SRP-4
Design Document

University of Alaska Fairbanks
Alaska Space Grant Program

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Chapter 1 – Mission Overview

Mission Statement

The SRP4 mission is to provide science data on the D-Region ionosphere plasma density while validating the performance of student-designed subsystems from Tokai University, Toyama University and the University of Alaska Fairbanks. The mission includes development of standardized payload subsystems and manuals that facilitate increasingly complex future payloads and the maximum transfer of corporate knowledge to future student participants. Additionally, the mission will provide opportunities for students to design, implement, and test innovative systems through hands-on experience and collaboration between disciplines, universities and practicing aerospace engineers and scientists.

Mission Objectives

The primary science objective is to study the ionization structure of the D-region of the ionosphere at high latitudes. Measurements of the ambient ionization will be made at altitudes of 50–85 km using a radio receiver to determine plasma cutoff frequencies for ground-based beacons in combination with in-situ probes to measure the relative plasma density. Measurement frequencies will be centered at 257 kHz (Chena), 660 kHz (KFAR), 820 kHz (KCBF), and 970 kHz (KIAK), all with 20kHz bandwidths. These instruments are being developed by students at Toyama Prefectural University under the guidance of Professor Toshimi Okada.

A second science objective is to validate the performance of a new 3-axis fluxgate magnetometer with increased sensitivity being built by students at Tokai University under the guidance of Professor Fumio Tohyama. This magnetometer will be used for attitude determination on the SRP-4 flight, and to search for magnetic perturbations associated with current systems that might exist in the D-region of the ionosphere. In the future, it will be used to measure magnetic field perturbations from auroral currents on future SRP flights that can reach the E-region of the high latitude ionosphere.

Mission Requirements

1.1.1 Schedule

This section includes critical items and their associated timeframes. Some deadlines are self-imposed; others are driven by external constraints.

- Preliminary Design Review (PDR) – Summer 2000
- Critical Design Review (CDR) – December 2000
- Flight hardware fabrication and testing – Spring 2000
- Integration of payload to rocket – March 2001
- Daytime launch – March 2001
- Payload recovery – post-flight
- Data analysis – post-flight

1.1.2 Successful Launch

This section includes those things necessary for a successful departure from the launch pad at t-0.

- Mechanical interfaces
    - Internal to payload
    - From payload to rocket
    - From stack to pad

- Electrical interfaces
  - Internal to payload
  - From payload to rocket
  - From stack to pad
- NASA/Poker Flats/UAF coordination

1.1.3 Successful Flight

This section includes the requirements to have a successful flight after the vehicle has left the pad.

- Minimum apogee altitude of 85 km
- Structural integrity
- Correct event timing
- Minimum mass
- Minimum drag
- Aerodynamic stability
- Nominal flight trajectory
- Structural integrity
- Correct event timing
- Aerodynamic stability

1.1.4 Recovery of Data

This section includes the requirements to insure the successful retrieval of system health, science, and Global Positioning System data. This mission requires both real-time and post-flight data recovery.

- Collection of Data
  - Flight Data Sensors
  - Science package
  - Global Positioning System
- On-board Data Processing
  - Sample science data
  - Sample flight data
- Analog to digital conversion
- Format data packets
- Store in memory
- Communication
  - Accept telemetry stream from flight computer
  - Transmit telemetry to ground antenna
  - Ground antenna tracking
  - Successfully receive/reconstruct telemetry stream
- Ground Support
  - Store telemetry data
  - Separate science and flight data
  - Analyze data

1.1.5 Recovery of Payload

A reasonable effort will be put forth to recover the payload from this flight. This section includes those requirements that insure a clean separation and parachute deployment.

- Separation of payload from rocket
  - Correct separation timing

    - Correct separation geometry
    - No damage to payload or recovery system
- Deployment of recovery system
    - Correct deployment timing
    - Recovery system must deploy at an altitude of less than 20,000 feet above sea level
    - No damage to payload or recovery system
- Ground recovery
    - Timely process for retrieval
    - Adequate budget for likely scenarios
    - Adequate scheduling for likely scenarios
    - Accurate location of touchdown

1.3.6 Technology Validation

The intent of this mission is to collect data for scientific research but also to test and validate student-fabricated systems. Data collected from these components will be used as a baseline for future designs and missions.

- Global Positioning System
    - Test function during flight
    - Analyze data post-flight to evaluate performance
- Magnetometer
    - Test function during flight
    - Analyze data post-flight
- Sun Sensor
    - Test function during flight
    - Analyze data post-flight

1.3.7 Overall System Requirements

These are requirements that are levied on all components in the system.

- Weight and balance
    - Maximum weight of integrated payload is 100 lbs
    - Payload balance
    - Ensure aerodynamic stability of rocket/payload combination
    - Ensure correct balance to achieve flat spin following separation
- Temperature environment
    - Design temperature range for internal payload compartment is 105 degrees C
    - Design temperature range for external skin of payload tube is TBD
    - Design temperature range for internal nose cone compartment is 105 degrees C
    - Design temperature range for external skin of nose cone is 399 degrees C at the tip and 177 degrees C at the base of the nose cone
    - All component design documents must indicate any minimum operating temperature limits
- Vibration environment
    - All components must be designed to withstand the vibration envelope defined for the Orion booster in the NASA Sounding Rocket Handbook
    - All components must be designed to withstand the “shock/jerk” loads defined for the Orion booster in the NASA Sounding Rocket Handbook
- Manufacturability
    - Design of components must consider manufacturability concerns

    - Concerns regarding construction and assembly of components must be included in the final design package
- Maintainability
    - Design of components must consider maintenance concerns
    - Concerns regarding pre-launch maintenance and trouble-shooting must be included in the final design package
    - Concerns regarding short and long-term storage of components must be included in the final design package
- Reusability
    - Possible reuse of components must be considered when designing components
    - Plans for reuse of components must be included in the final design package
- Receiver/probe science mission requires external mounting of plasma probes

