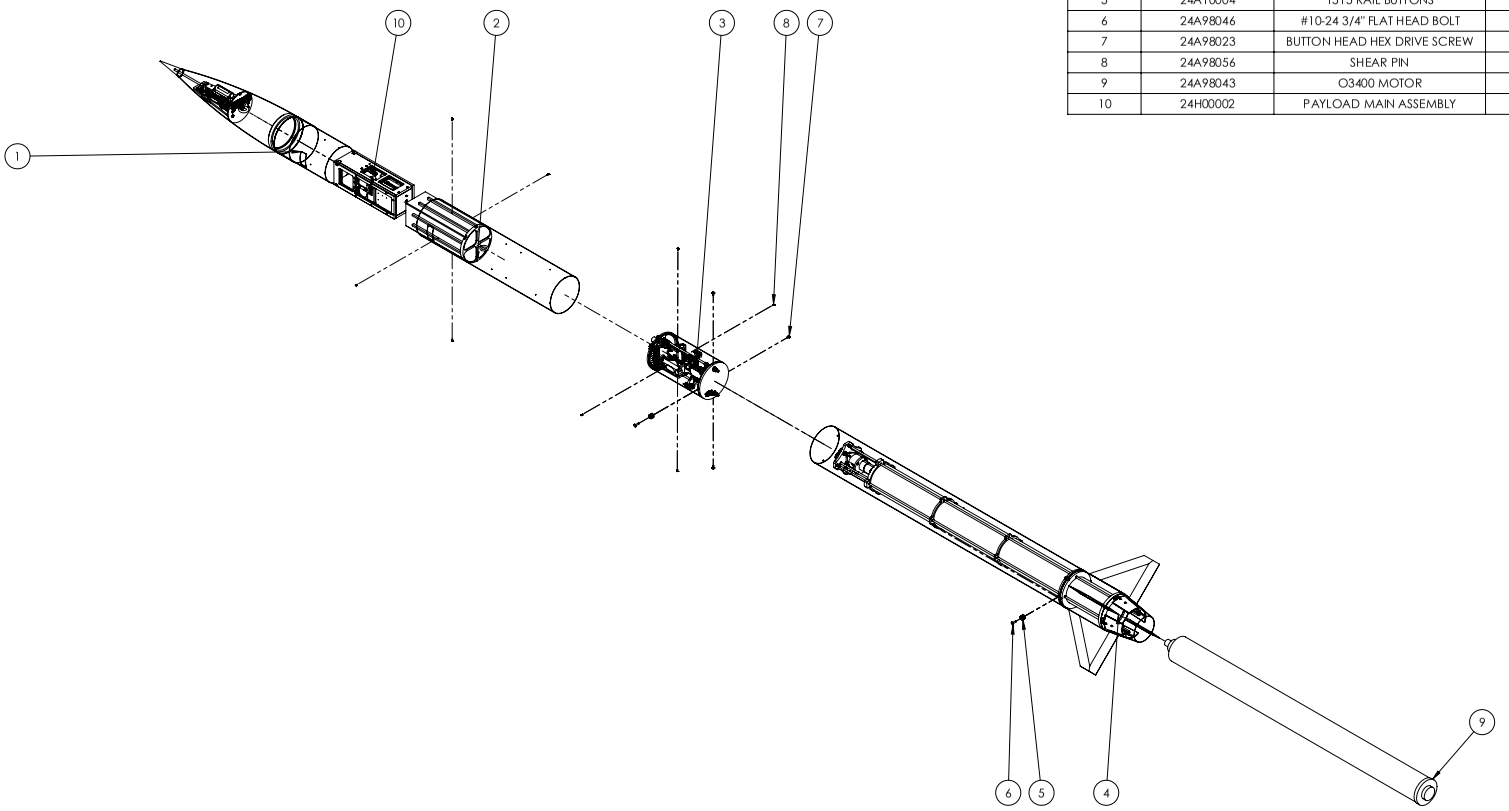
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: MAIN ASSEMBLY			
SIZE: C	DATE: 2/12/2024	DRAWN BY: DCF69	
MATERIAL: N/A		PART #: 24A00000	REV: A

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24A00007	NOSE CONE SUBASSSEMBLY	1
2	24A00008	PAYLOAD SUBASSEMBLY	1
3	24A00009	E-BAY SUBASSEMBLY	1
4	24A00010	LOWER BODY SUBASSEMBLY	1
5	24A10004	1515 RAIL BUTTONS	2
6	24A98046	#10-24 3/4" FLAT HEAD BOLT	2
7	24A98023	BUTTON HEAD HEX DRIVE SCREW	3
8	24A98056	SHEAR PIN	8
9	24A98043	O3400 MOTOR	1
10	24H00002	PAYLOAD MAIN ASSEMBLY	1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

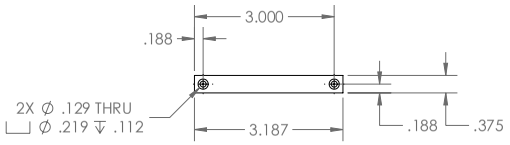
CASE ROCKET TEAM

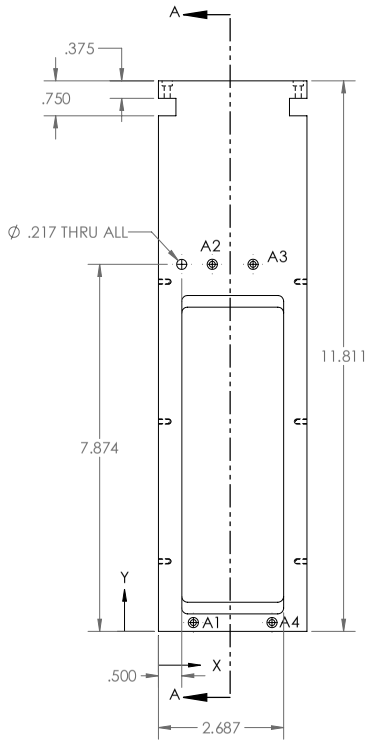
CASE WESTERN RESERVE UNIVERSITY

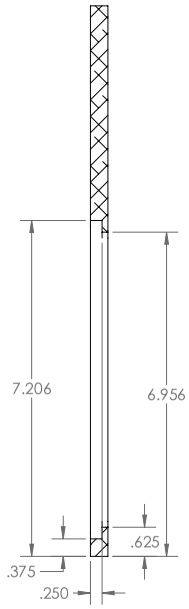
TITLE:			
MAIN ASSEMBLY			
SIZE:	DATE:	DRAWN BY:	
C	2/12/2024	DCF69	
MATERIAL:		PART #:	REV:
N/A		24A00000	A

SOLIDWORKS Educational Product. For Instructional Use Only.

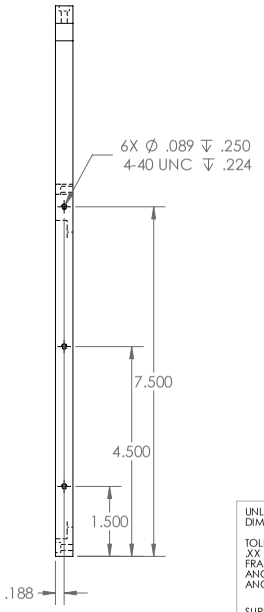
TAG	X LOC	Y LOC	SIZE
A1	.75	.19	⌀ .129 THRU ALL ⌴ ⌀ .219 ↧ .112
A2	1.16	7.87	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A3	2.03	7.87	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A4	2.44	.19	⌀ .129 THRU ALL ⌴ ⌀ .219 ↧ .112







SECTION A-A
SCALE 1 : 2



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

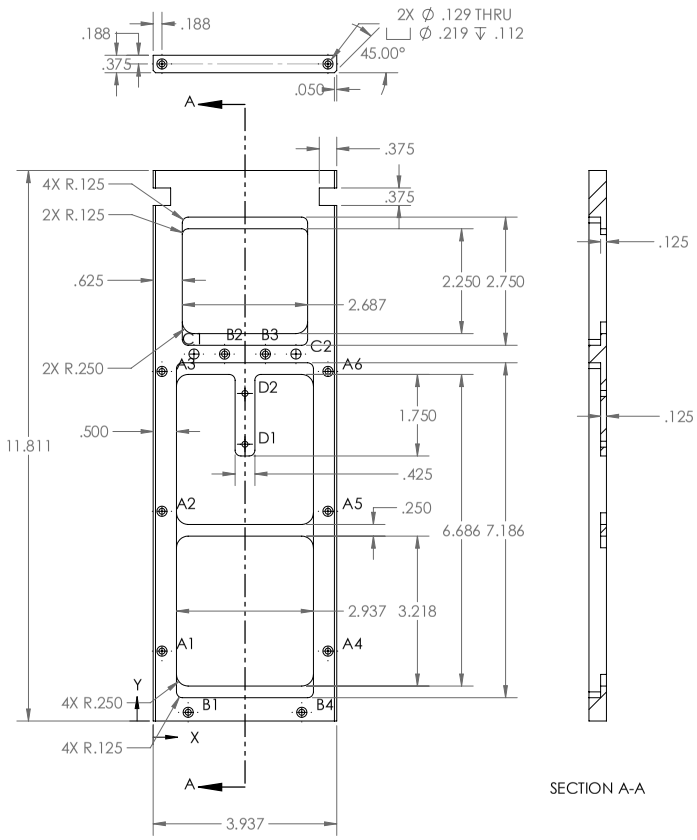
CASE WESTERN RESERVE UNIVERSITY

TITLE: Side Plate

SIZE:	DATE:	DRAWN BY:
B	3/5/2024	lma84

MATERIAL:	PART #:	REV:
		A

SOLIDWORKS Educational Product. For Instructional Use Only.



SECTION A-A

TAG	X LOC	Y LOC	SIZE
A1	.19	1.50	∅ .129 THRU ⌴ ∅ .219 ↧ .112
A2	.19	4.50	∅ .129 THRU ⌴ ∅ .219 ↧ .112
A3	.19	7.50	∅ .129 THRU ⌴ ∅ .219 ↧ .112
A4	3.75	1.50	∅ .129 THRU ⌴ ∅ .219 ↧ .112
A5	3.75	4.50	∅ .129 THRU ⌴ ∅ .219 ↧ .112
A6	3.75	7.50	∅ .129 THRU ⌴ ∅ .219 ↧ .112
B1	.75	.19	∅ .129 THRU ⌴ ∅ .219 ↧ .112
B2	1.53	7.87	∅ .129 THRU ⌴ ∅ .219 ↧ .112
B3	2.41	7.87	∅ .129 THRU ⌴ ∅ .219 ↧ .112
B4	3.19	.19	∅ .129 THRU ⌴ ∅ .219 ↧ .112
C1	.88	7.87	∅ .217 THRU
C2	3.06	7.87	∅ .217 THRU
D1	1.97	5.94	∅ .129 THRU
D2	1.97	7.03	∅ .129 THRU

