Preliminary Design Report

MH Space Grant's High-Powered Rocketry Competition

University of St. Thomas

UST Rocketry Team

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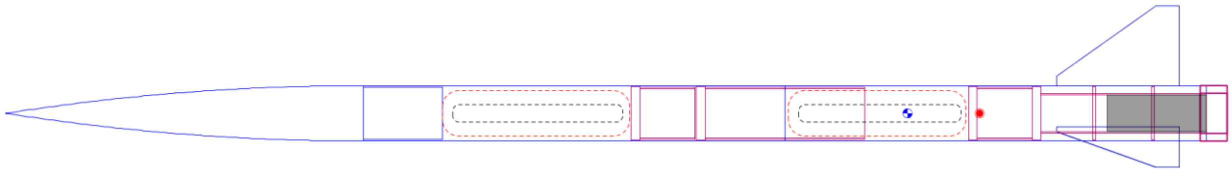
Diagrams of the Center of Gravity and Center of Pressure

<u>For the complete rocket</u>:

CP: 141 cm from tip of nose cone (noted by the red dot)

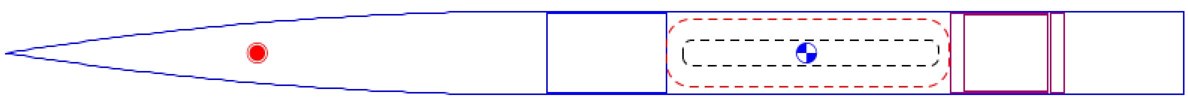
CG: 131 cm from tip of nose cone (noted by the blue/white dot)



<u>For the dart only</u>:

CP: 24.1 cm from the tip of the nose cone (noted by the red dot)

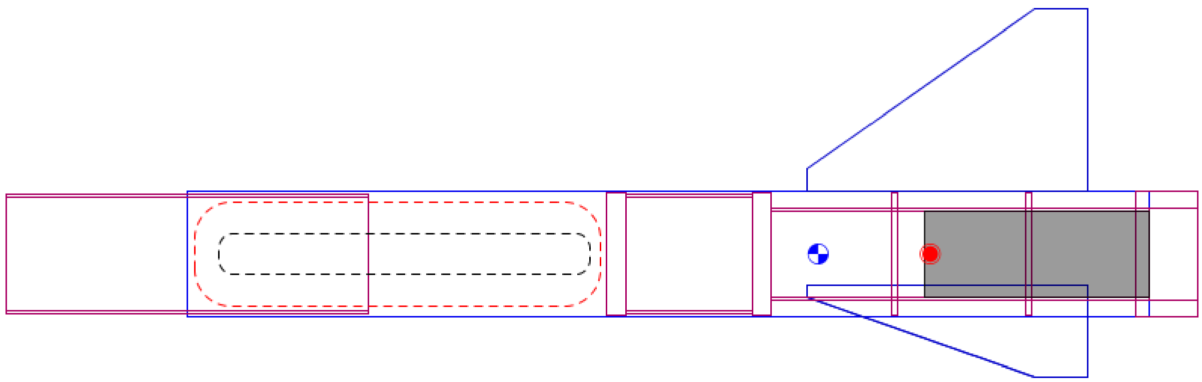
CG: 76.7 cm from the tip of the nose cone (noted by the blue/white dot)



<u>For the booster only</u>:

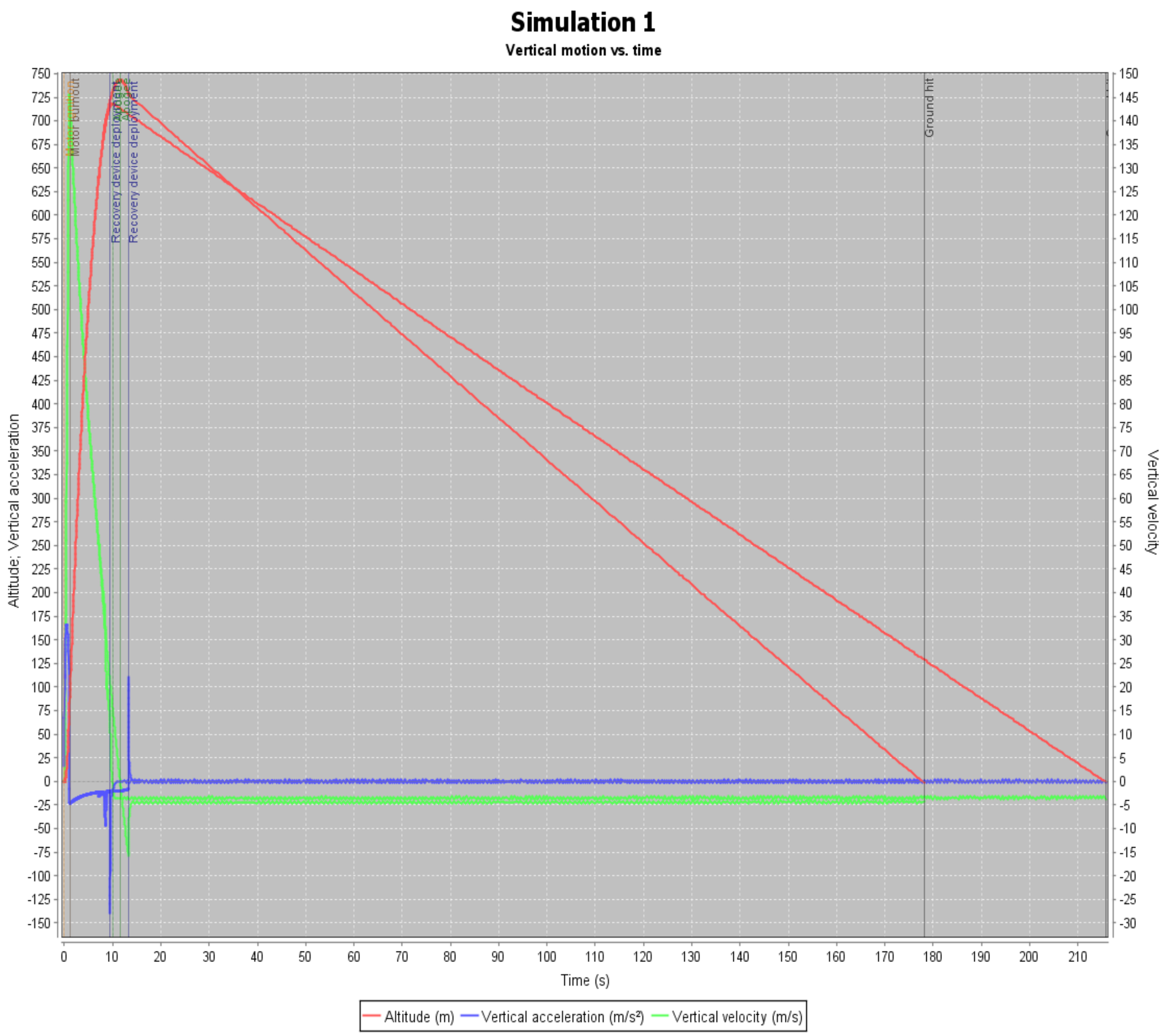
CP: 40 cm from the forward tip of the coupler (noted by the red dot)

CG: 47.1 cm from the forward tip of the coupler (noted by the blue/white dot)



Simulation Results

These simulation results plot motor burn out, apogee, ignition, dart separation, ground hit and recovery device deployment.