Chapter 2 – Mechanical Systems

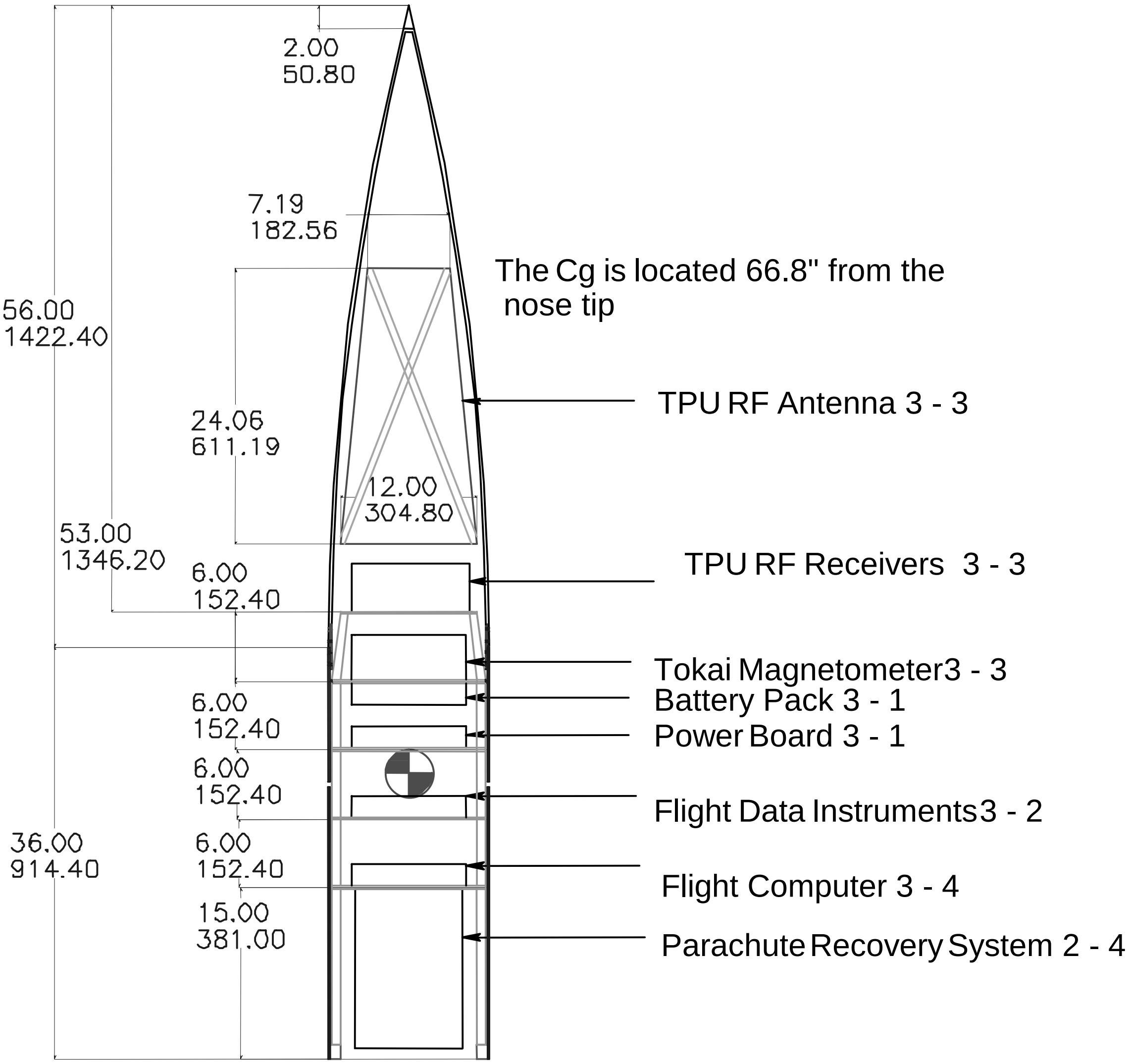


Figure 2.0.1 Overall View

2.1 Nose Cone

Requirements

- RF transparent
- Light-weight
- Maintain integrity to 700 degrees F at tip and 350 F at base
- Mate to payload tube
- Withstand aerodynamic loading
- Be constructed to minimum tolerances

Description

- A 4 to 1 tangent ogive has been chosen for the nose cone. This shape will provide superior aerodynamic performance at speeds of > mach 1.
- Due to extreme aerodynamic heating, the top 2" of the nose tip will be made of mild steel. To reduce this heating as much as possible the tip will have a 3/16" radius. This will project the shock wave approximately 15" in front of the rocket's nosetip.
- The nose cone will also support TPU's RF antenna. This will be attached with four screws that run through the nose cone and into the antenna support.

Materials

- The nosecone is to be constructed of a RF transparent material, probably glass-reinforced epoxy approximately 1/8" thick.
- A commercial supplier will be located if the nosecone cannot be fabricated "in house".

Interfaces

The nose cone will be attached to the payload tube by a 4" aluminum ring. The ring will extend 2" into the nose cone and 2" into the payload tube. It will be connected by two rows of 10 screws in both the payload and nose cone. These will be flat head screws set flush to the surface.

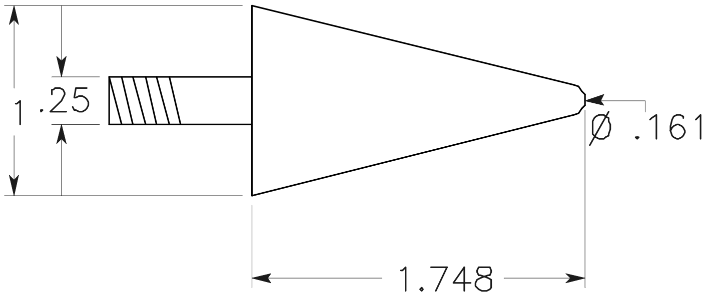


Figure 2.1.1
Nose Tip

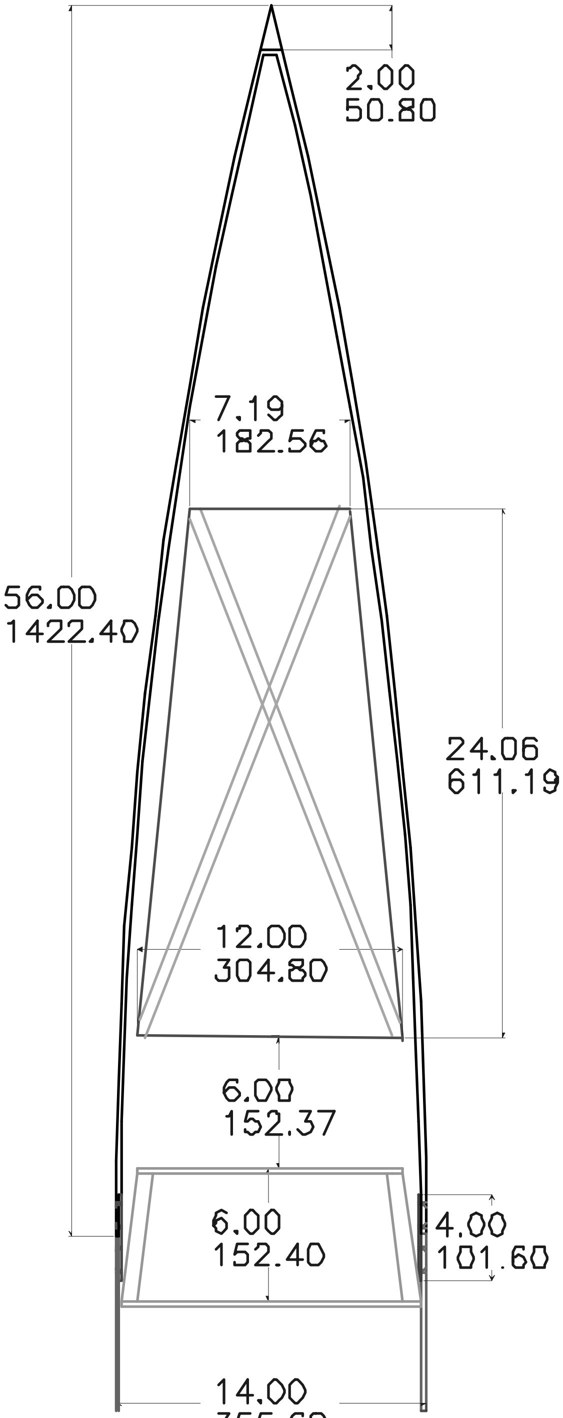


Figure 2.1.2
Nose Cone

2.2 Payload Tube

Requirements

- 14” outside diameter
- Mate to nosecone on top end
- Mate to separation system
- Minimum bending moment of 100,000 in-lbs

