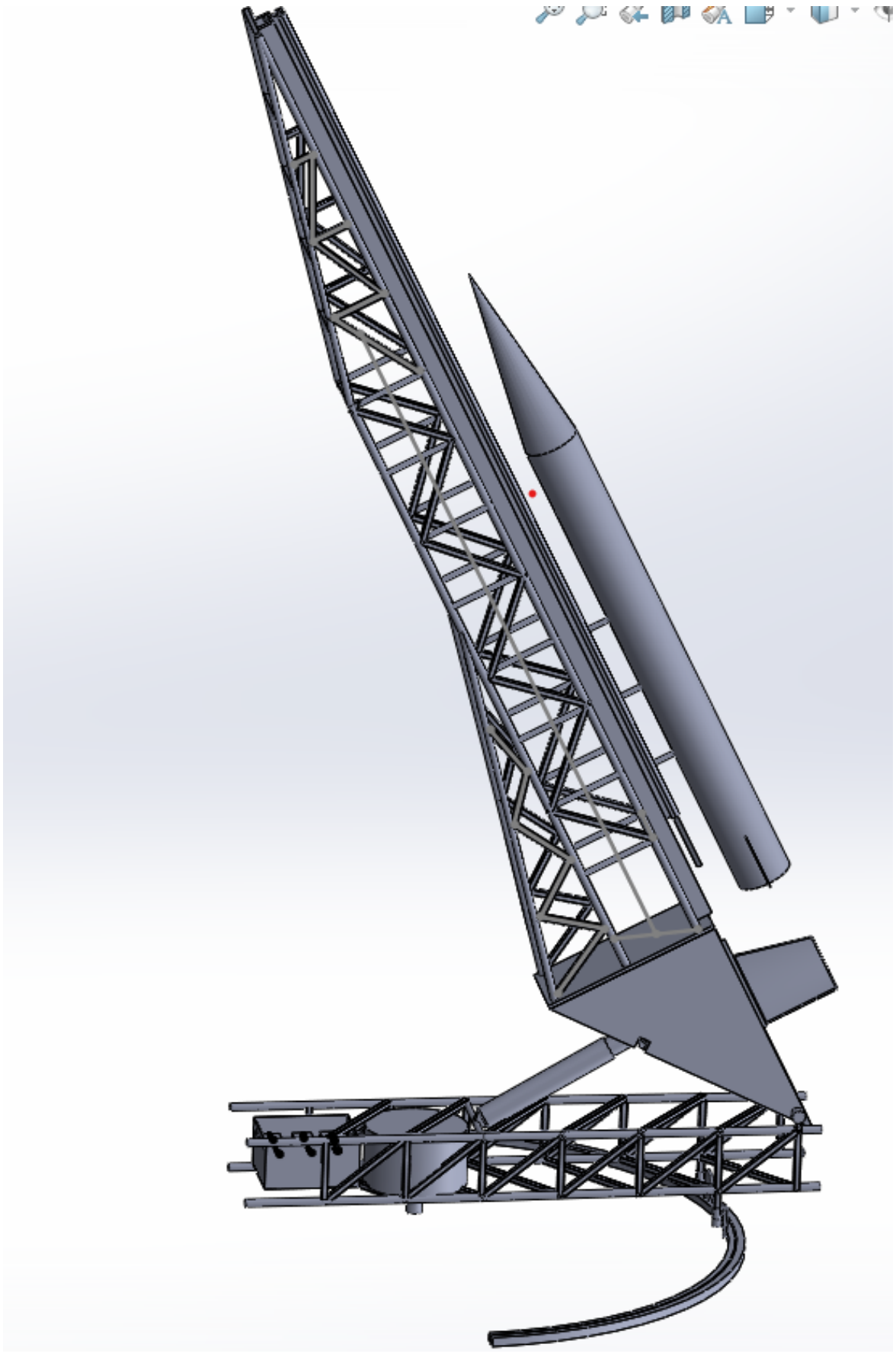
Designing a LaunchPad for Sounding Rocket
Team No. 35

Introduction:

The design process of a launchpad for sounding rockets is a critical process that includes factors like ignition, safety mechanisms, structural compatibility and avionics system deployment. It varies according to the type of sounding rocket. This report describes the design of a launchpad which will consist of a tilted truss-mounted rail system controlled through a linear-actuator based shaft-system and a circular wheel-rail mechanism to point it in the right direction at liftoff, two rotational degrees of freedom. For fuelling mechanisms, the sounding rocket uses hybrid propellant as fuel. We use a pipeline system with automatic detach and seal for liquid oxidiser, whereas we place solid propellant directly. A V-shaped bifurcating flame deflector will be mounted on the rotating rocket mount at the bottom of the rocket to prevent possible fire to the launchpad.

The avionics system will be a cable guided system that handles the communication between the rocket and the launch pad. It will contain several command circuits within. These include ignitor circuit, launch command (release) circuit, abort circuit in case of emergency, fuelling command circuit, orientation circuit commanding the rails' motion. The preliminary CAD model of the launchpad is as follows



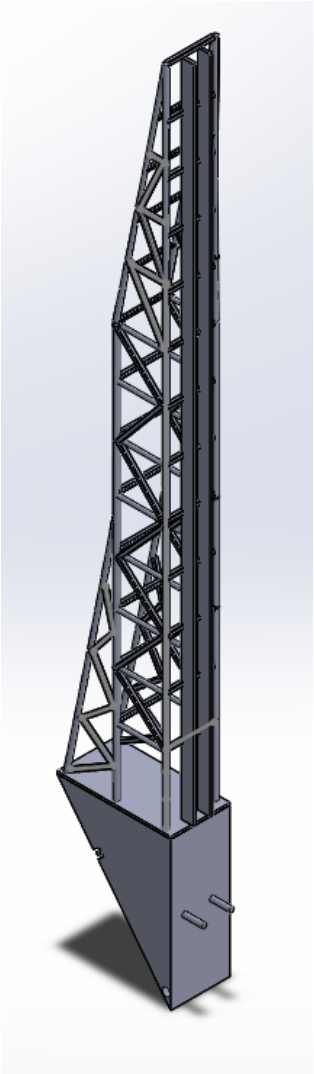
Components, design process and mechanisms:

The design of our launchpad includes the following components:

- **Vertical stand** (to hold rocket)
- **Horizontal stand** (to hold the vertical stand and change direction when rotated)
- **Semicircular rail** (to change the direction)
- **Vertical rail** (to guide rocket in particular direction smoothly)
- **Hydraulic jack** (linear actuator)
- **Angular actuator** (to rotate the horizontal stand)
- **Electronics box** (Avionics)
- **Retractable wheels** (to move launchpad)
- **Flame deflector** (to prevent damage from flames)
- **Fueling mechanism** (to fill liquid oxidiser)
- **Automatic detach and seal components**
- **Igniter** (to start the rocket)
- **Linear hinges** (to attach a rocket to vertical rail)