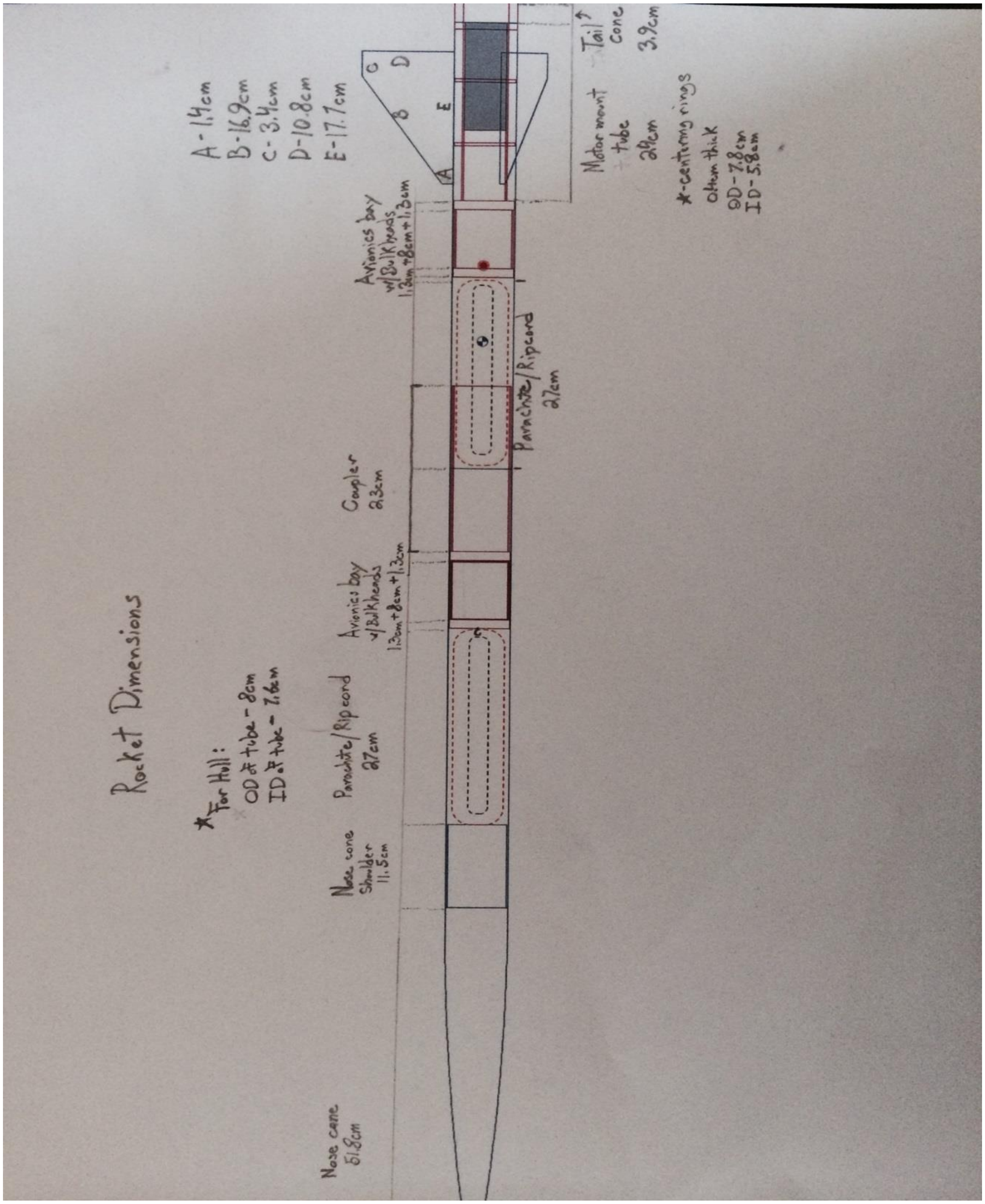


Setting up the Simulation

We used a software called Openrocket to form a simulation which requires measuring each individual part of our rocket and inputting into what is essentially an atmospheric calculator. I then used my knowledge as a helicopter pilot to check various aviation weather forecasts to input proper atmospheric conditions into the simulation. All forecasts can be found on AviationWeather.gov or NOAA.gov. I then used a software called Skyvector.com to look up the geographic coordinates to input into Openrocket as to simulate accurate flight data.