Description

The payload tube is to be 14" in diameter tube with a wall thickness of 1/8". It will have holes machined into it to allow for the following penetrations:

- Sun sensor
- 4 - Pressure equalizing ports
- Umbilical block
- GPS antenna cables
- Transmitter antenna cables

Materials

The payload tube construction method will largely depend on what materials can be acquired at a reasonable cost. The options, in order of most to least preferable are:

- Wound Carbon Fiber Tubing. This would provide the highest strength-to-weight ratio. A custom supplier will probably be necessary for this option (minimum orders around $2000).
- Extruded Aluminum Tubing. This would be the preferred choice for an aluminum tube. 7075 aluminum has high tensile strength and excellent machining properties. Its main drawback is that it can’t be welded without subsequent heat-treating. Therefore, it must be a seamless extruded tube as opposed to a rolled and welded tube. 2024 aluminum also is an option. It has the same properties as 7075 with the exception of a slightly lower tensile strength.
- Rolled Aluminum Tubing. Our margin of safety would be much lower than with an equivalent weight tube in 7075, but a payload tube of this type should be more than adequate for SRP-4. The main advantage is that 6061 can be welded. This allows for local fabrication at a reasonable cost (approximately $400).

Interfaces

The payload tube will attach to the nose cone with a double row of screws (see nosecone section) and it will attach to the radex joint with a lap joint. Due to the structural weakness of the lap joint a high strength epoxy is recommended to hold this joint together. Several 2-part room-temperature cure epoxies have been located that have shear strengths around 200K in-lbs at 200 degrees F and much higher strengths at lower temperatures. NASA requires a bending moment of 100K in-lbs at this interface. Since this is a new technique, it is proposed that the joint be reinforced with a double row of 20 button-head screws. The button-head screws are chosen rather than flat-head screws, because they provide superior shear resistance. Protrusions from the payload skin in this region are not a significant issue due to the behavior of the boundary flow layer.

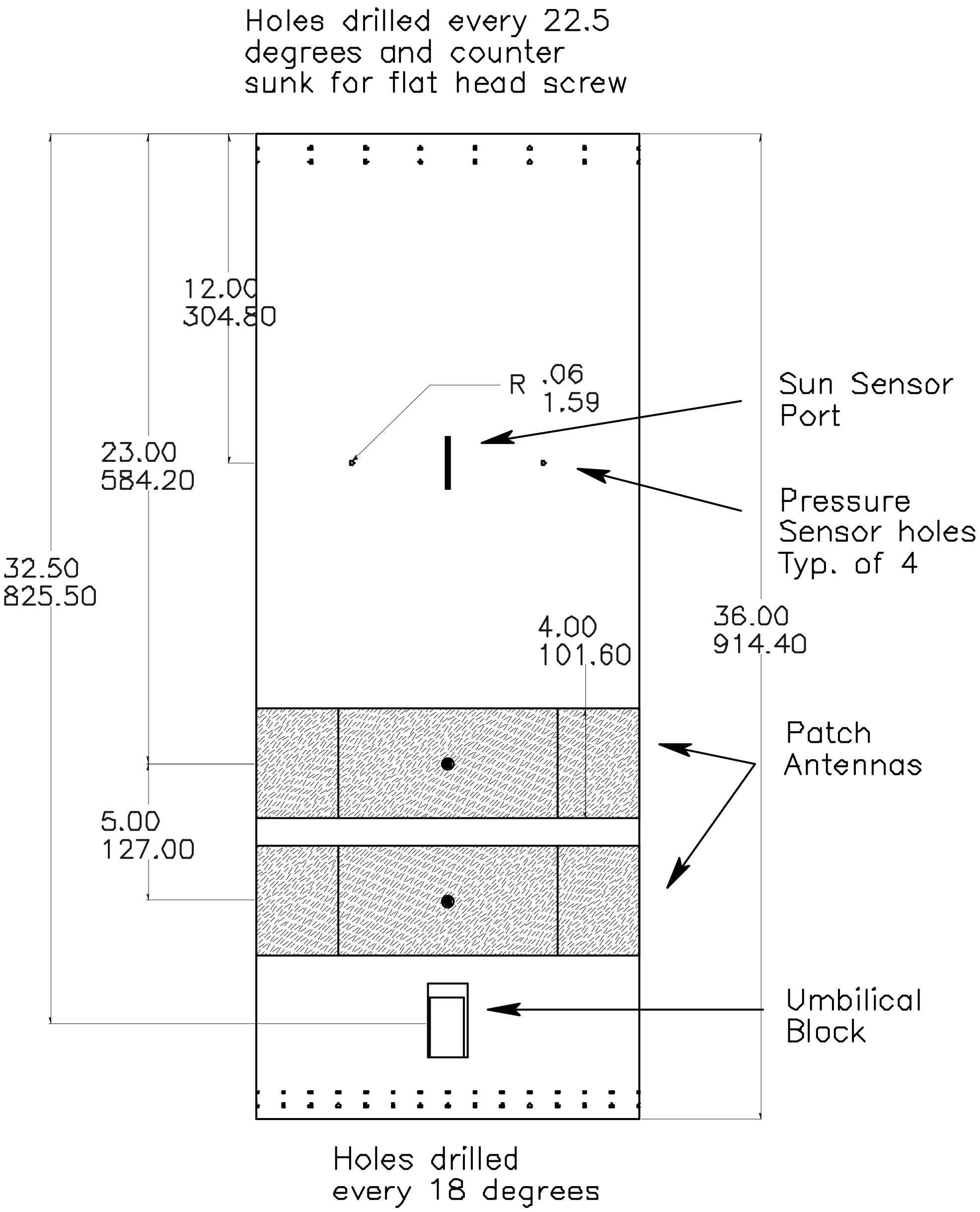
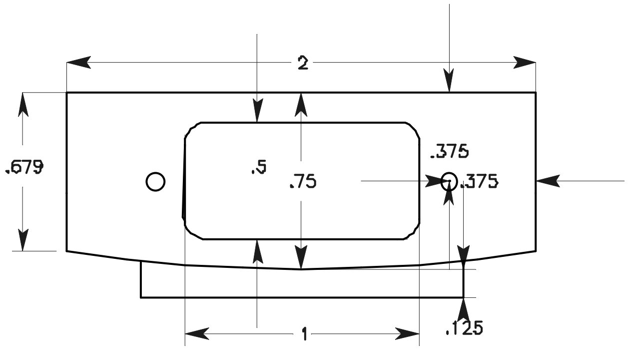
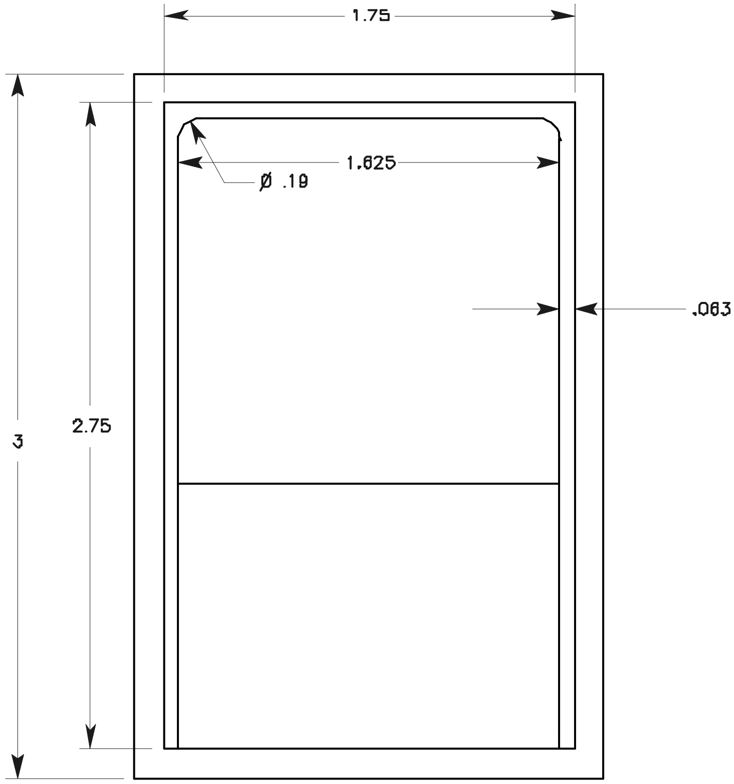