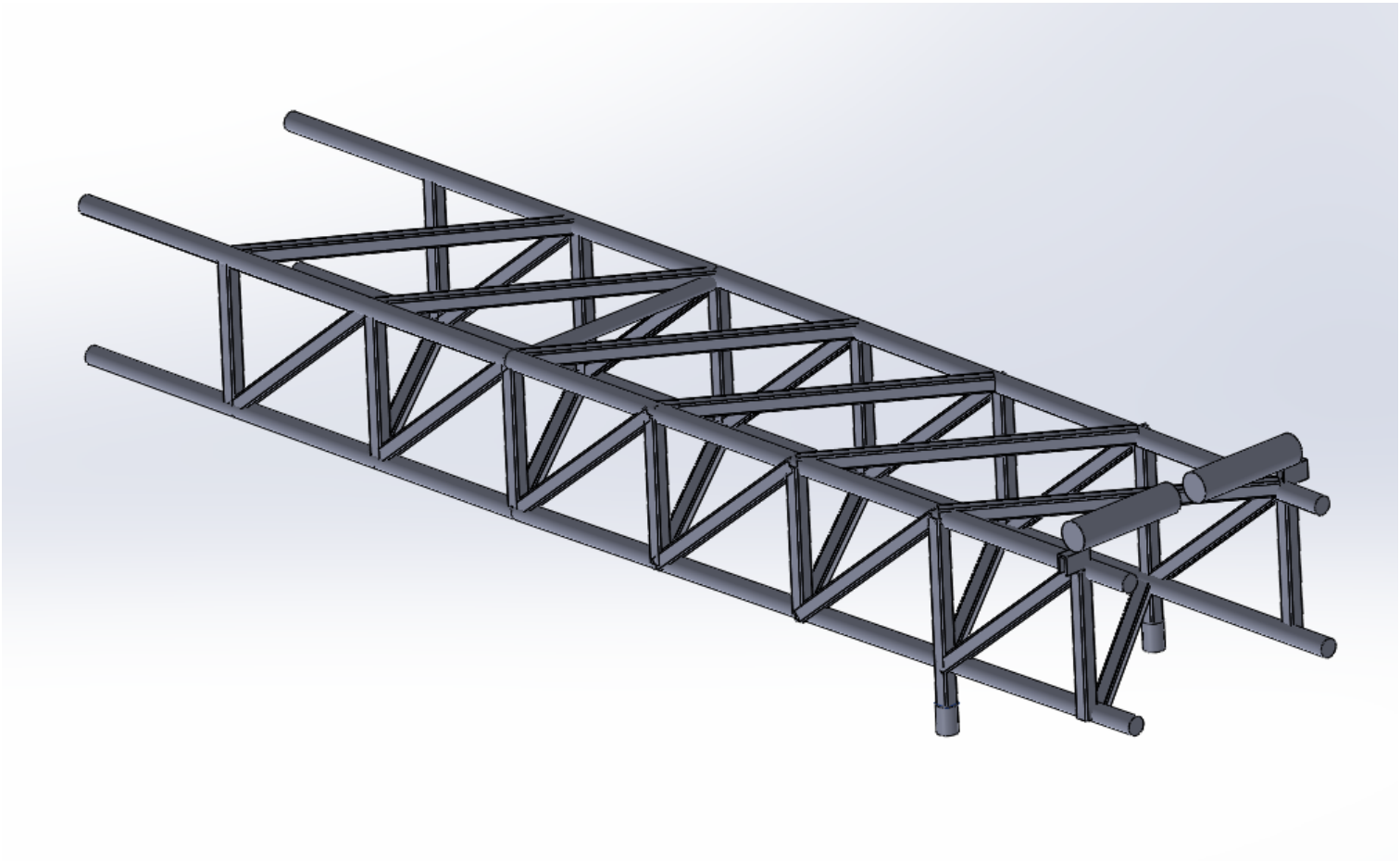
Vertical Rail/ Stand:

The vertical rail/stand is one of the most important components of our launchpad. It serves not only as standing support for the rocket but also provides a way for effective communication between the rocket and the avionics system of the launch pad. It also connects the rocket to the fuelling system pipes when required and thus helps in liquid oxidiser fuelling. The structure of the vertical rail to support such functions is truss based to provide structural strength, less weight as well as the required vacancies for the components like launch rails, flame deflector and ignitor switch to fit. The total height of our vertical rail is around 15m. The CAD model for our vertical rail is as follows:



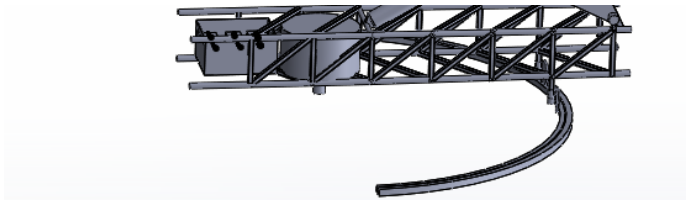
Horizontal Stand/Rail:

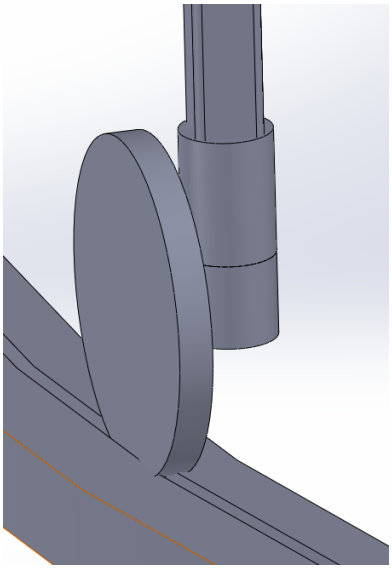
While the vertical rail directly supports the rocket, the horizontal rail supports the vertical rail. This component of the launchpad is also very important because it is responsible for both the rotational degrees of freedom of the launch pad. It connects with the vertical shaft through a linear actuator, described ahead, which is responsible for changing the inclination of the rocket while launching with respect to the ground. A hinge has also been used to connect it to the vertical shaft to provide additional support. Apart from this, as visible in the CAD figure below, the horizontal rail also has two rotatable wheels near the hinge, which allow it to laterally rotate the vertical assembly by moving the rails on a semicircular rail fitted to the ground using a distantly placed motor. This provides the pad with its second rotational degree of freedom. Moreover, the horizontal stand is also the place where the avionics box of the launch pad is placed on the end away from the rocket. The horizontal rail is nearly 7m long.The CAD model for horizontal rails is as follows:



Semicircular Rail and wheel assembly:

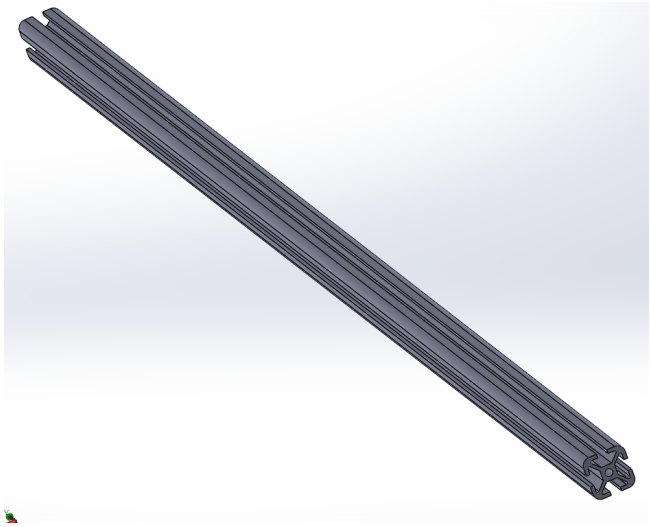
The wheel assembly attached to the two front axles provided in the horizontal stand moves on a semicircular rail which is such that the wheels are locked inside it while moving, and thus the lateral rotation of wheels which was otherwise permitted in the absence of semicircular rail is hindered and the assembly remains stable. As the wheels move on the semicircular rail, the direction of the launch of the rocket varies while keeping the angle of inclination with respect to the ground as constant.