Dimension Specifications

We found that a picture outlining all of the dimensions would be far more advantageous (as well as easier for the reader) than listing out dimensions. Below is that picture.



Recovery System Design Specifications

Our recovery system consists of a standard electronic deployment using two Stratologgers to deploy two “TAC-1” parachutes sold by GiantLeapRocketry.com from both the first and second stage tethered to their respected stages by a part Kevlar part nylon rip cord.

<u>Second stage recovery</u>: (top half of rocket or the “dart”)

At apogee (In our current built apogee is at 750 meters or 10 seconds after launch) a **Stratologger** triggers a pyrogenic pressure spike inside of a small contained space located just aft of nose cone. That pressure spike forces the nose cone from the hull of the dart taking with it one attachment point of the rip cord. The other end of the rip cord is attached to an anchor firmly planted in a bulkhead at the bottom of the dart via screws and epoxy. The parachute is attached 80cm down the cord length from that dart housed anchor. In the aforementioned contained space is the **parachute**, the **parachute shroud**, the **rip cord**, a **swivel mount** and an **anchor**. To mitigate several failure points of the recovery system, we did a few things.

<u>First stage recovery</u>: (bottom half of our rocket assisted by the engine)

At 8 seconds into flight we are having the StratologgerCF separate the two stages. This is done at a considerable speed so we have to allow the jettisoned stage slow down a little bit more before deploying the parachute. After the desired speed has been reached, deployment of the first stage will be exactly the same as the first stage with one acceptation. Instead of pushing the nose cone off we will be pushing a weak plastic cover off designed only to keep the parachute from deploying during the slow down period.

<u>Equipment involved</u>:

-**The Stratologger**: We are using a StratologgerCF sold by Perfectflite which is an on-board altimeter with a built in accelerometer that will be used to deploy the recovery system via 2 pyrogenic avenues for redundancy purposes.

-**The Rip Cord**: Firstly, we split the rip cord into two different materials. We needed our cord to be very resilient around the part that may come in contact with the edge of the dart as to mitigate a potential separation by cutting when the line becomes taut but we also needed it to be elastic to absorb some of the force produced when the line would become taut since we are essentially tethering a projectile (the nose cone) to a base (the anchor). We found that a combination of Kevlar around the section of potential cutting and an elastic nylon running the remaining length of the cord was optimal.

-**The Swivel mount**: We decided to use a swivel mount in our rocket build because we felt it necessary to eliminating a potential problem with the parachute deployment. There is a possibility of having the parachute spin so much that it arrests the parachute from being able to deploy. The introduction of the swivel mount reduces that possibility.

-**The Parachute Shroud/The Parachute**: We settled on the “TAC-1” design sold by

GiantLeapRocketry along with a Kevlar protector to go with it. This type of parachute design is incredibly light weight and almost guarantees a consistent deployment if used properly.

Here is a picture of a slightly smaller TAC-1 while deployed:

-**The anchor**: We simply put a normal steel hook rooted inside of a Spruce bulkhead and secured it by locking washers. This is a rudimentary yet effective way to ensure that our anchor will be able to absorb the force generated by the rip cord going taut. We found via testing on the ground and in the air that his was a successful way to mitigate worrying about another potential failure point on our recovery system. The bulkhead to which the anchor is attached is also supported by AeroPoxy adhesive as well as 2 screws.

Propulsion System Specifications

We are using a Cesaroni 475-I445-16A (54mm, 1 grain, Vmax) as our rocket motor which is required by the competition. We secured this motor in our first stage via a few different methods:

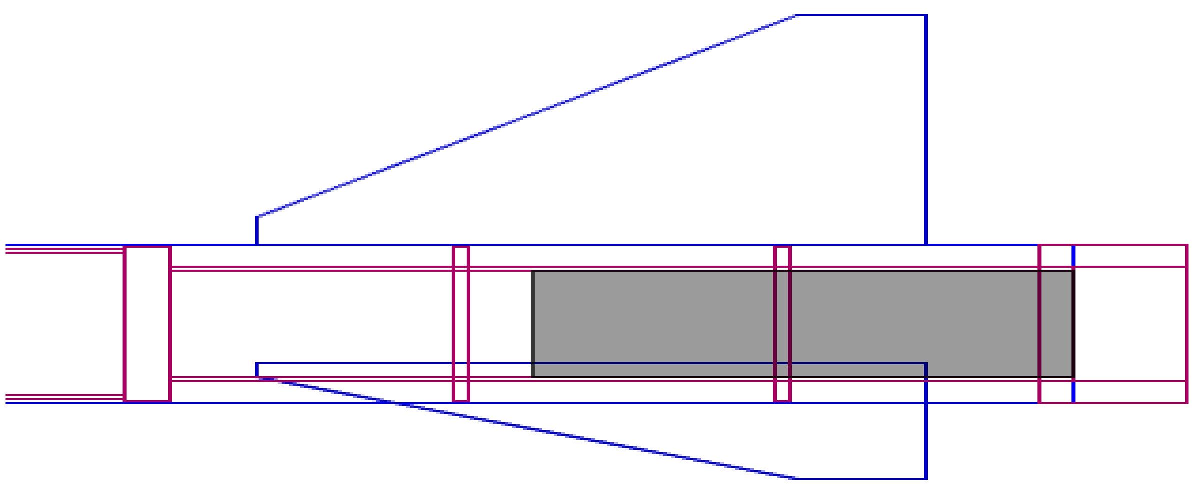
-Firstly, we have the “reloadable” secured in an aluminum heat shroud offered by Cesaroni. The reloadable is secured into this aluminum tube by a screwed in end cap which allows for the protrusion of the 1.5 grain charge exit port as well as the nozzle of engine.

-Secondly, the aluminum heat shroud is secured inside of the motor mount tube by the use of a retainer screwed into a tail cone. This allows easy interchanging of the motor “reloadable” if either failure were to occur or if another launch was necessary.

-Thirdly, the motor mount tube is secured into the hull by the application of 2 centering rings in addition to the tail cone. These centering rings are held in place by AeroPoxy adhesive as well as slits in the tail fins which protrude 2 cm into the rocket body coming flush with the motor mount tube. This allows for an added level of stability in the structure in case the epoxy was to fail.

Picture of the aft end of our two stage rocket

Forward Aft



Avionics System Design Specifications

For our avionics bays we found that simple phenolic tubing way sufficient to housing the electrons of our Stratologgers, their power sources, and the JollyLogic altimeters. This choice though could lead to two potential problems, however, that we planned for accordingly.

-Firstly: the separation charge could crush the phenolic tubing quite easily. We remedied this problem by adding reinforcing steel rods that run the entire length of the phenolic tubing. These screw into the two Spruce bulkheads the cover both sides of the Avionics bay.

-Secondly: the separation charge might knock the bulkhead loose if we are using friction alone to keep it in place. To remedy this we added screws penetrating the hull of the rocked and securing into the bulkhead on the side that is going to receive the blast.

We also had to run wires through the bulkhead to allow the Stratologger to trigger the separation charge near the coupler. This was done by drilling very precise holes and running the wire through these ports in order to allow for separation without damaging the electrons. These ports were then sealed with electronic tape. We also had to add static ports (2 per avionics bay) in the hull of the rocket to allow ambient air pressure to equal the pressure inside of the avionics bay. Equal pressure is required to get an accurate readout from the JollyLogic as well as is required for the Stratologger to function.

Planned Construction Solutions & Techniques

A full plan was drafted of how to assemble the parts in certain orders. To do this however, we had to modify most of the parts we purchased and we had to do so safely. Below are a few examples of how we safely executed out construction plan.

We utilized The University of St. Thomas' machine shop to safely modify all parts used in our rocket to tailor fit our design. As to be expected, parts ordered from a 3rd party were never exactly "perfect" and required some machining. We always made sure we wore safety goggles when modifying wood and always did so under observation of the shop's knowledgeable machine operators. From this, we learned how to safely use drills, saws, and other machines that helped us build our rocket.