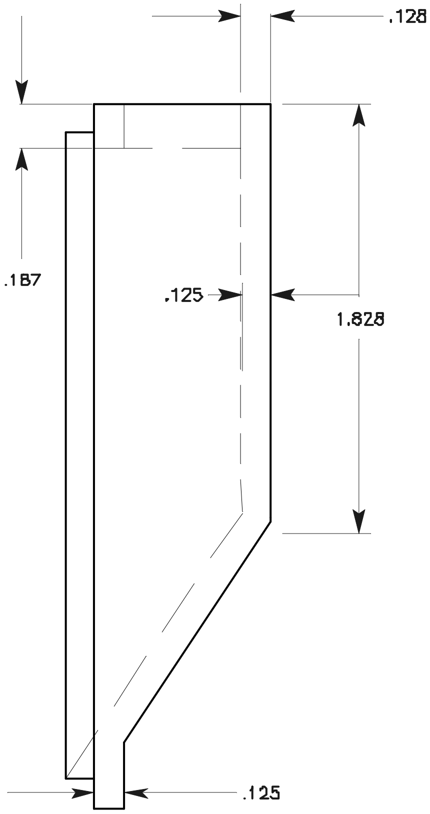
Figure 2.2.1 Payload Tube

Umbilical Block

The aluminum umbilical block will support the umbilical plug. The umbilical block will be located below the patch antennas to prevent the block from interfering with the installation of the payload frame. It will also allow access to the block so that the cable can be attached once the payload is installed. The umbilical block requires a 1 ¾” x 2 ¾” (4.44 cm x 6.99 cm) hole for installation. The face of the block will be machined to match the 14” dia. curve of the payload tube. The block will be held in place by 6 flat-head screws.







Radex Joint

A radex joint will be used to attach the payload tube to the separation system. This will allow the use of the epoxy-reinforced lap joint described above and will provide the ability to change separation systems as necessary. The radex joint will also provide support for the lower end of the recovery system housing tube and house the drag plate which is utilized in the deployment of the recovery system.

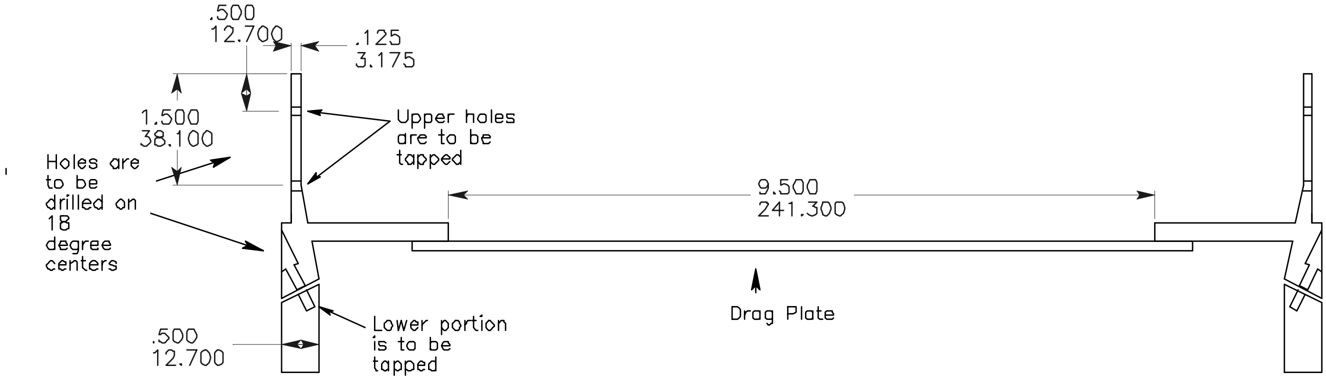


Figure 2.2.2 Radex Joint

2.3 Payload Frame

Requirements

- Fit inside payload tube
- Provide mounting surface for electronics
- Withstand 20g in high vibration environment
- Have mounting structure for parachute recovery system
- Withstand shock from parachute opening

Description

- The payload frame consists of two main components: the longerons and the deck plates.
- The longerons will consist of ½” x ½” (1.27 cm x 1.27 cm) square rods that bend in at the top to clear the sides of the nose cone. Fastened to the inner side of each longeron will be ½” x ¼” (1.27 cm x 0.64 cm) strips. These strips will support the weight of the deck plates. They will be fastened with 2 button-head screws per strip. This eliminates stress risers that would occur if the longerons were solid pieces with notches cut out of them. This also greatly increases the flexibility of the deck plate locations.
- The deck plates will be ¼” (0.64 cm) plates that are machined to fit the interior diameter of the payload tube. They should fit as close as possible while still being able to slide freely within the tube. (It should be noted that the tube is not expected to be an exact diameter and machining of the deck plates should not be done until the payload tube is in hand and can be measured accurately). The deck plates will have two ½” x ½” (1.27 cm x 1.27 cm) notches located 180 degrees apart. These will accommodate the longerons and allow the deck plate to extend to the payload tube. Located 90 degrees from the notches the deck plates will be “trimmed” back ½” (1.27 cm). This will allow the plates to clear the other two longerons and still be installed and removed while three of four longerons are assembled. This will allow easy removal of the deck plates while working on the electronics during integration. The deck plates will have four 2” (5.1 cm) holes drilled in them for wiring through-holes and to reduce weight.