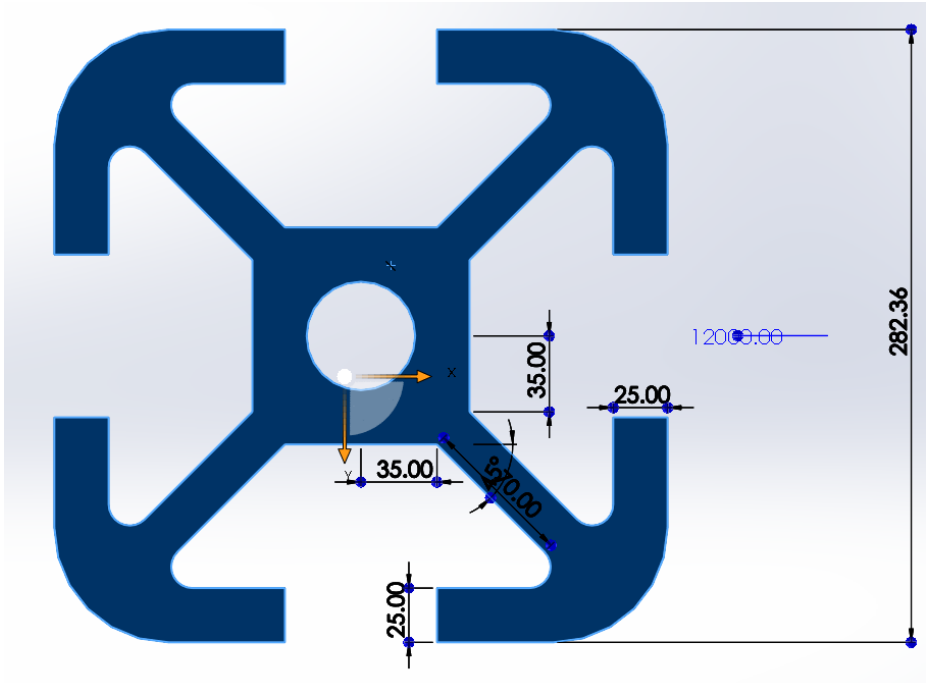


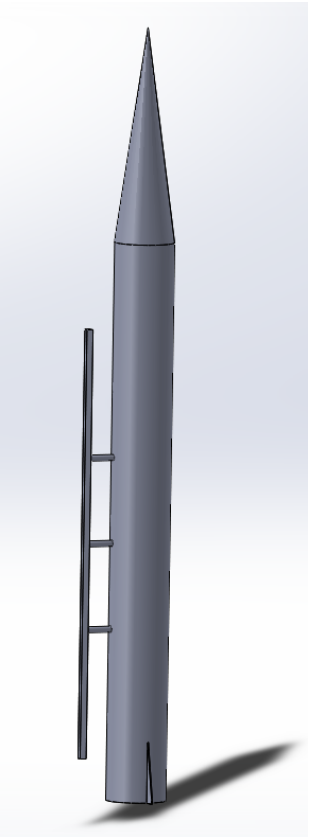


Vertical Launch Rail:

A system of launch rail has been used to guide the rocket smoothly for appropriately directioned launch. The launch rail system has been chosen over the launch rods keeping in mind the size of the rocket. The rocket moves on the launch rail, quite smoothly by being connected to linear hinges, which get off the rocket just before the launch. The CAD model for the rail and hinges connecting the rocket are as follows: (the shown model of rocket is only representative)

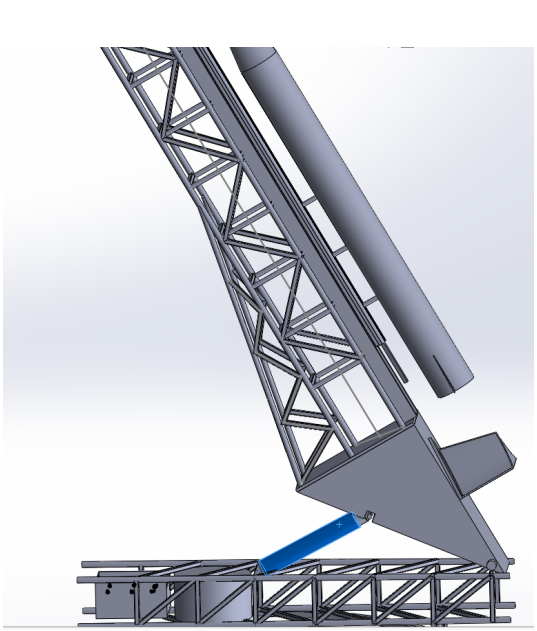


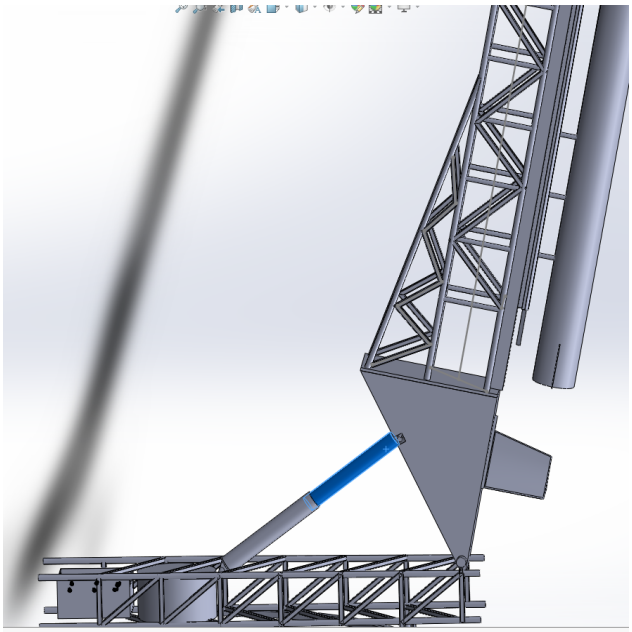




Hydraulic Jack (Linear Actuator):