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

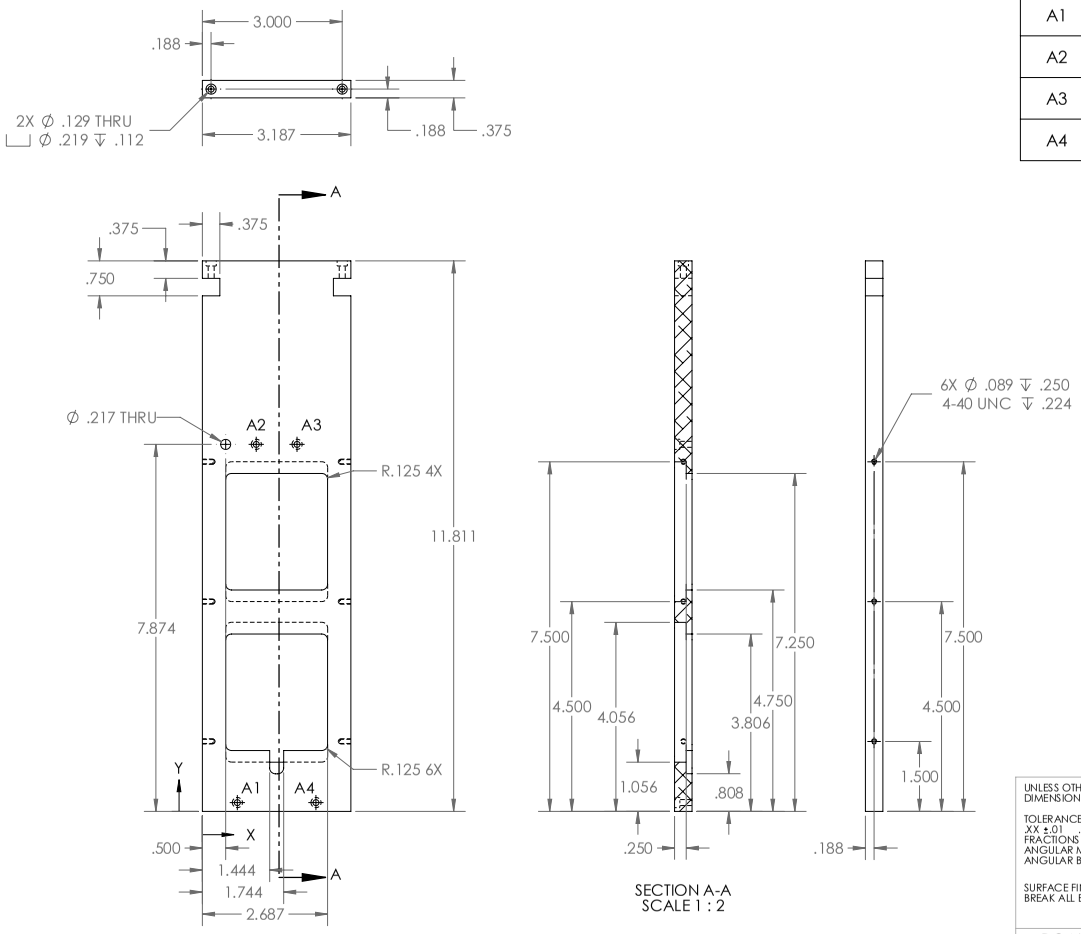
TITLE: Front Plate

SIZE:	DATE:	DRAWN BY:
B	3/5/2024	CAR185

MATERIAL:	PART #:	REV:
302 Stainless Steel	24H02003	A

SOLIDWORKS Educational Product. For Instructional Use Only.

TAG	X LOC	Y LOC	SIZE
A1	.75	.19	⌀ .129 THRU ALL ⌴ ⌀ .219 ↧ .112
A2	1.16	7.87	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A3	2.03	7.87	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A4	2.44	.19	⌀ .129 THRU ALL ⌴ ⌀ .219 ↧ .112



SECTION A-A
SCALE 1 : 2

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

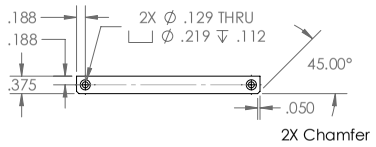
CASE WESTERN RESERVE UNIVERSITY

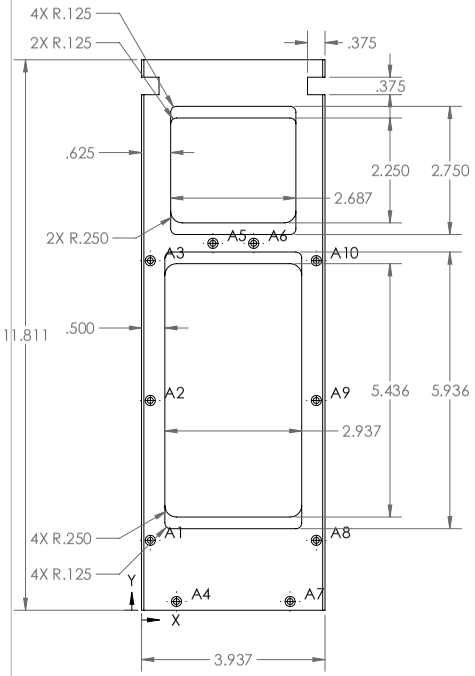
TITLE: Side Plate

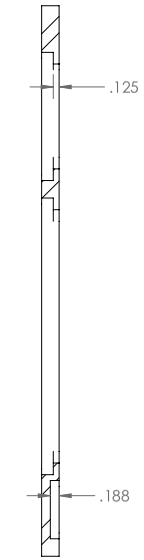
SIZE:	DATE:	DRAWN BY:
B	3/5/2024	lma84

MATERIAL:	PART #:	REV:
		A

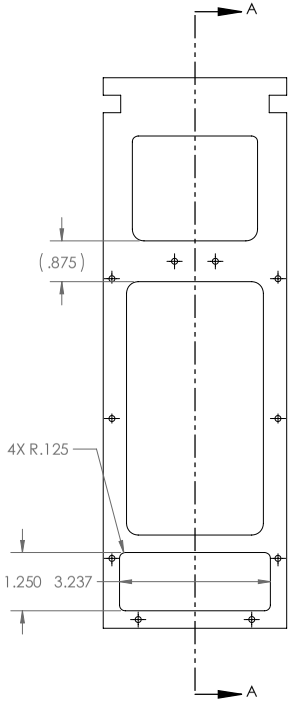
TAG	X LOC	Y LOC	SIZE
A1	.19	1.50	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A2	.19	4.50	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A3	.19	7.50	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A4	.75	.19	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A5	1.53	7.87	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A6	2.41	7.87	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A7	3.19	.19	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A8	3.75	1.50	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A9	3.75	4.50	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112
A10	3.75	7.50	⌀ .129 THRU ⌴ ⌀ .219 ↧ .112







SECTION A-A



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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

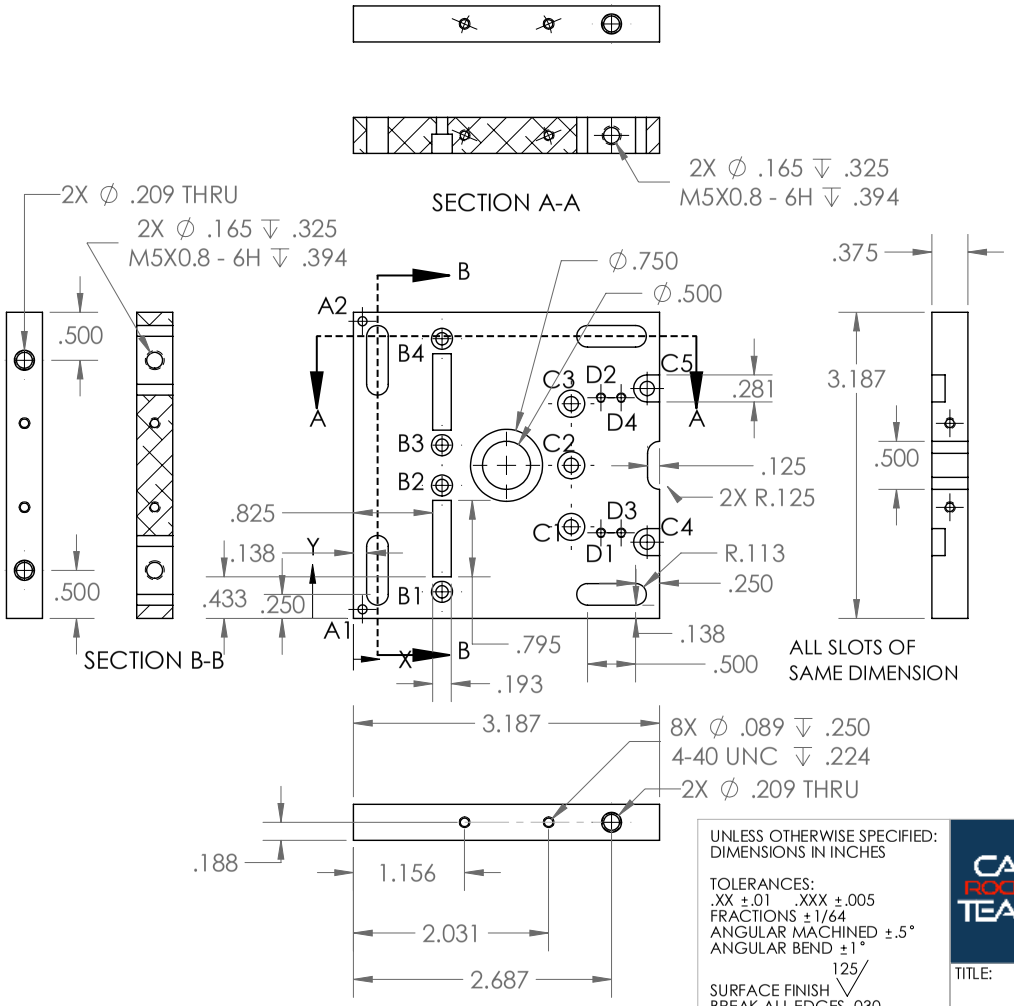
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: Front Plate

SIZE:	DATE:	DRAWN BY:
B	3/5/2024	CAR185

MATERIAL:	PART #:	REV:
302 Stainless Steel	24H02001	A



TAG	X LOC	Y LOC	SIZE
A1	.094	.094	∅ .094 THRU
A2	.094	3.093	∅ .094 THRU
B1	.922	.276	∅ .129 THRU ⌴ ∅ .219 ↧ .200
B2	.922	1.384	∅ .129 THRU ⌴ ∅ .219 ↧ .200
B3	.922	1.803	∅ .129 THRU ⌴ ∅ .219 ↧ .200
B4	.922	2.911	∅ .129 THRU ⌴ ∅ .219 ↧ .200
C1	2.267	.953	∅ .150 THRU ⌴ ∅ .281 ↧ .138
C2	2.267	1.594	∅ .150 THRU ⌴ ∅ .281 ↧ .138
C3	2.267	2.235	∅ .150 THRU ⌴ ∅ .281 ↧ .138
C4	3.058	.794	∅ .150 THRU ⌴ ∅ .281 ↧ .138
C5	3.058	2.394	∅ .150 THRU ⌴ ∅ .281 ↧ .138
D1	2.576	.890	∅ .082 THRU 3-56 UNF ↧ .200
D2	2.576	2.297	∅ .082 THRU 3-56 UNF ↧ .200
D3	2.787	.890	∅ .082 THRU 3-56 UNF ↧ .200
D4	2.787	2.297	∅ .082 THRU 3-56 UNF ↧ .200