Once the parts were modify for our use, we followed our design plan which called for an order of parts to be assembled first. For instance, we had to insert and adhere all the centering rings before we put in our fins because these two parts locked into each other. A design idea that helps structural integrity.

I also made my team wear Nitrite gloves when handling the AeroPoxy adhesive used to secure our centering rings and fins. In addition, I made sure we worked in a well ventilated workspace when mixing the adhesive and apply it.

Structural Analysis of 3rd Party Made Parts.

Certain areas of our rocket required testing before launch of the final product was to happen. Our recovery system, for instance, was tested prior to our first launch to see if several things were going to happen as we believed they would. For instance:

-We tested to see if the tube could withstand a blast of 2 grams of ffffg type black powder. This is .5 grams over the amount found in the delay charge of the Cesaroni engine that we are using.

-We tested to see if the recovery system with deploy with resistance (meant to simulate the force opposing the nose coming off when the rocket would be moving vertically) and it preformed admirably.

-We tested the resilience of all parts we purchased individually when they came in. The last thing we wanted is to have an electronic system or tail cone retainer break mid-flight.

Budget – UST Rocket Team

Equipment	Name	Distributor	Price
(1) Transponder	AT-2B Transmitter	Communication Specialists, INC	$99.95
(2) Reciever	R-300A	Communication Specialists, INC	$349.95
(3) Engine	Cesaroni 475-I445-16A	The mortorman HPR	$170.49
(4) Altimeter	Jolly Logic AltimeterTwo (2)	Amazon	$139.90
(5) Hull (2)	(3inch-54mm G10 Fiberglass) 48"	Rocketry Warehouse	$349.60
(6) Printable checklist		Kinkos	$5.00
(7) Launch pad/guide rod			$5
(8) Engine Centering Rings (2)	3inch 54mm G10 centering ring	Rocketry Warehouse	$18.00
(9) Parachute (2)	36" parachute (PAR-STD-36)	Rocketry Warehouse	$135.80
(10) Fins (2 sets)			$193.60
(11) Tripoli Safety Inspection		Tripoli	$50.99
(12) Adhesive/bindings		Gaint Leap Rocketry	$9.70
(13) Rocket nose (3)	3inch:1 Ogive (FGNC-3-3-O)	Rocketry Warehouse	$90.00
(14) Tailcone Retainer(2)	3inch tailcone 54MM retainer	Rocketry Warehouse	$90.00
(15) Apogee explosive charges		Giant Leap Rocketry	$46.72
(16) Motor mount tubes (2)		Mad Cow Rocketry	$42.80
(17) Rip cords		Off We Go Rocketry	$6.99
(18) Electronics deployment altimeters x2		Gaint Leap Rocketry	$274.18
(19) Electronics (Stratologgers)		Gaint Leap Rocketry	$167.90
(20) Electronics (USB Data transfer wires) x2		Giant Leap Rocketry	$67.90
(21) "ffffg" type black powder		10 Ring - Houston	$21.99
(22) Registration Fee			$400
(23) *Total fund set aside for Hotel/Travel			$2,500.00
Rocket budget total			$5,709.47

*In addition to all the equipment purchased a $2,000 has been placed aside for traveling expenses (including hotels) as well as a $500 amount in case of emergency.

Executive Summary

The two stage rocket leaves some room for improvement, especially in the weight category. However, as it stands now, it is an incredibly robust system that is capable of hitting an altitude of 750m with a max separation distance between dart and booster. When we were building the rocket, we decided that carbon fiber would the best material to construct the hull out of. This gave us a great balance between having our airframe strong enough to withstand a potential failure while keeping weight to a minimum. With the learning curve of rocketry defeated, we look forward to improving our design with other concepts that give us a lighter overall weight. Once we have completed that, we can be far more competitive in the competition and explore other avenues of expanding the distance between the separation of both stages of our rocket.