The linear actuator has been fixed between the horizontal and the vertical stand. It is the component as mentioned before, which is responsible for changing the inclination angle of the launch. The linear actuator used in our design is a hydraulic type linear actuator, which is activated by the appropriate circuit in the avionics box. The hydraulic jack consists of two shafts out of which one is hollow and the other shaft moves in and out of it to change the length of the actuator, and thus the inclination angle. The minimum and maximum inclinations thus achieved by this linear actuator are 62 degrees and 105 degrees respectively, which are good as compared to usual launch inclinations of sounding rockets i.e 88 degrees. The orientations of the launch pad in these two extreme inclinations are as shown below.





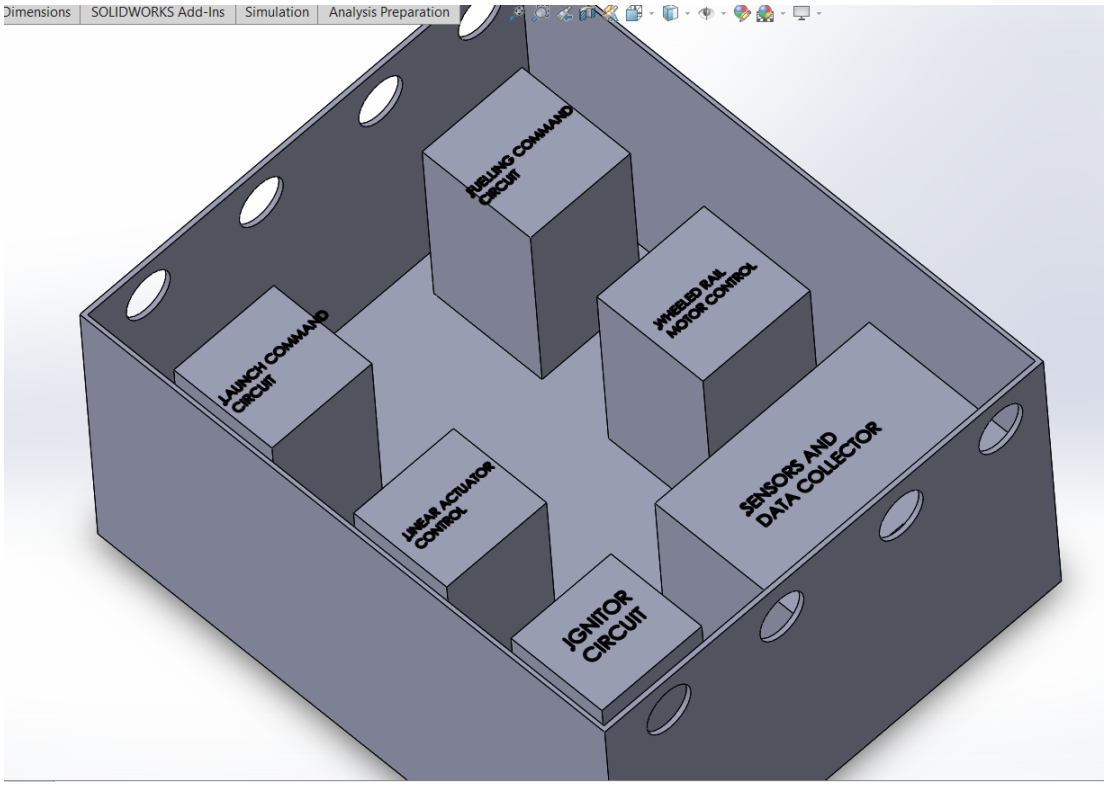
Angular Actuator:

A simple angular actuator (high powered motor) is fitted in the horizontal rails for the horizontal rotation of the assembly. It is placed just ahead of the avionics box and is suitably connected.