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

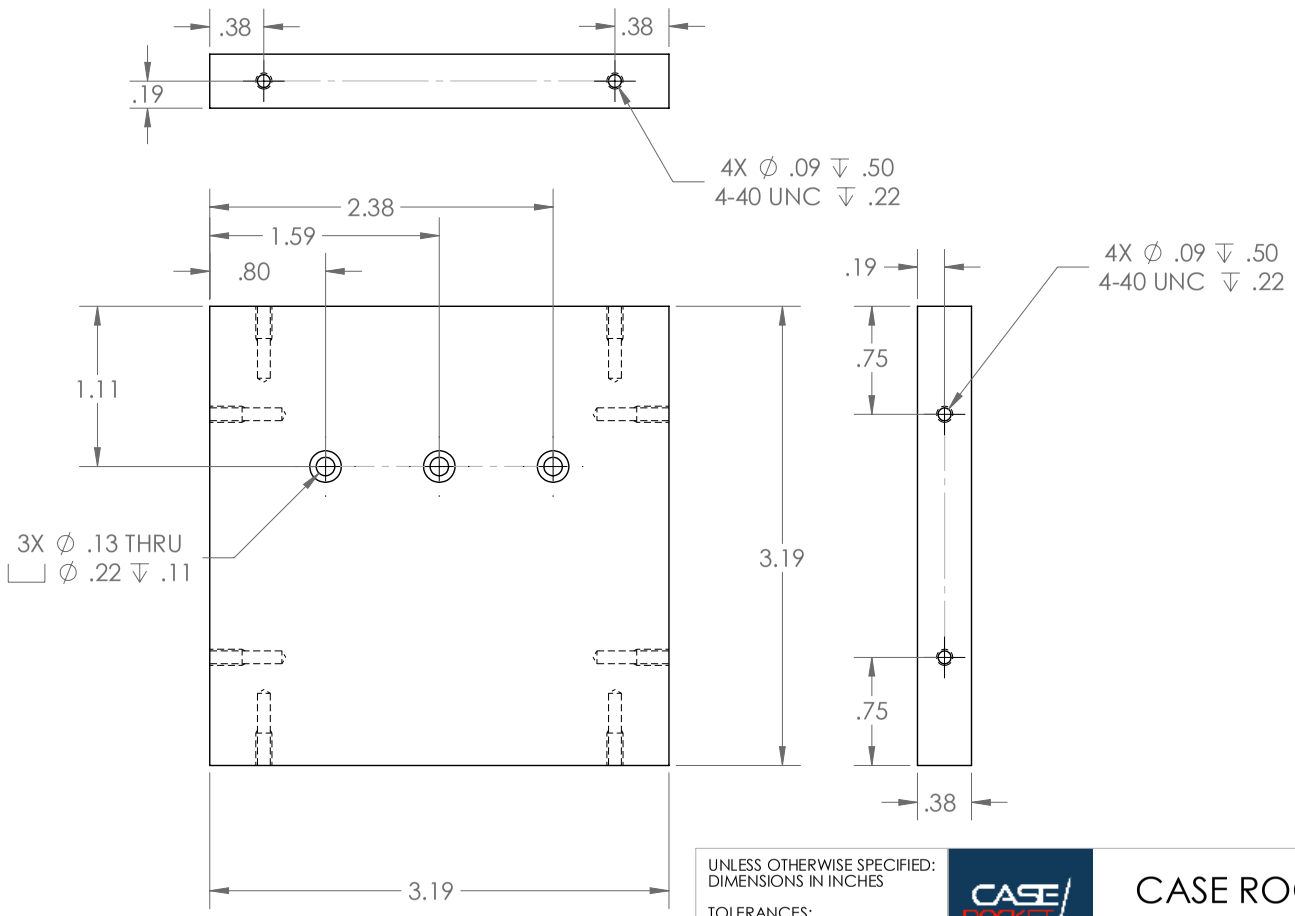
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: RECOVERY BULKHEAD

SIZE:	DATE:	DRAWN BY:	
A	3/7/2024	CAR185	
MATERIAL:		PART #:	REV:
6061-T6		24H02006	A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

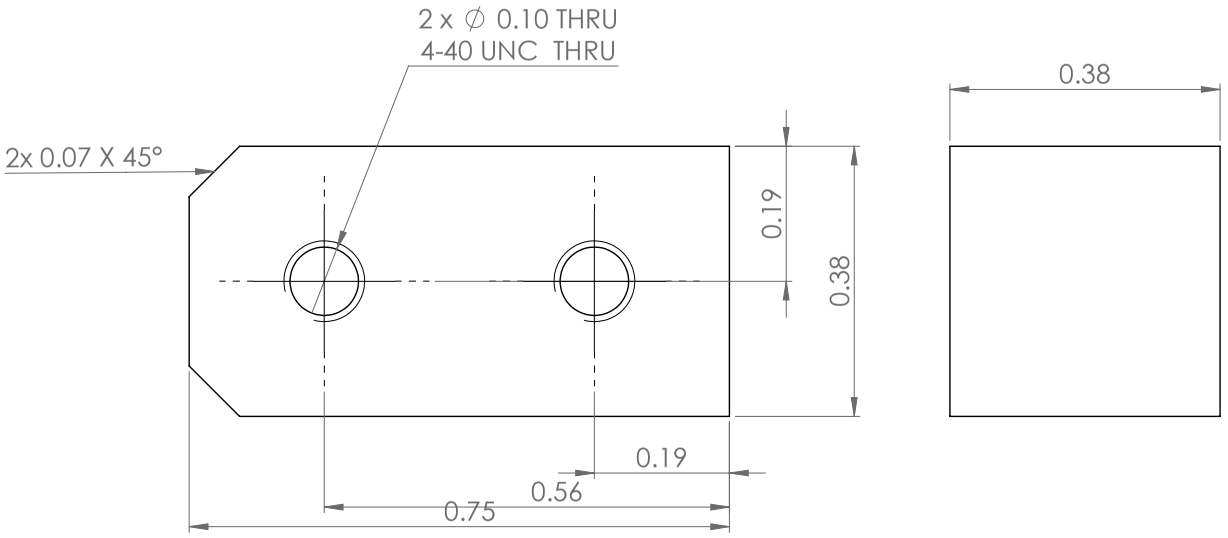
SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: LOWER BULKHEAD			
SIZE: A	DATE: 3/7/2024	DRAWN BY: CAR185	
MATERIAL: 6061-T6		PART #: 24H02005	REV: A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

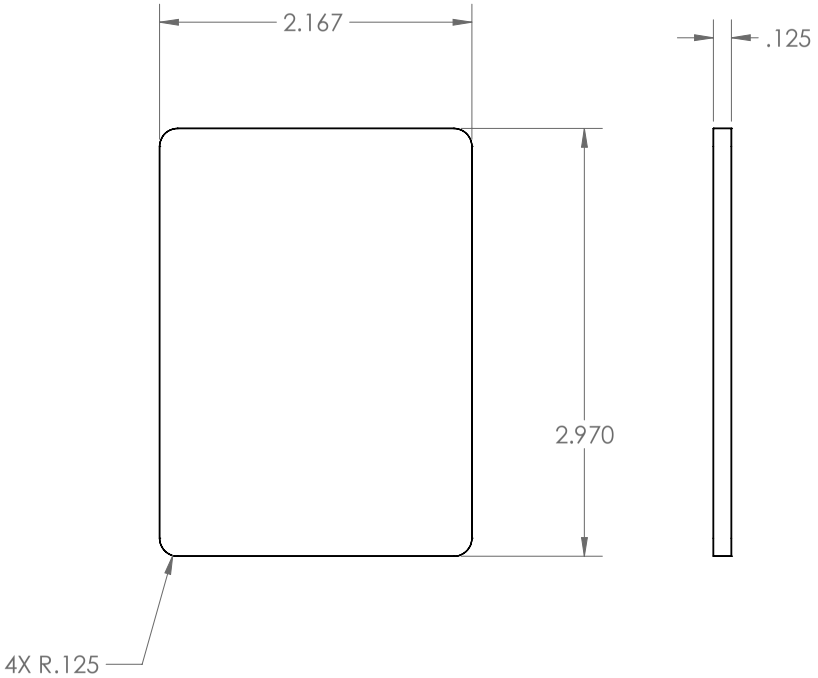
SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: FRAME PLATE CONNECTOR			
SIZE: A	DATE: 3/5/2024	DRAWN BY: PAQ4	
MATERIAL: PETG		PART #: 24H02009	REV: B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

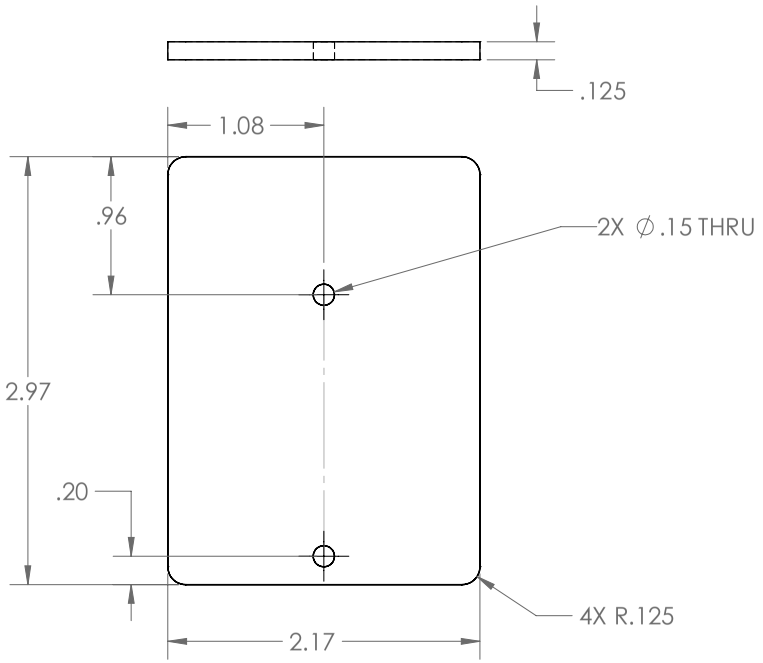
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: FAME SHIELD 1

SIZE:	DATE:	DRAWN BY:	
A	3/7/2024	CAR185	
MATERIAL:		PART #:	REV:
ACRYLIC (MEDIUM-HIGH IMPACT)		24H02010	A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

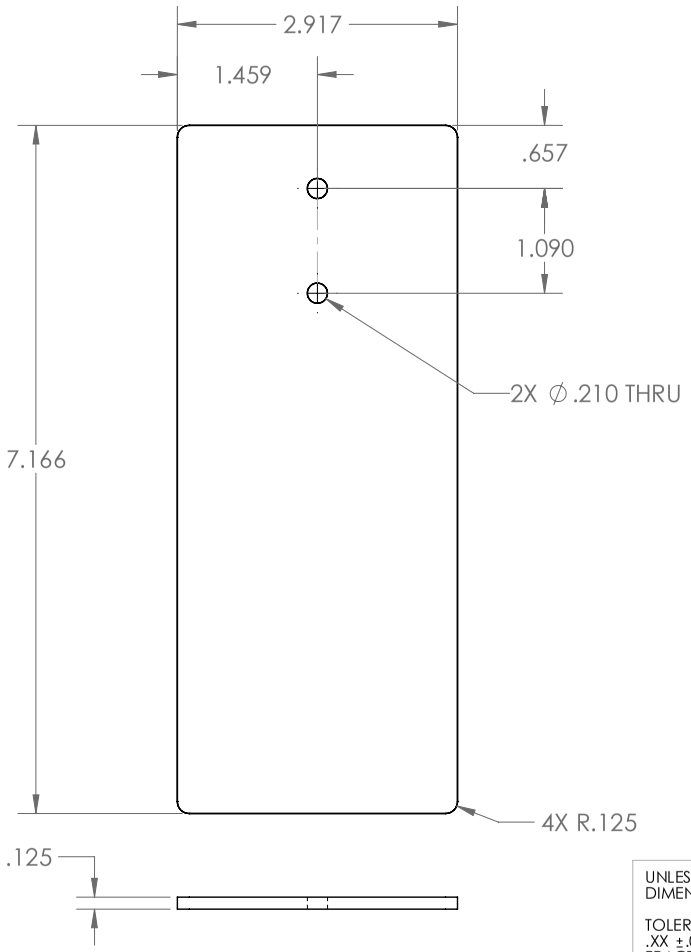
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: FRAME SHIELD 02

SIZE:	DATE:	DRAWN BY:	
A	3/7/2024	CAR185	
MATERIAL:		PART #:	REV:
ACRYLIC (MEDIUM-HIGH IMPACT)		24H02011	A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