Materials

The deck plates and longerons can be machined out of either 6061 or 7075 aluminum alloy. Simple compression calculations from *Mechanics of Materials* by F.P Beer and E. R. Johnston for the longerons have been done.

Compression of columns under static load for 6061 aluminum:

$$\text{Buckling Load} = 20.2 - 0.126\left(\frac{L}{r}\right)\text{Ksi}$$

where L = length of column, and r = radius of column

The 6" section of longeron between screws would have compression strength of 4294 lbs (1951.8 kg). This is far in excess of the 120 lb (54.5 kg) maximum load expected on an individual longeron.

A similar equation modified for 2014 aluminum yields a compression strength of 6295 lbs (2861.3 kg). (2014 has a tensile strength similar to that of 7075 aluminum).

The deck plates do not carry enough load for strength to be an issue and as designed they do not weigh enough to justify going to a thinner deck plate.

Interfaces

The longerons will rest directly on top of the radex joint's upper ring. This will allow the weight of the payload to transfer directly to the motor instead of to the payload tube. The longerons will be attached to the payload tube at least every 6" with flat-head screws to prevent deflection under load. Although the top deck plate is inside the nose cone, there is no contact between the payload frame and the nose cone.

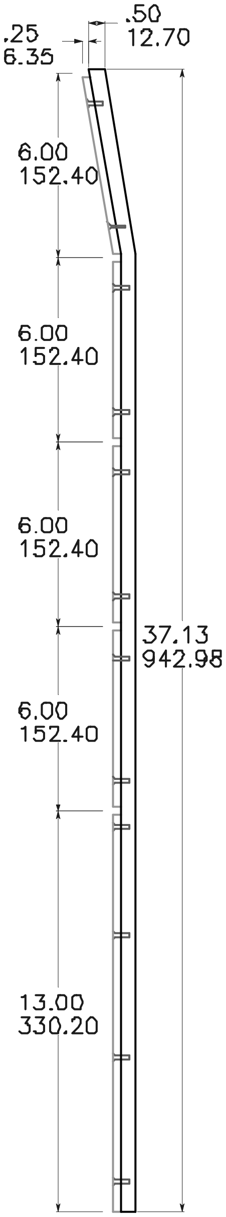
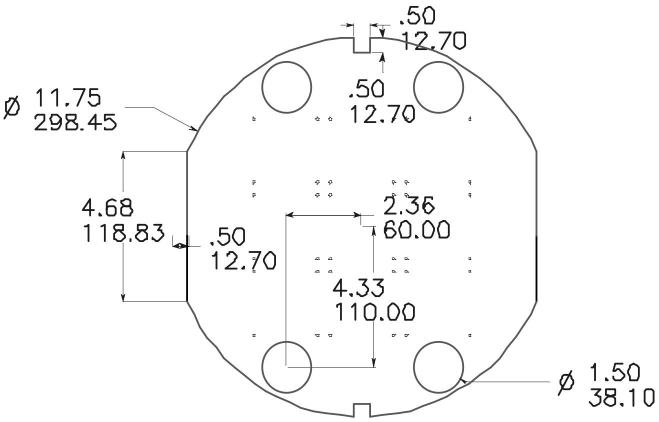


Figure 2.3.1 Longeron



Notes:
Deck plates are to be .25'' aluminum plate

1 small deckplate
3 large deckplates

Figure 2.3.2
Top deck plate (D5)