Electronic box

Avionics are the electrical systems necessary for flight and are driven by software. We used an electronic box which includes all avionics and sensors used in the launch pad. It contains several command circuits within. This box includes ignitor circuit, launch command circuit that can be operated by mobile (to keep a track of rocket, abort circuit in case of emergency), fuelling command circuit, orientation circuit commanding the rails' motion. This box also includes sensors within it like temperature sensors.
Some of them are mentioned below:

- *Launch command circuit:* Used to activate launch operation
- *Linear Actuator control:* used to adjust the length of linear actuator which accordingly change the angle of the vertical stand
- *Ignitor circuit:* Used to ignite fuel
- *Sensor and data collector:* It collects all the mission information and current status data of rocket like pad temperature relative to ambient conditions, fuel tank pressures, orientation of the launching assembly and transfers this information to the designated circuits.
- *Fueling command circuit:* It is used to activate pipeline mechanism and automatic detach and seal mechanism
- *Wheel rail motor control circuit:* used to rotate the horizontal rail on semicircular part



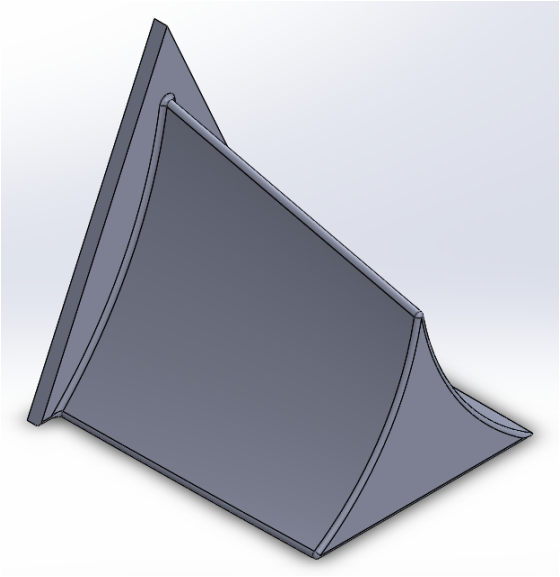
Retractable wheels

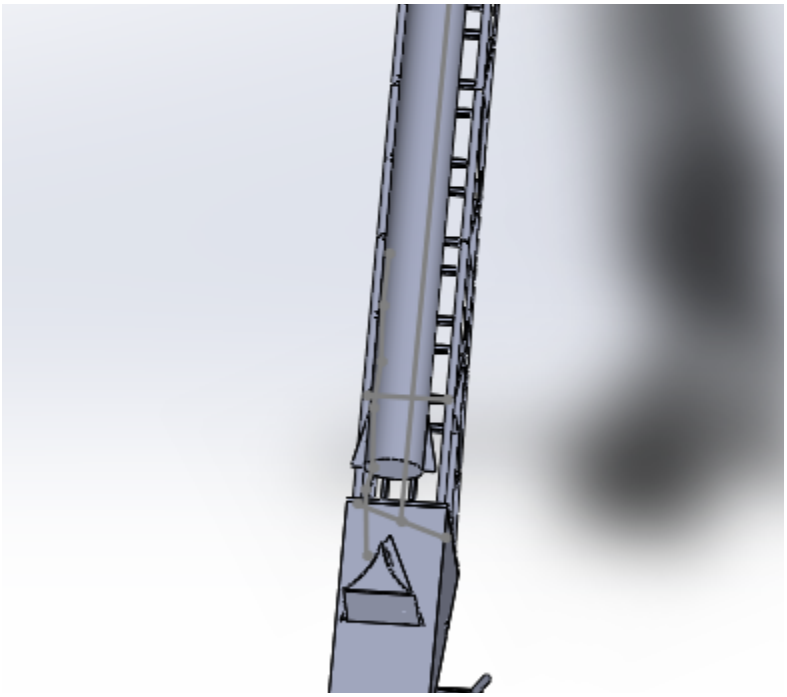
The retractable wheels are attached to the horizontal stand and used to move the launchpad with hydraulic jack as a linear actuator, it is used to move wheels up and down according to the needs like when we are moving the launchpad, axle of the wheels expand and wheelbase is in contact with ground to move launch pad and when launchpad is fixed the wheels go up to perform launch operation appropriately