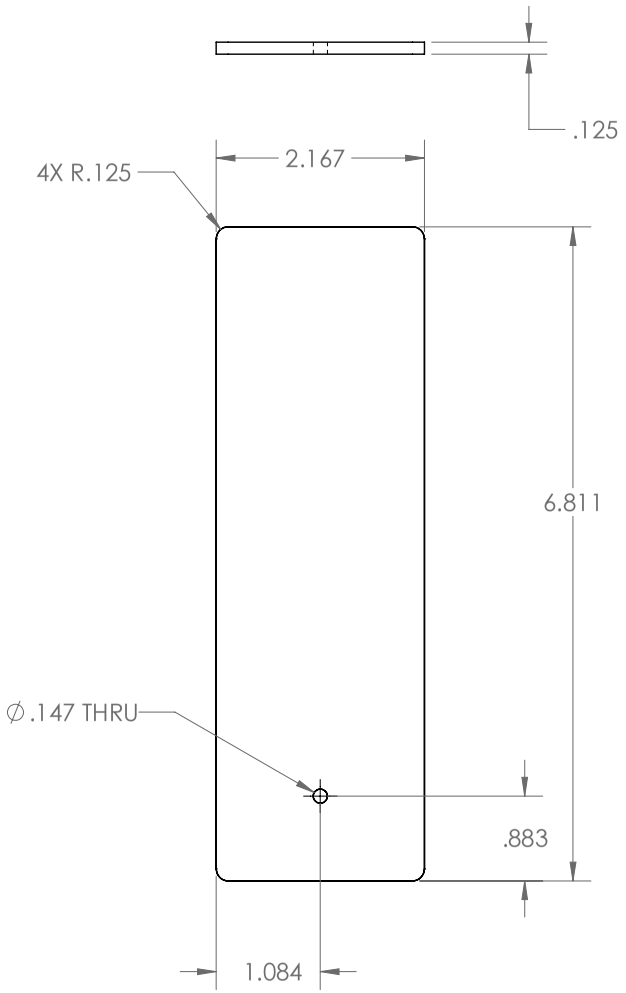
SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: FRAME SHIELD 03			
SIZE: A	DATE: 3/7/2024	DRAWN BY: CAR185	
MATERIAL: ACRYLIC (MEDIUM-HIGH IMPACT)		PART #: 24H02012	REV: A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

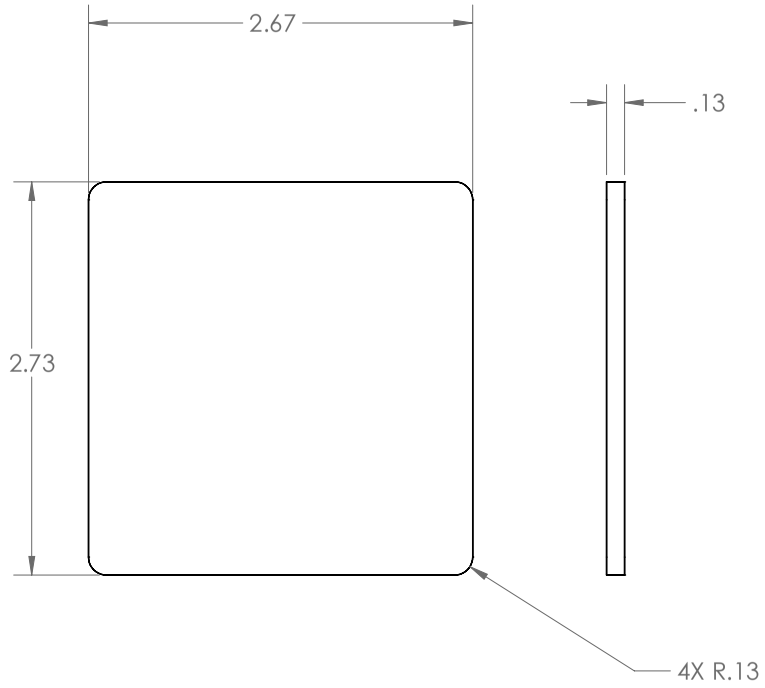
SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: FRAME SHIELD 4			
SIZE: A	DATE: 3/7/2024	DRAWN BY: CAR185	
MATERIAL: ACRYLIC (MEDIUM-HIGH IMPACT)		PART #: 24H02013	REV: A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

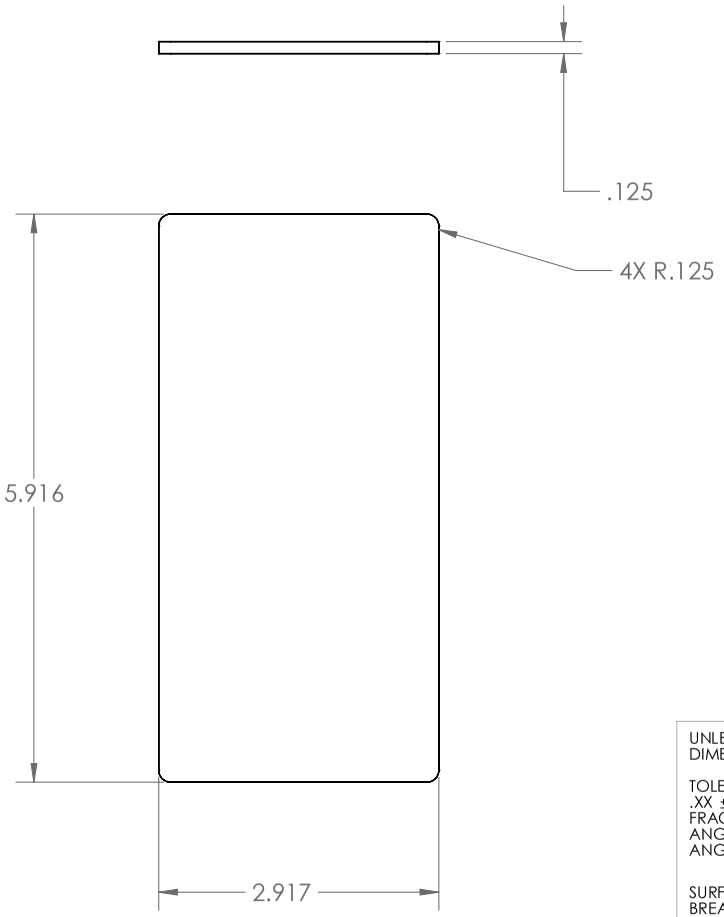
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: FRAME SHIELD 5

SIZE:	DATE:	DRAWN BY:	
A	3/7/2024	CAR185	
MATERIAL:		PART #:	REV:
ACRYLIC (MEDIUM-HIGH IMPACT)		24H02014	A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

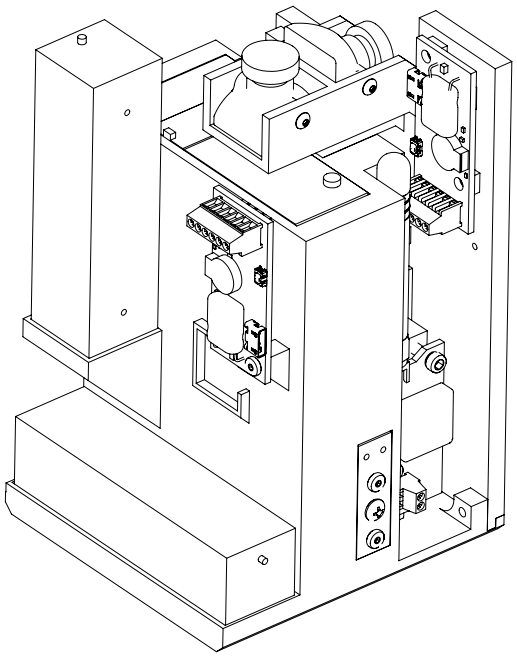
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: FRAME PLATE 6

SIZE:	DATE:	DRAWN BY:	
A	3/7/2024	CAR185	
MATERIAL:		PART #:	REV:
ACRYLIC (MEDIUM-HIGH IMPACT)		24H02015	A

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ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24H03011	Rear Electronics Sled	1
2	24H03002	Raven 4 Altimeter	2
3	24H03004	Featherweight GPS	1
4	24H03005	Featherweight Antenna	1
5	24H03007	Screw switch	3
6	24H03008	RunCam Board	2
7	24H03003	RunCam Split 3	2
8	24H03010	Main Electronics Sled	1
9	24H03018	Double Li-ion cell holder	1
10	24H03016	Snigle Li-ion cell holder	2
11	24H03017	LiFe Battery	2
12	24H98007	18-8 Stainless Steel Low-Profile Socket Head Screw	10
13	24H98003	Black Oxide 18-8 Stainless Steel Socket Head Screw	2
14	24H98008	18-8 Stainless Steel Button Head Hex Drive Screw	16
15	24H98016	Rounded Head Thread-Cutting Screws for Metal	3
16	24H03030	Supernova	1
17	24H03031		1

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

CASE ROCKET TEAM

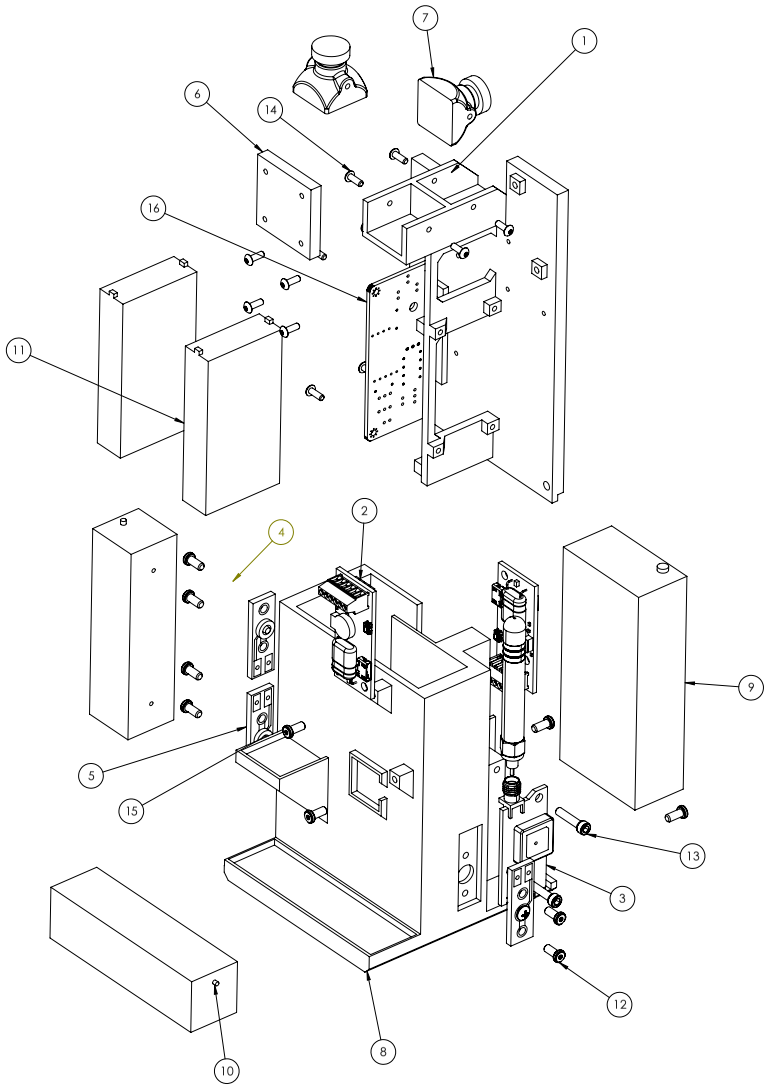
CASE WESTERN RESERVE UNIVERSITY

TITLE: Electronics Mount Exploded View

SIZE:	DATE:	DRAWN BY:
C	3/7/2024	CAR185

MATERIAL:	PART #:	REV:
	24H03012	A

SOLIDWORKS Educational Product. For Instructional Use Only.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24H03011	Rear Electronics Sled	1
2	24H03002	Raven 4 Altimeter	2
3	24H03004	Featherweight GPS	1
4	24H03005	Featherweight Antenna	1
5	24H03007	Screw switch	3
6	24H03008	RunCam Board	2
7	24H03003	RunCam Split 3	2
8	24H03010	Main Electronics Sled	1
9	24H03018	Double Li-ion Holder	1
10	24H03016	Single Li-ion Holder	2
11	24H03017	LiFe Battery	2
12	24H98007	18-8 Stainless Steel Low-Profile Socket Head Screw	10
13	24H98003	Black Oxide 18-8 Stainless Steel Socket Head Screw	2
14	24H98008	18-8 Stainless Steel Button Head Hex Drive Screw	16
15	24H98016	Rounded Head Thread-Cutting Screws for Metal	3
16	24H03030	Supernova	1
17	24H03031		1