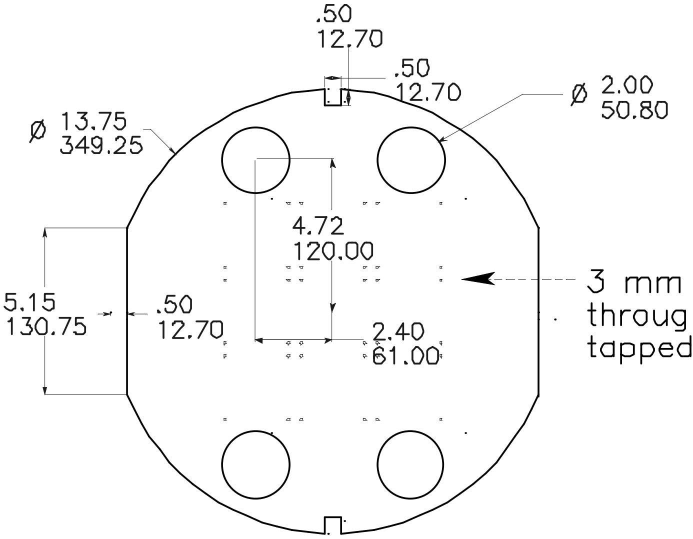


Figure 2.3.3
Deck plates D2 – D4

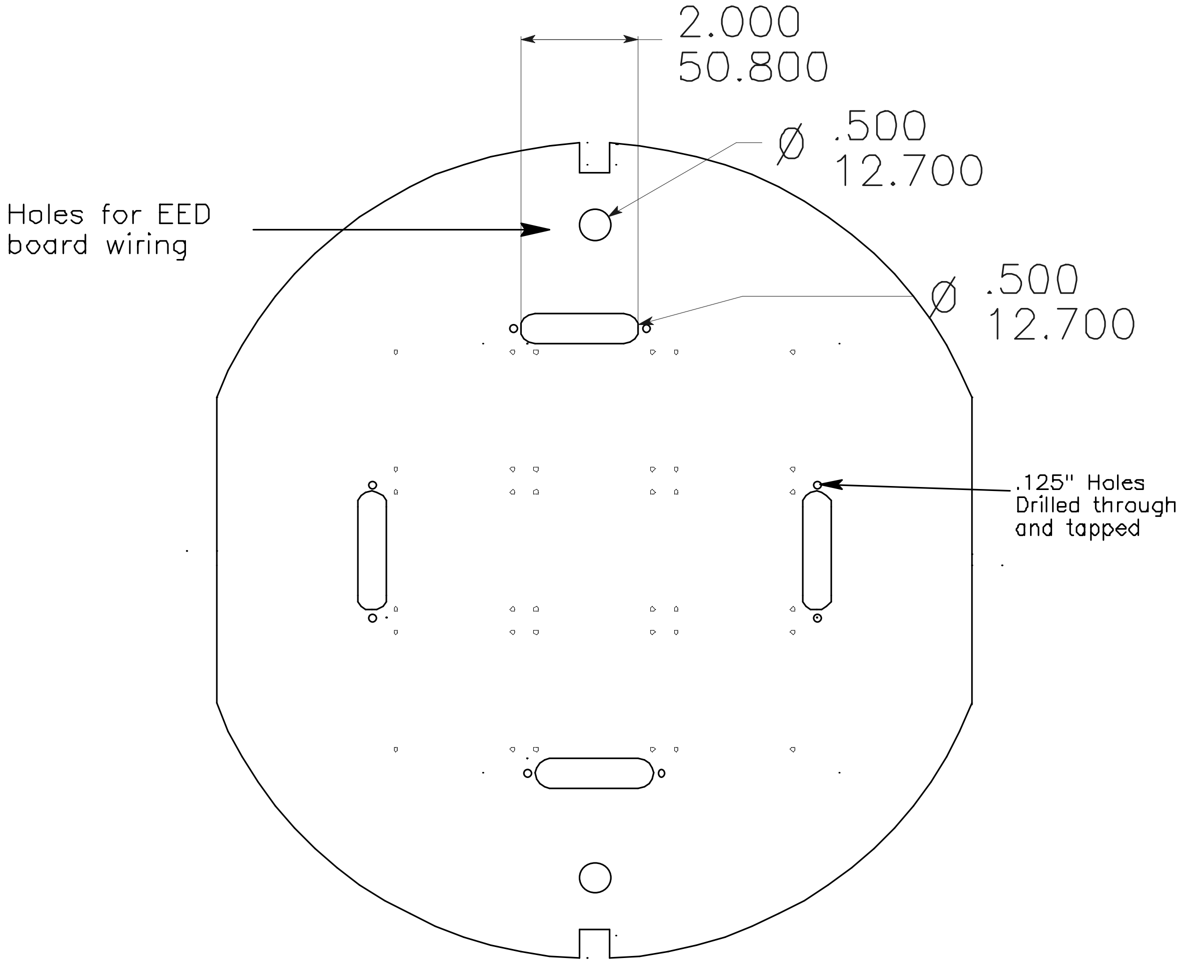


Figure 2.3.4
Parachute Attachment Deck Plate (D1)

2.4 Parachute Recovery System

Requirements

- Lower payload at a rate that will avoid damage at impact
- Deploy reliably at any payload orientation
- Have mission failure modes (Deploy early if boost phase is aborted)
- Adhere to FAA regulations concerning our launch (deploy below 20,000 ft.)

Description

The SRP4 2-stage parachute recovery system consists of a 6 ft guide surface drogue and a 33 ft main cross parachute designed to recover a 75-lb to 150-lb sounding rocket payload. The recovery system is deployed from the aft end of 3-ft long payload tube with a 14-in diameter secured to a 4:1 ogive nose cone for a total payload length of 92-in.

At approximately 65km on the descent the payload section is separated from the Orion rocket motor using a pyrotechnic device yet to be determined. The payload then tumbles or flat-spins during reentry to gain maximum passive aerodynamic deceleration prior to deploying the parachute recovery system. At 20,000 ft, a barometric pressure switch will send an electrical signal to two Holex 2900-1 pyrotechnic thrusters to break shear pins on the parachute canister to jettison drag plates to extract and deploy the drogue parachute. The drogue parachute will fly for 10 seconds to stabilize and further decelerate the payload prior to deploying the main cross parachute. Drogue deployment will pull pins to mechanically activate the 10-second pyrotechnic charge of the Technical Ordnance pyrotechnic pencil cutters on the drogue staging bridle. After 10 seconds, the pencil cutters will fire to sever the staging bridle drogue parachute drag to extract and deploy the main cross parachute. The main cross parachute will then be deployed for inflation with or without skirt reefing using another two 750-lb Technical Ordnance pencil cutters. The cross parachute will stabilize the payload for descent from to touch down.

Total rocket flight time is approximately 30 minutes from launch to touch down under the main parachute. Time to apogee is approximately 2.5 minutes. Payload free-fall reentry time from apogee to parachute recovery system deployment at 20,000 feet is approximately 4 minutes. Time of payload descent under the main parachute from the deployment altitude of 20,000 ft to touch down is approximately 19 to 23 minutes for a payload weight range of 100-lb to 150-lb. Final payload weight may be lower than 100-lb, this figure was chosen as a conservative estimate.

This recovery system was successfully drop tested from an Air Force C-130 in 1997 and qualified as flight worthy hardware for launching on a NASA sounding rocket from Poker Flat Research Range. This parachute recovery system will fly on the Orion 30.047UP mission to recovery the sounding rocket payload with its science mission instruments.

Drag plate

The Drag plate is an aluminum disk, which covers the back end of the rocket during re-entry, and pulls the drogue chute out of its bag. The drag plate will be attached to the back end by two nylon (or similar low strength) screws. These screws will be broken by two explosive actuators that push against the plate. This will separate the plate from the payload and air drag will do the rest.

Interfaces

The parachute recovery system will ride in a thin walled rigid tube that has a 9 ½” (24.13 cm) diameter this tube will be secured to the bottom of deck plate 1 with a couple of screws. The parachute will be attached to the payload frame by a 4 - way bridle. This bridle will be constructed from nylon straps. The straps will stick through ¼” x 1 ½” (0.64 cm x 3.81 cm) slots in the deck plates and mount to ¼” (0.64 cm) dia. aluminum bars that attach to the top of the deck plate.