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 2

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

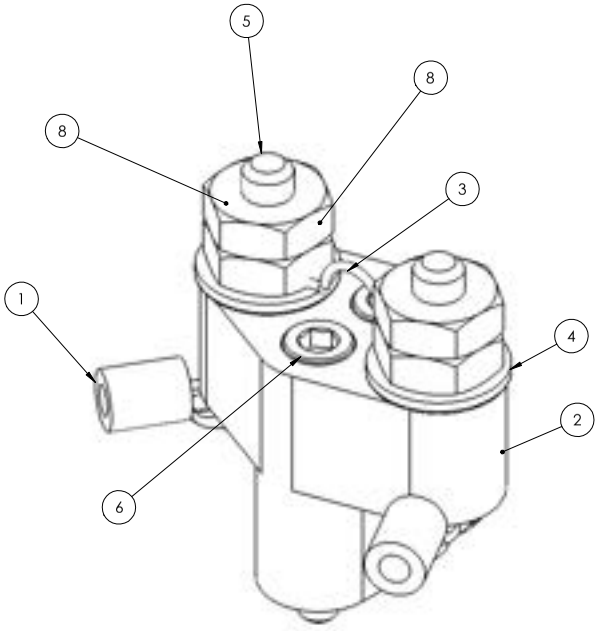
TITLE: Electronics Mount Exploded View

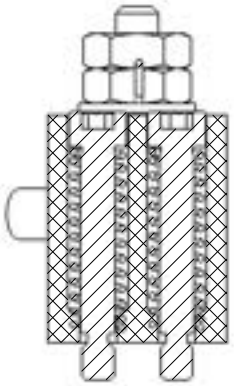
SIZE:	DATE:	DRAWN BY:
C	3/7/2024	CAR185

MATERIAL:	PART #:	REV:
	24H03012	A

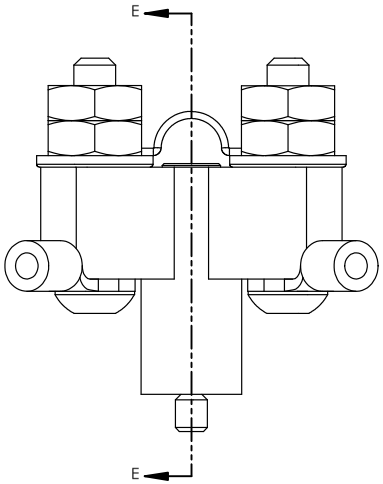
SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24H98017	Ring Terminals	2
2	24H06002	wire holdey part	1
3	24H06004	NICHROME WIRE	1
4	24H98011	316 Stainless Steel Washer	2
5	24H98013	316 Stainless Steel Button Head Hex Drive Screw	2
6	24H98014	18-8 Stainless Steel Shoulder Screw	2
7	24H98015	Compression Spring	2
8	24H98016	Super-Corrosion-Resistant 316 Stainless Steel Hex Nut	4





SECTION E-E
SCALE 4 : 1



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

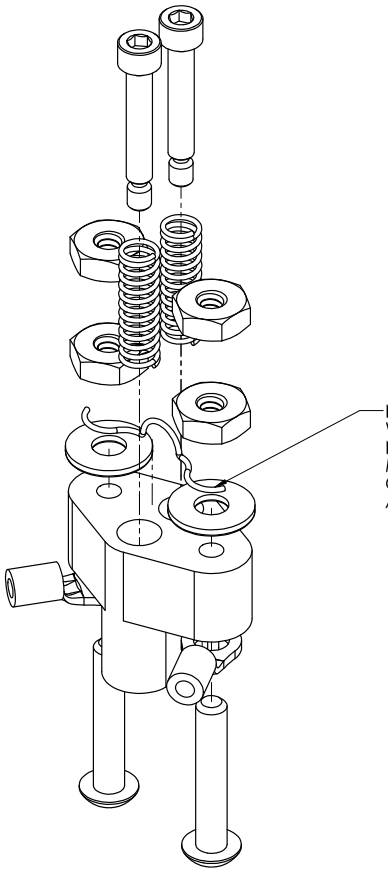
SHEET 1 OF 2

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

TITLE: NICHROME CUTTER SA

SIZE:	DATE:	DRAWN BY:	
B	3/7/2024	S FOX	
MATERIAL:		PART #: 24H06000	REV: 0

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NICHROME SHOULD BE WRAPPED CLOCKWISE SO NUT DOES NOT UNDO IT. MODEL IS FOR VISUAL AID ONLY IS AND AN APPROXIMATION.

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

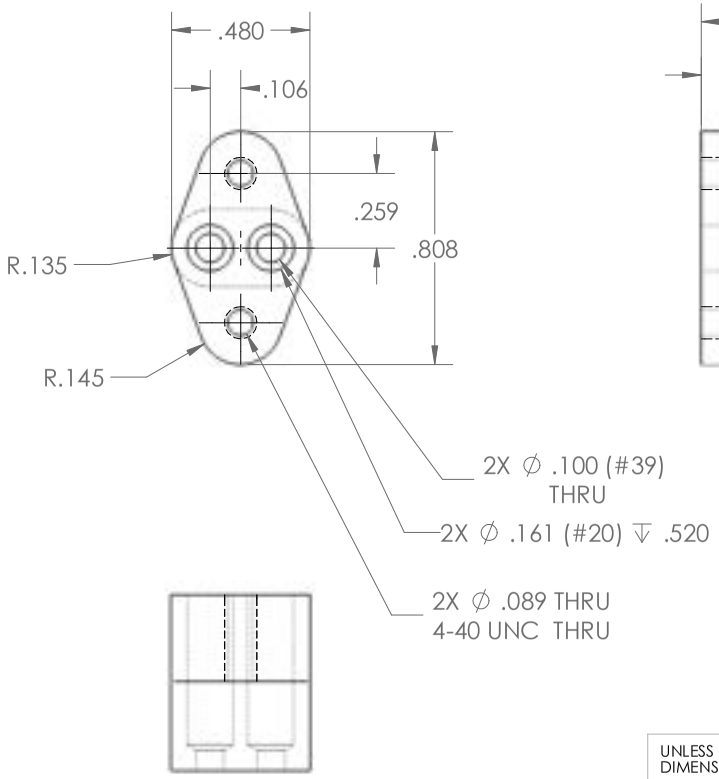
SHEET 2 OF 2

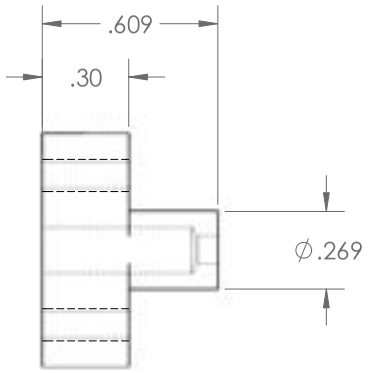
CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

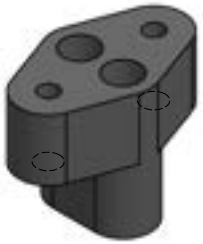
TITLE: NICHROME CUTTER SA

SIZE:	DATE:	DRAWN BY:	
B	3/7/2024	S FOX	
MATERIAL:		PART #: 24H06000	REV: 0

SOLIDWORKS Educational Product. For Instructional Use Only.







UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

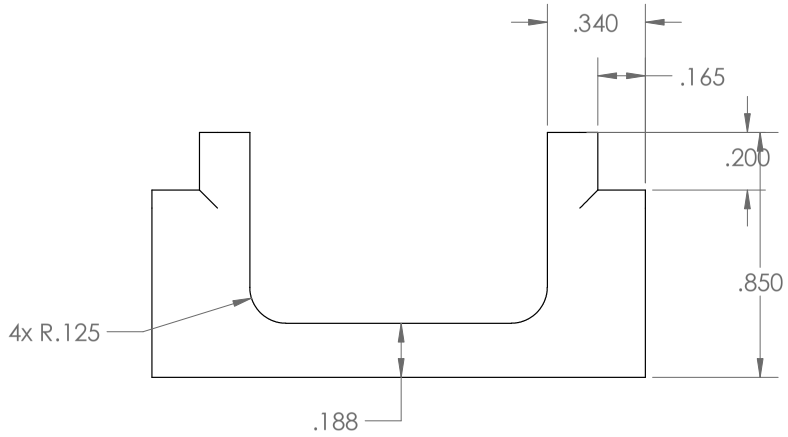
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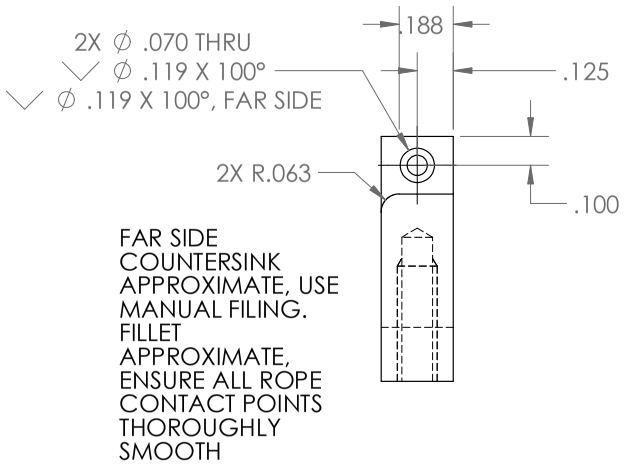
SHEET 1 OF 1

CASE SCHOOL OF ENGINEERING
CASE WESTERN RESERVE UNIVERSITY

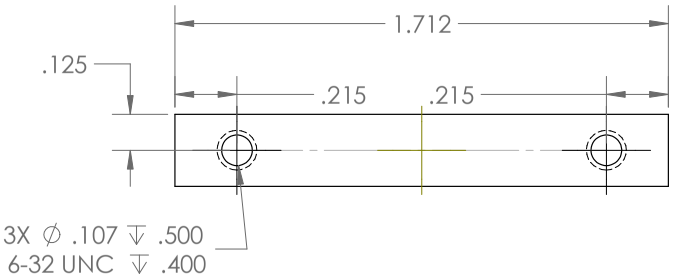
TITLE: NICHROME HOLDER			
SIZE: A	DATE: 3/7/2024	DRAWN BY: S FOX	
MATERIAL: DELRIN		PART #: 24H06002	REV: 0

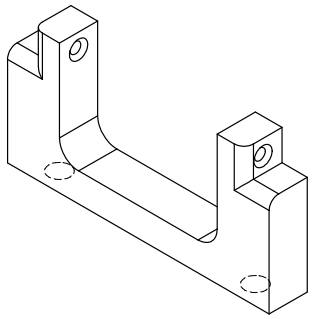
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FAR SIDE COUNTERSINK APPROXIMATE, USE MANUAL FILING. FILLET APPROXIMATE, ENSURE ALL ROPE CONTACT POINTS THOROUGHLY SMOOTH





UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

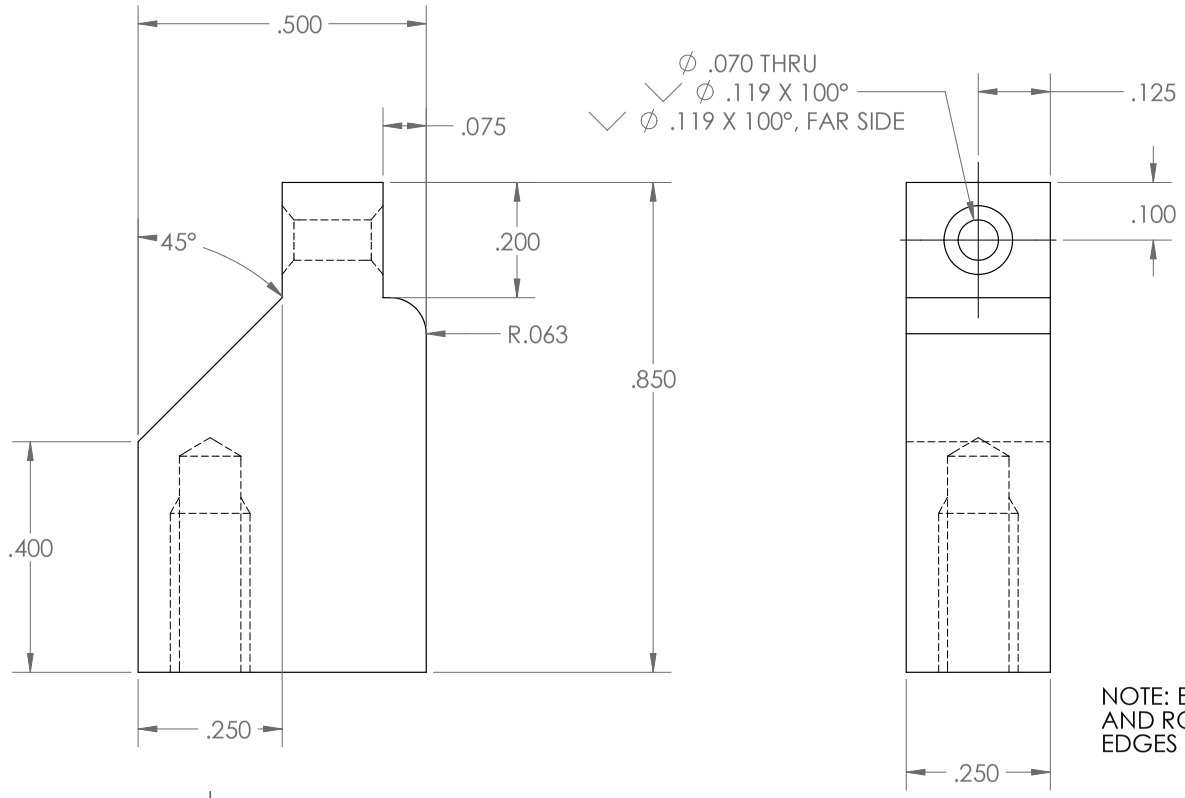
SHEET 1 OF 1

CASE ROCKET TEAM

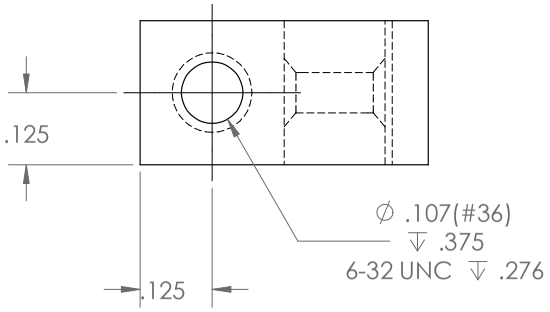
CASE WESTERN RESERVE UNIVERSITY

TITLE: ROPE GUIDE 1			
SIZE: A	DATE: 3/7/2024	DRAWN BY: CAR185	
MATERIAL: 6061-T6		PART #: 24H06004	REV: A

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NOTE: EXTRA THOROUGHLY BREAK AND ROUND ROPE CONTACT EDGES



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

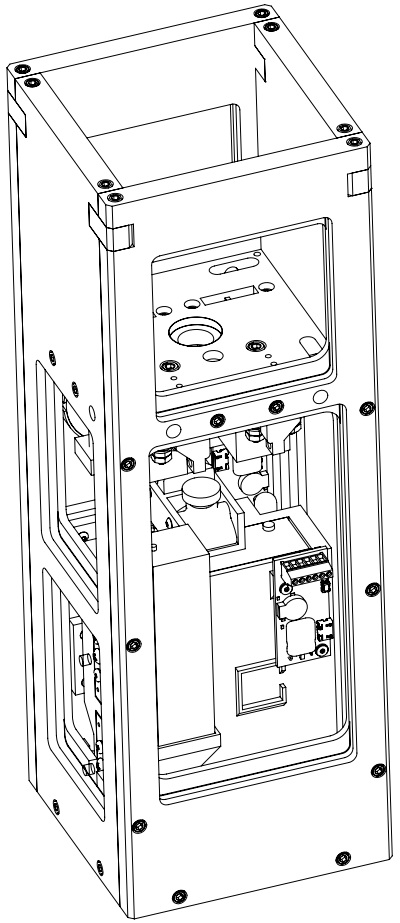
SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: ROPE GUIDE 2			
SIZE: A	DATE: 3/7/2024	DRAWN BY: CAR185	
MATERIAL: 6061-T6		PART #: 24H06005	REV: A

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ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24H02001	FRONT PLATE	1
2	24H02002	SIDE PLATE	1
3	24H02003	FRONT PLATE	1
4	24H02004	SIDE PLATE	1
5	24H02009	FRAME PLATE CONNECTOR	4
6	24H02005	LOWER BULKHEAD	1
7	24H03012	ELECTRONICS MOUNT EXPLODED VIEW	1
8	24H02007	RECOVERY BULKHEAD	1
9	24H03021	SERVO DRUM COVER	1
10	24H02010	FAME SHIELD 1	1
11	24H02011	FRAME SHIELD 02	1
12	24H02012	FRAME SHIELD 03	1
13	24H02013	FRAME SHIELD 4	1
14	24H02014	FRAME SHIELD 5	2
15	24H02015	FRAME PLATE 6	1
16	24H98003	BLACK OXIDE 18-8 STAINLESS STEEL SOCKET HEAD SCREW	41

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 3

CASE ROCKET TEAM

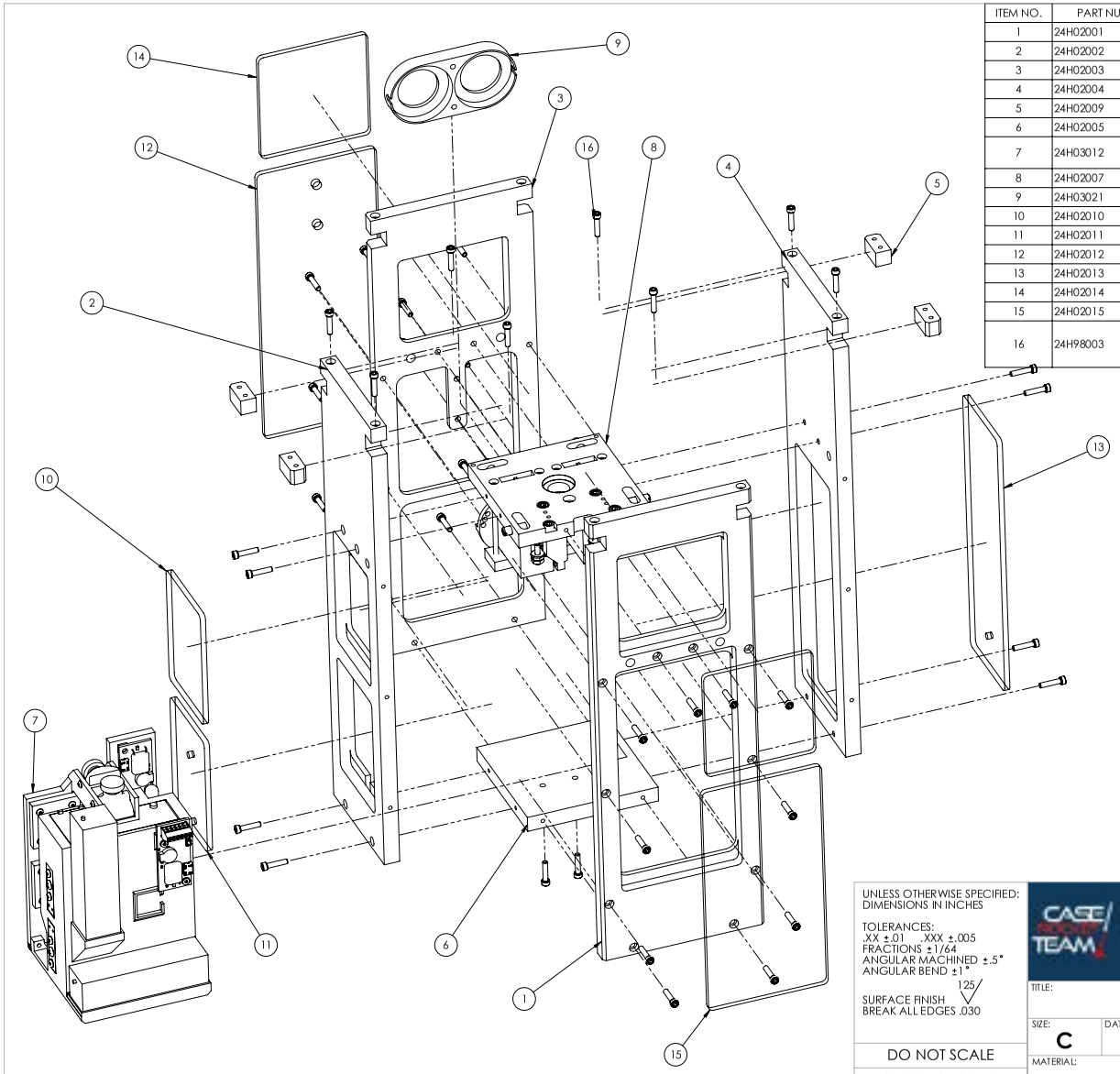
CASE WESTERN RESERVE UNIVERSITY

TITLE: Main Assembly

SIZE:	DATE:	DRAWN BY:
C	3/7/2024	CAR185

MATERIAL:	PART #:	REV:
	24H00002	A

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ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	24H02001	FRONT PLATE	1
2	24H02002	SIDE PLATE	1
3	24H02003	FRONT PLATE	1
4	24H02004	SIDE PLATE	1
5	24H02009	FRAME PLATE CONNECTOR	4
6	24H02005	LOWER BULKHEAD	1
7	24H03012	ELECTRONICS MOUNT EXPLODED VIEW	1
8	24H02007	RECOVERY BULKHEAD	1
9	24H03021	SERVO DRUM COVER	1
10	24H02010	FAME SHIELD 1	1
11	24H02011	FRAME SHIELD 02	1
12	24H02012	FRAME SHIELD 03	1
13	24H02013	FRAME SHIELD 4	1
14	24H02014	FRAME SHIELD 5	2
15	24H02015	FRAME PLATE 6	1
16	24H98003	BLACK OXIDE 18-8 STAINLESS STEEL SOCKET HEAD SCREW	41

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

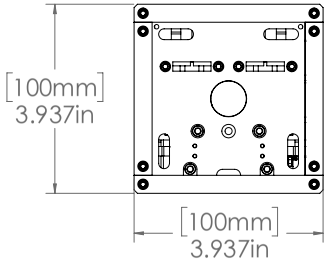
SHEET 2 OF 3

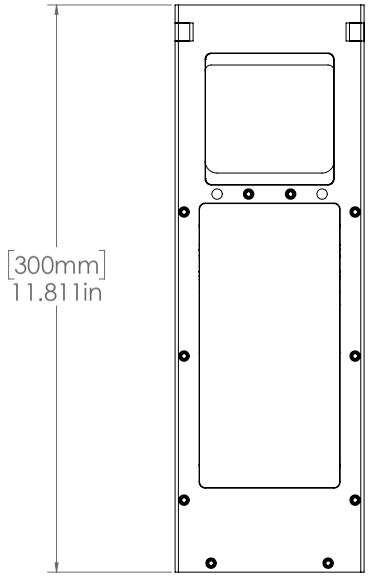
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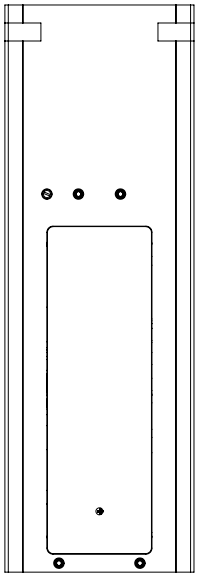
CASE WESTERN RESERVE UNIVERSITY

TITLE:			
Main Assembly			
SIZE: C	DATE: 3/7/2024	DRAWN BY: CAR185	
MATERIAL:		PART #: 24H00002	REV: A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 3 OF 3

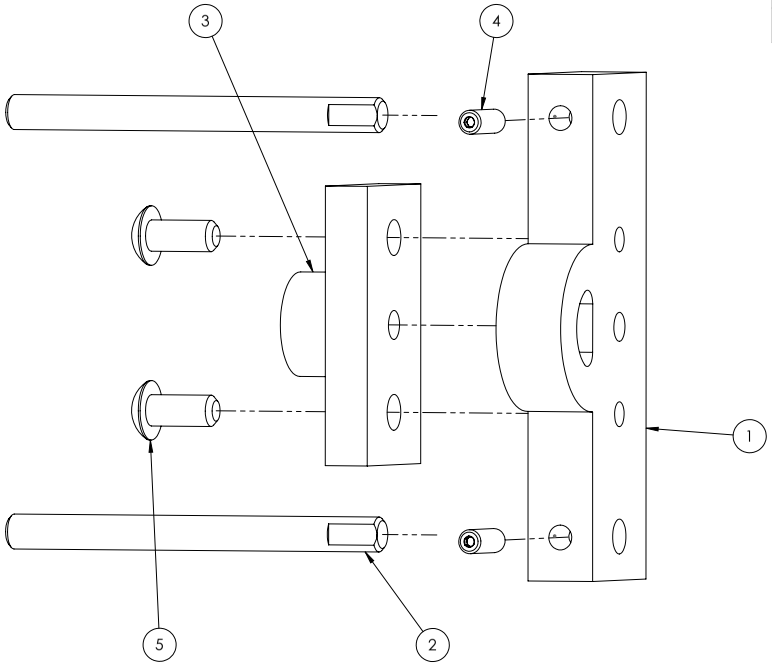
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: Main Assembly			
SIZE: C	DATE: 3/7/2024	DRAWN BY: CAR185	
MATERIAL:		PART #: 24H00002	REV: A

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ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	23L01003	TENDIE PLATE	1
2	98312A111	1/8" SS DOWEL PIN	2
3	23L01002	CHARGE WELL CAP	1
4	23L02005	18-8 STAINLESS STEEL FLAT-TIP SET SCREWS	2
5	23L02008	18-8 STAINLESS STEEL BUTTON HEAD HEX DRIVE SCREW	2



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

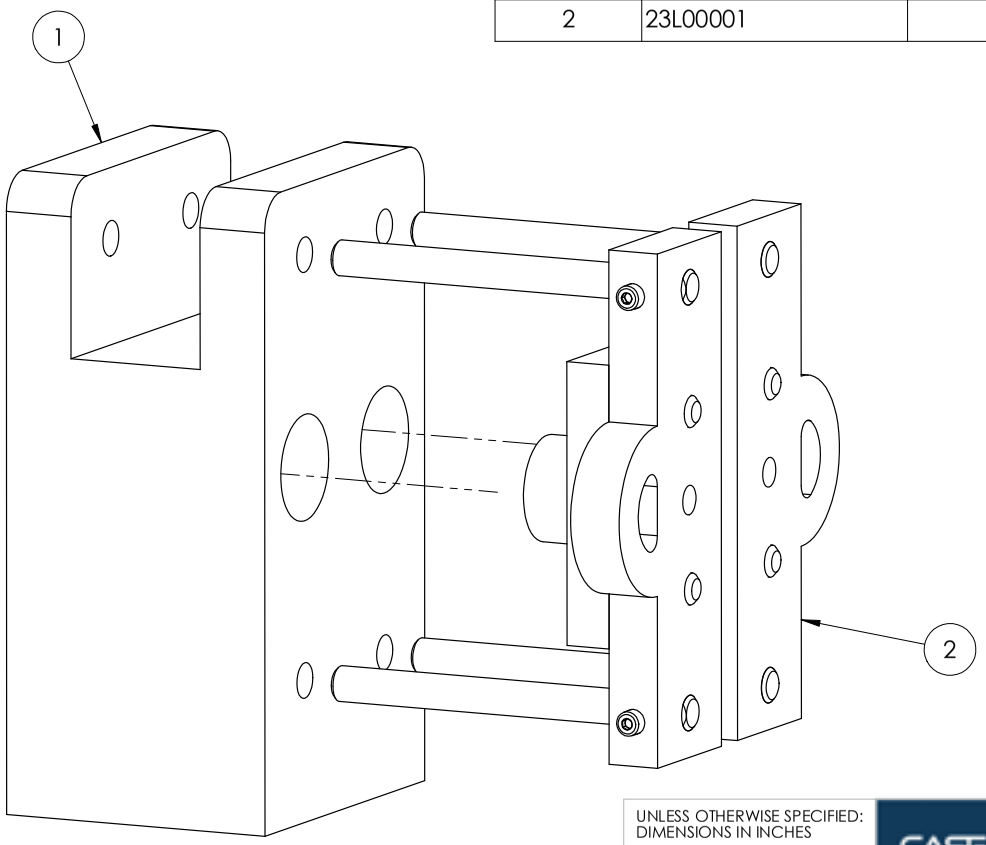
TITLE: Ejector Plate

SIZE:	DATE:	DRAWN BY:
B	2/21/2023	GGB32

MATERIAL:	PART #:	REV:
	23L00001	A

SOLIDWORKS Educational Product. For Instructional Use Only.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	23L01005	Tendie Main Body	1
2	23L00001	Ejector Plate	2



UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 2

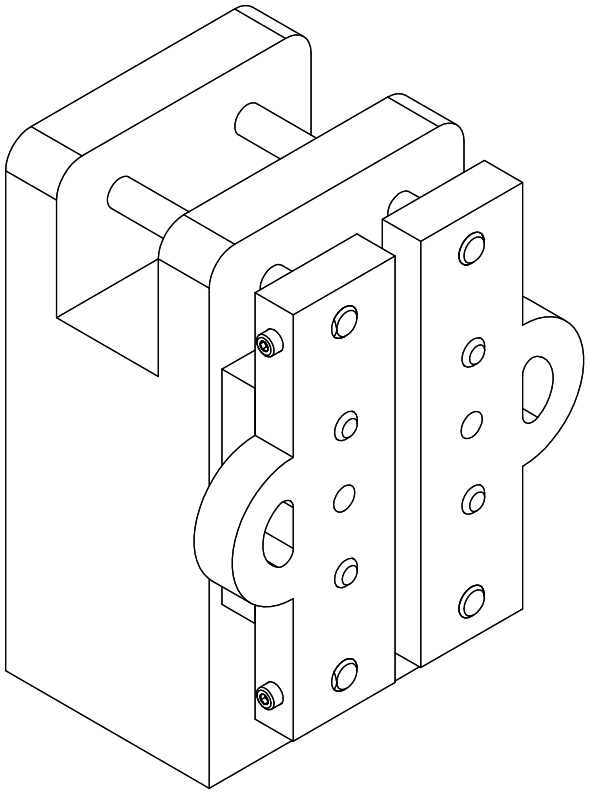
CASE ROCKET TEAM

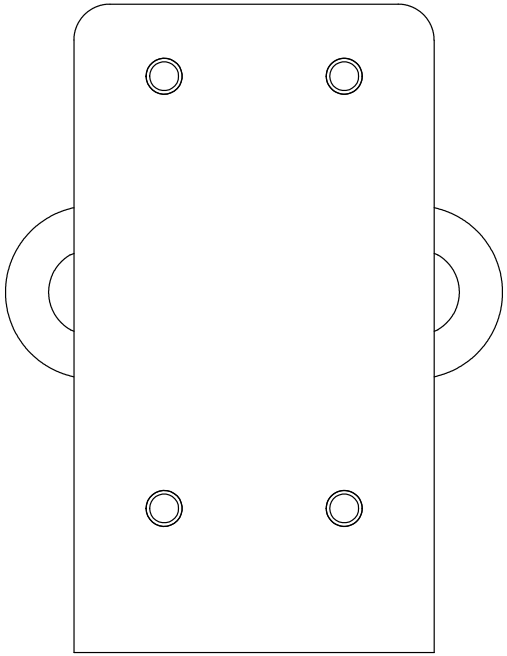
CASE WESTERN RESERVE UNIVERSITY

TITLE:
TENDIE MAIN ASSEMBLY

SIZE:	DATE:	DRAWN BY:	
A	2023-02-07	GGB32	
MATERIAL:		PART #: 23L00002	REV: B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 2 OF 2

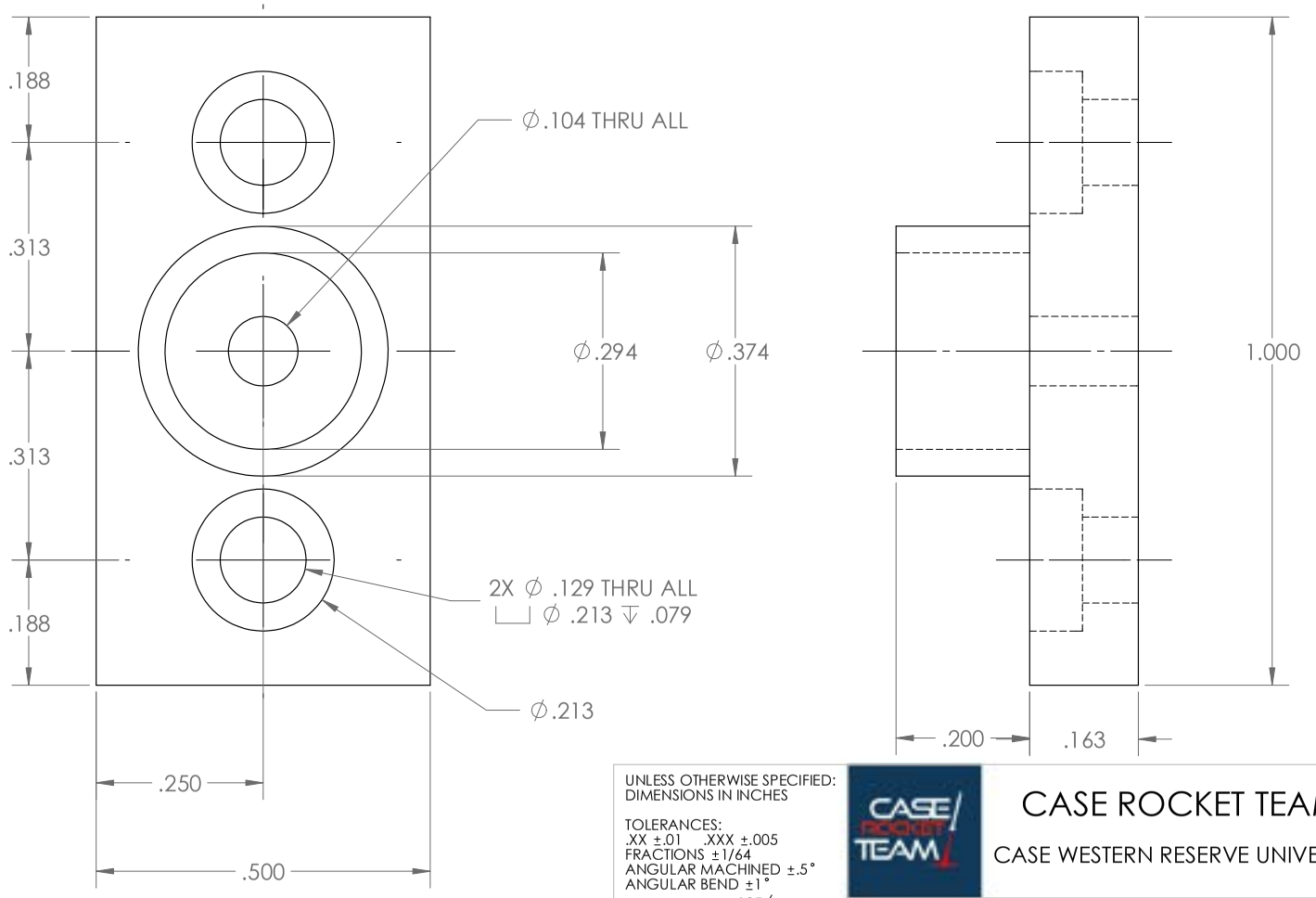
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: TENDIE MAIN ASSEMBLY