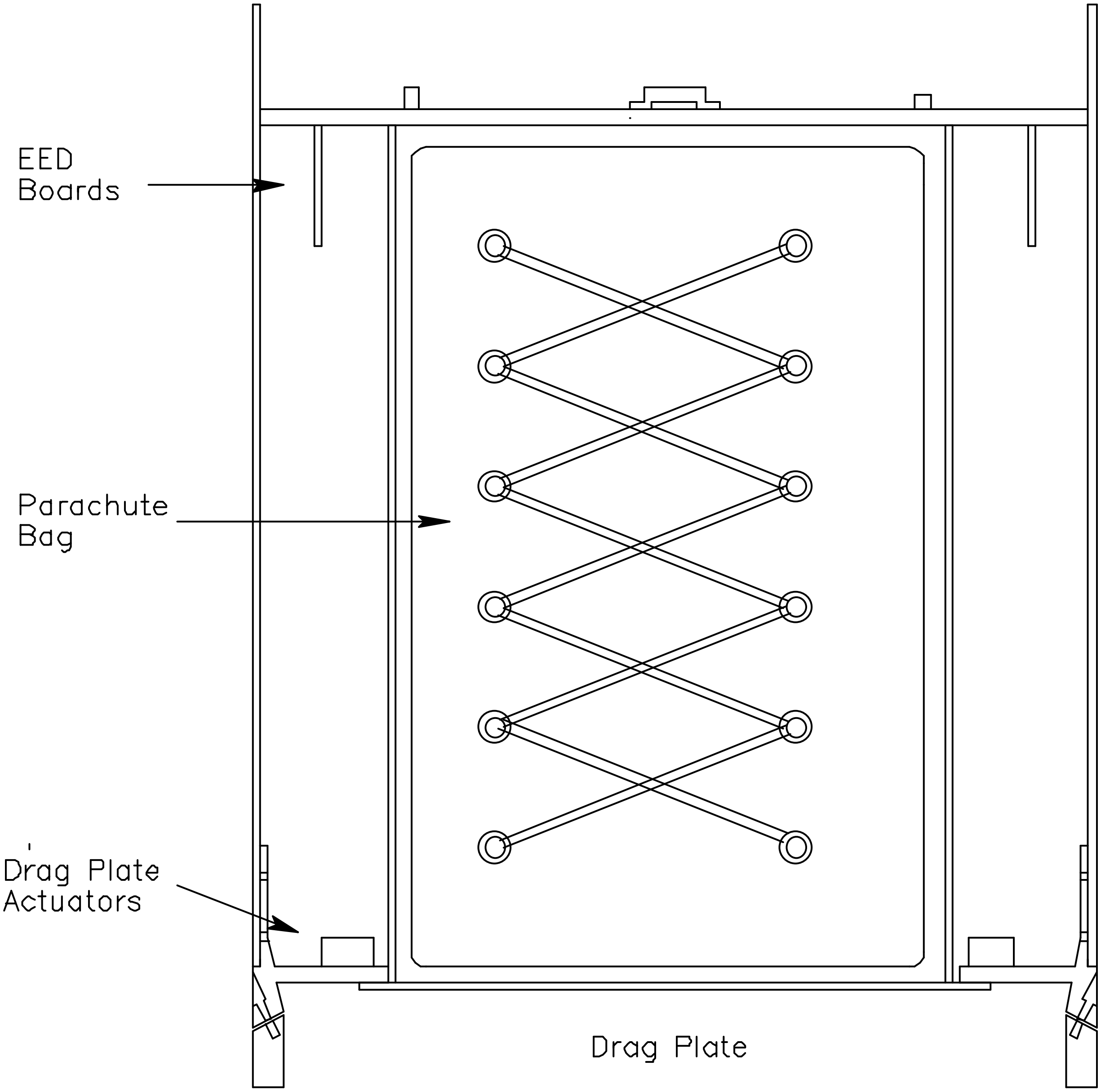


Figure 2.4.1 Parachute Recovery System

2.5 Separation System

Requirements

- Mate to payload tube/frame
- Hold payload to motor within acceptable deviation at > 100,000 in-lbs torque
- Have > 9.5” hole in center for recovery system deployment
- Provide positive separation in zero g and zero drag environments

Description

The separation system needs to perform two opposing functions:

- Hold the rocket together rigidly during boost

- Release the payload from the motor quickly and cleanly

Systems Under Consideration

There are two separation systems that we are considering for SRP 4:

- A student built separation system from UAF
- An “off the shelf” separation system from NASA

The student built system is still in the early design phase. It will be evaluated for acceptance when a prototype is presented.

Interfaces

The separation system will attach to the payload tube by the radex joint described above and attachment to the Orion motor will be according to NASA specifications. The separation system’s triggering device will also need to interface with the EED board.

2.6 Center of Gravity and Mass Budget

The center of gravity (Cg) is critical to a rocket’s performance. If the Cg is located too far forward the rocket will become unstable. If the Cg is located too far back the rocket will be overly stable resulting in poor flight performance. To evaluate this for SRP 4 the following spreadsheet has been created using the weights of the various components and the distance of their Cg to the nose tip.

Center of Gravity calculations	Weight		Distance of Cg NEP		weighted average
	(lbs)	(kg)	(in)	(cm)	
Nose Cone	14	6.349206	34.91	88.6714	488.74
TPU Antenna	1	0.453515	36	91.44	36
TPU Receiver Deck (D5)	2.5	1.133787	53.13	134.9502	132.825
TPU Receiver	1	0.453515	50.77	128.9558	50.77
Tokai Magnetometer Deck (D4)	3.6	1.632653	59	149.86	212.4
Tokai Magnetometer	2	0.907029	57	144.78	114
Battery Pack	4	1.814059	60	152.4	240
Power Board Deck (D3)	3.6	1.632653	64.75	164.465	233.1
Power Board	0.25	0.113379	63.75	161.925	15.9375
Flight Data Board Deck (D2)	3.6	1.632653	70.5	179.07	253.8
Flight Data Board	0.25	0.113379	69.5	176.53	17.375
Flight Computer (D1)	3.6	1.632653	76.5	194.31	275.4
Flight Computer	0.25	0.113379	75.5	191.77	18.875
Payload Recovery System	14.5	6.575964	84	213.36	1218
Longerons	3.636	1.64898	73	185.42	265.428
Separation Mechanism	6	2.721088	91.5	232.41	549
Payload Tube	20	9.070295	74	187.96	1480
Total Mass	83.786	37.99819			5601.6505
Cg of Payload	66.85664073		in NEP		
	169.8158674		cm NEP		
	(lbs)	(kg)			
mass of main deck plates	3.6	1.632653			
mass of small deck plates	2.5	1.133787			

Table 2.6.1 Cg Calculations

Accuracy

Breaking the rocket down into indvidual components allows us to calculate a very accurate Cg location. Some of these numbers are estimates but it is far easier to get a close estimate on a component than on the system as a whole. As of this report, all electrical component weights are an educated guess. They do give a representative weight distribution that is fairly accurate. The locations are definite. They are based on the locations of the indvidual deck plates which are known quite precisely. For most of the electical components the upper surface of the deck plate has been used as the Cg for that deck plate. Heavier components, such as the magnetometer, have a more precisely calculated Cg. The actual Cg is expected to be very close to the one calculated here.

Requirements

No advice from NASA has been provided regarding where the Cg needs to be located. Once this criteria is given it will be a simple matter to decide what, if anything, needs to be moved.

Spin-Balancing

The above Cg calculation takes care of the rocket’s balance in the longitudinal direction. The other factor is the rocket's radial balance. If there is more weight concentrated on one side of the rocket than another or the weight is unevenly distibuted the rocket will want to wobble as it spins. This results in what is known as pitch - roll coupling and has disasterous effects on the rocket’s preformance. TR1 is a good example of this (although TR1's pitch - roll coupling was more likely aerodynamicaly induced than balance induced.).

To overcome this problem it is recommended that each deckplate be spin balanced individually. It is possible for the rocket to be stable with some decks individually unbalanced, but this requires complicated design techniques and tests.

2.7 Definition of a Tangent Ogive

Definition

A tangent ogive is created by a pair of arcs whose base end is tangent to the adjoining cylinder. The radius of these arcs is given by the formulas below.