SIZE:	DATE:	DRAWN BY:	
A	2023-02-07	GGB32	
MATERIAL:		PART #: 23L00002	REV: B

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

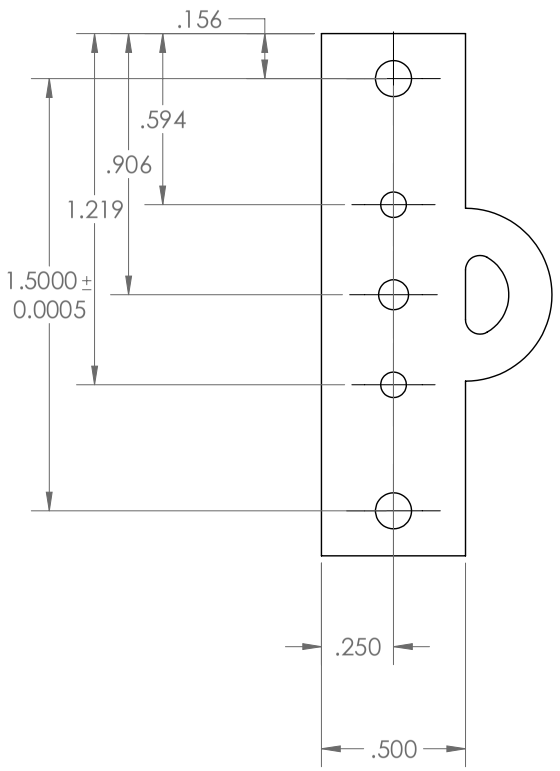
SHEET 1 OF 1

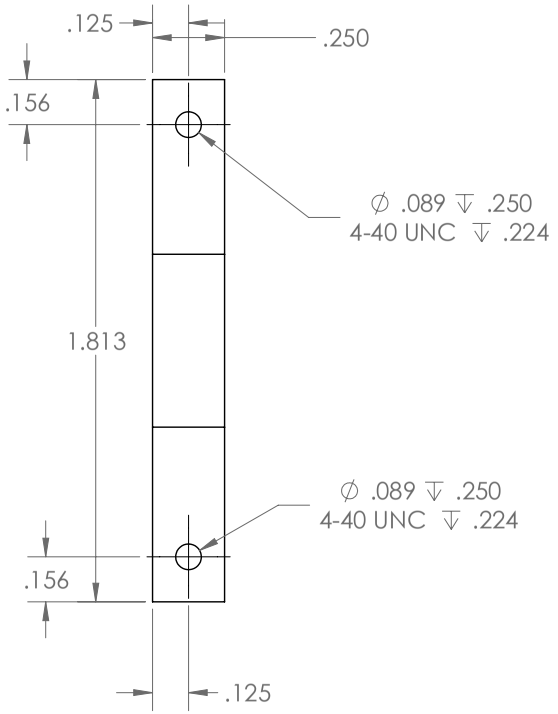
CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: CHARGE WELL CAP			
SIZE: A	DATE: 2/2/2023	DRAWN BY: NJB118	
MATERIAL: DELRIN		PART #: 23L01002	REV: A

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

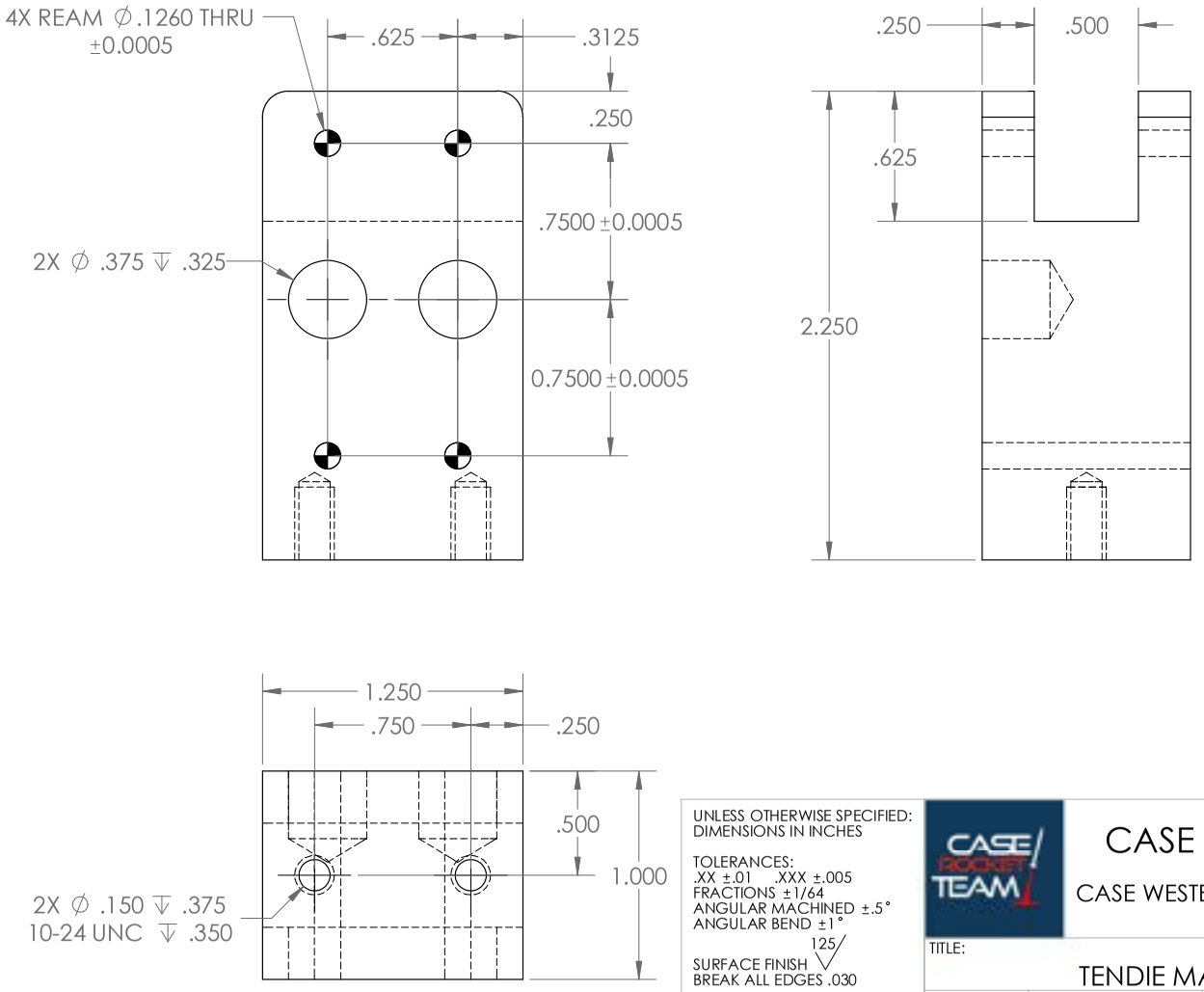
SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: TENDIE PLATE			
SIZE: A	DATE: 2/2/2023	DRAWN BY: GDB43	
MATERIAL: 6061-T6		PART #: 23L01003	REV: C

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°

SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

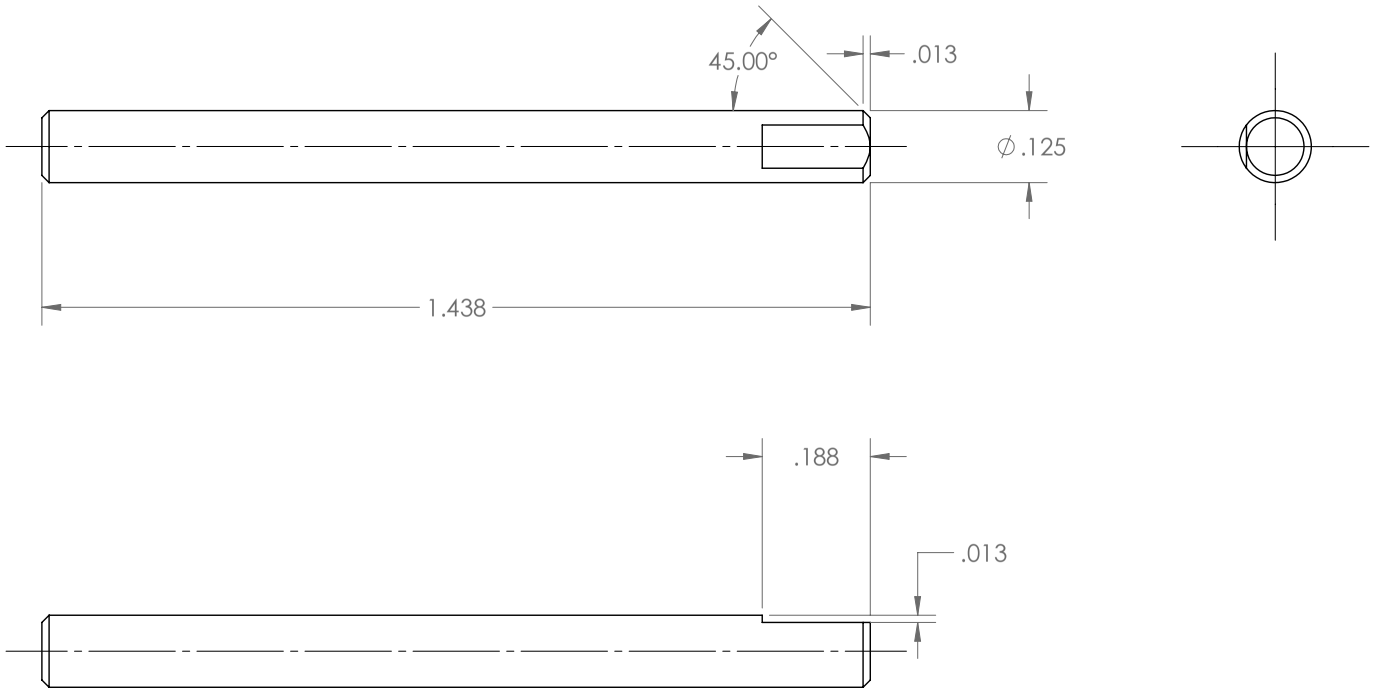
SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: TENDIE MAIN BODY			
SIZE: A	DATE: 2023-02-02	DRAWN BY: GGB32	
MATERIAL: 6061 T6		PART #: 23L01005	REV: C

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UNLESS OTHERWISE SPECIFIED:
DIMENSIONS IN INCHES

TOLERANCES:
.XX ±.01 .XXX ±.005
FRACTIONS ±1/64
ANGULAR MACHINED ±.5°
ANGULAR BEND ±1°
SURFACE FINISH 125
BREAK ALL EDGES .030

DO NOT SCALE

SHEET 1 OF 1

CASE ROCKET TEAM

CASE WESTERN RESERVE UNIVERSITY

TITLE: 1/8" SS DOWEL PIN

SIZE:	DATE:	DRAWN BY:	
A	2/2/2023	GGB32	
MATERIAL:		PART #:	REV:
STAINLESS STEEL		23L02001	D

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Acknowledgments

The Case Rocket Team would like to thank our university sponsors: Larry Sears and Sally Zlotnick Sears think[box], the Case Alumni Association, and the CWRU Undergraduate Student Government. We would like to thank our mentor, Ben Ault, for providing us with advice and a launch site for certification and test launches. Additionally, we would like to thank our advisor Dr. Stephen Hostler, the Mechanical and Aerospace Engineering Department faculty, and the Case School of Engineering for supporting and assisting the team. Finally, we would like to thank all of our sponsors for their contributions and support. Their information can be found on the team's website sponsor page, https://caserocketteam.org/sponsors.

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[1] Choquette, A., "Thrust Curve Hobby Rocket Motor Data," n/d. URL https://www.thrustcurve.org/motors/Cesaroni/2106203400-P/.

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[7] Deperrois, A., "xflr5," 2024.

[8] Tripoli Rocketry Association, "Safety Information," n/d. URL https://www.tripoli.org/safety.

[9] National Association of Rocketry, "High Power Rocket Safety Code," n/d. URL https://www.nar.org/safety-information/high-power-rocket-safety-code/.

[10] National Fire Protection Association, "NFPA 1127: Code for High Powered Rocketry," n/d. URL https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=1127.