Formulas

Radius $\boxed{R = d(C^2 + .25)}$

Caliber $\boxed{C = \frac{L}{d}}$

Distance from center of ogive to start of radius $\boxed{K = d(C^2 - .25)}$

Formula to plot ½ tangent ogive $\boxed{y = \frac{d}{2} - \left[\frac{x^2}{2 \times L \times C}\right]}$

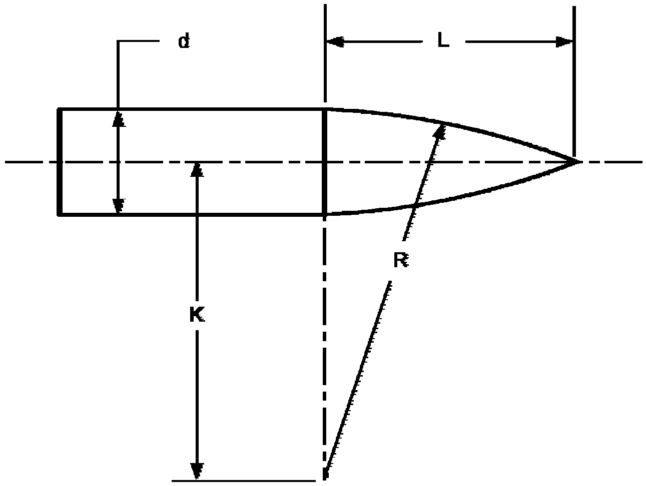


Figure 2.7.1
Tangent Ogive

2.8 Mechanical Systems Test Plan

The purpose of this plan is to insure that all mechanical systems have a low probability of failure during anticipated flight conditions.

Nose Cone

The nose cone needs to withstand 250 psi and temperatures up to 700 degrees F. A purchased nosecone will not be tested to the point of failure. Rather, the supplier will be given our requirements and the nose cone will be built to them. If a nose cone is fabricated "in house", compression tests should be performed to determine its rigidity. This should be possible with a simple press. The temperature test will be much more difficult, and published material specifications may be used instead.

Payload Tube

The payload tube, connecting joint and separation mechanism must have a bending moment in excess of 100,000 in-lbs. This will be tested at NASA Wallops. They have the appropriate equipment to perform this test.

Payload Frame

The payload frame needs to support 32 lbs. at 20 G’s. This is the equivalent of 600 lbs. However it is in a high vibration environment so a 300% overbuild seems reasonable for static testing. Since the load is distributed throughout the payload frame it is not feasible to test the integrated payload frame. A compression test of a 6” longeron section should be feasible. If this proves to have compression strength greater than 450 lbs. the entire payload frame can be considered to be of sufficient strength. This test can be done with a press.

2.9 Assembly Instructions

Assemble Payload Frame

- Attach all PCBs to the proper deck plates
- Attach parachute bridle to D5

- Attach D5 to 3 longerons
- Install the remaining deck plates
- Make all electrical connections
- Test all electrical boards
- Install last longeron
- Double-check all screws to make sure they are tight and that none protrude from the surface

Assemble Nose Cone

- Install nose tip
- Install TPU antenna
- Install the nose cone-payload tube mating ring

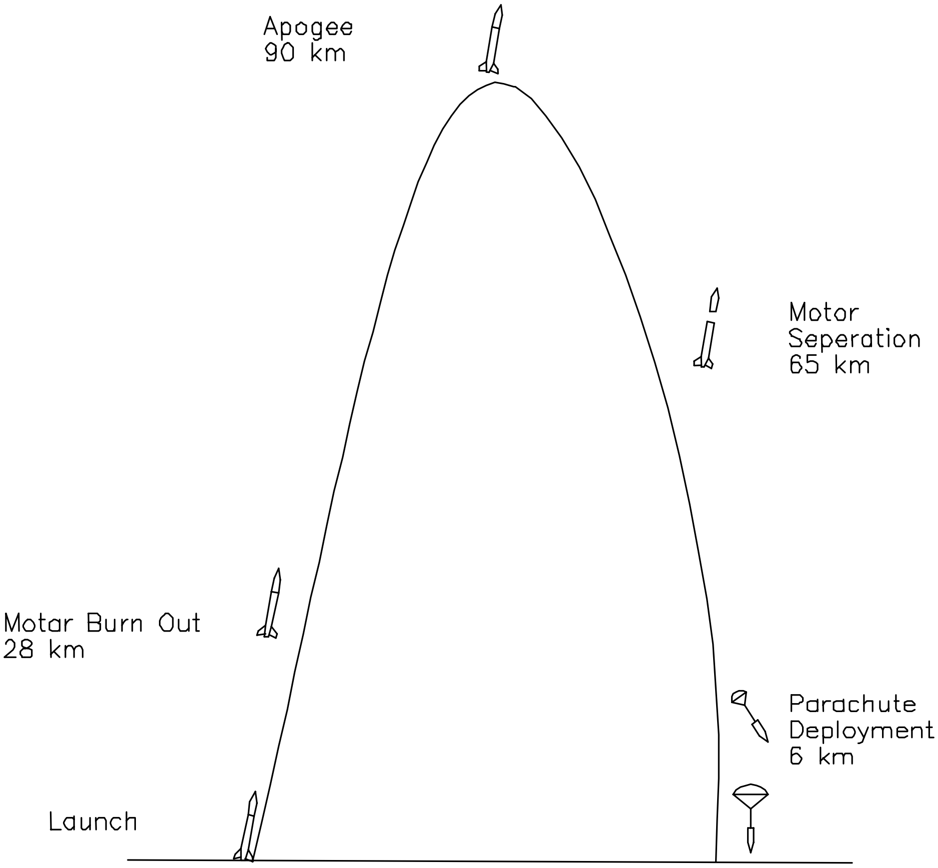
Install Payload Frame into Payload Tube

- Slide payload frame into payload tube until longerons rest on the radax joint ring
- Align payload frame with screw holes in payload tube
- Install a few screws to keep payload frame aligned
- Attach sun sensor wires to the sun sensor
- Install the sun sensor panel
- Attach coaxial cable to the transmitter antenna and to the GPS antenna
- Attach umbilical block wires
- Feed separation system wires from the EED board through holes in the radax joint ring
- Attach drag plate actuator wires from EED board
- Install PRS housing
- Attach PRS to bridle
- Pack PRS bags into housing
- Attach drag plate to PRS
- Attach drag plate to radax joint ring
- Install the remainder of the screws into the payload frame
- Double-check all screws to make sure they are tight
- Attach Nose Cone to Payload Tube
- Connect ion probe wires
- Connect TPU antenna wires
- Slide nose cone onto payload tube
- Install screws through payload tube

Attach Separation Mechanism

- Prepare separation mechanism
- Attach firing wires from EED board
- Attach separation mechanism to payload tube
- Make sure screws are tight

2.10 Flight Profile



Event	Time (min)	Altitude (ft)	Altitude (km)	Velocity (ft/sec)	Velocity (mph)	Velocity (m/sec)
Launch	0	647	0.20	0	0	0
Motor Burn Out	0.53	90000 to 100,000	27.4	3900	2659	1189
Coast To	1.95	N/A	N/A	N/A	N/A	N/A
Apogee	2.3					
Apogee	2.48	278,871	85.0	617	421	188
	2.78	311,670	95.0			
Payload	3.50	213,255	65.0	TBD	TBD	TBD
Separation	4.10					
Aero	4.45	130,000	39.0	623	425	TBD
Decel	5.28	to	to	to	to	
		115,000	35.0	619	422	
Drogue	5.71	20,000	6.10	207	141	61
Deploys	6.65					
Main	5.88					
Parachute	6.82	18,500	5.64	128	87	39
Deploys						
Touch	33.18	TBD	TBD	12.8	8.7	3.9
Down	34.65					