Flame deflector

A flame deflector is a structure that prevents damage to a launch vehicle and a launchpad due to the exhaust plumes of a lifting-off launch vehicle. Flame deflectors such as flame trenches serve a number of purposes. Firstly they prevent damage to the rocket caused by the rebounding of foreign objects such as concrete particles up into the rocket. Secondly, they ensure that hot exhaust gases are directed away from the launch pad facilities to minimise exposure.

We attach a flame deflector at the bottom of the vertical stand just below the rocket to prevent damages. It is tilted outwards so that flame go outwards and has much low effect on launchpad





Fueling mechanism

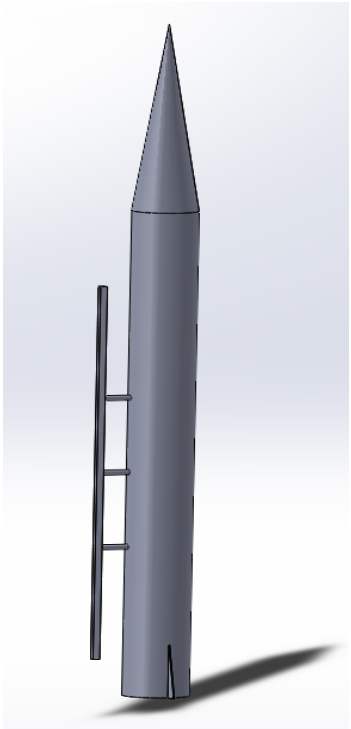
Rocket has a hybrid engine in which Nitrous oxide is selected as an oxidizer as it is relatively safe to store and handle, plus it is self pressurizing. Both of these advantages reduce complexity and cost and increase safety in a rocket program and it solidifies within a few hours. So, fuel can't be kept in the engine before launch. That's why we use a pipeline mechanism to feed fuel into the engine just before the launch. We have designed a fueling mechanism in which there is an insulated pipe attached between vertical and horizontal stand/rail with a linear actuator in vertical stand and when we mount a rocket on the vertical stand, the pipe will go automatically into the fueling hole of the rocket when we activate it using electronic circuits. It then automatically seals the hole when fueling is completed. There are various sensors attached to the sealing pad to ensure proper sealing and then the pipe comes back into the vertical stand providing no hindrance to the rocket.
For solid propellant we can directly replace the solid motor at the time of rocket assembly.

Igniter

Rocket engines are always ignited electrically from a safe distance. The igniter (which is sold with the motor) is typically made from wires that connect to a thin wire coated in pyrogen. This pyrogen-coated tip is inserted into the rocket motor's nozzle and is in contact with the solid propellant. When sufficient electrical current is passed through the igniter, the thin wire heats, igniting the pyrogen, which then ignites the motor propellant.

Linear hinges

Linear hinges are attached to a rod that goes into the vertical launching rail. Very highly specialized hinges are used to release the rocket at predetermined angles just before the launch



and configurations as well as permit antennas to properly deploy. These hinges use a latching mechanism that locks a rocket into position.

Review on mobility of the launch pad:

The launch pad can be provided with two retractable wheels in the front part of the horizontal stand for translational movement. These retractable wheels are not restricted to move in a single direction. They are free to rotate about their vertical axis and thus provide additional translational degrees of freedom. The wheels are retractable in the sense that they are pulled back while the launch pad has to perform in the stationary mode by removing their ground contact to ensure stability of the launchpad during the launch. Thus, the launchpad can be operated in two different modes: stationary as well as mobile launcher.

Summarised approach:

1. First, we have designed a vertical stand in Solidworks used to hold the rocket, launch rail, Flame deflector and Pipeline system made up of a truss bridge that will give very high strength so that it will handle the high thrust and rocket weight.
2. Then we designed a Horizontal stand in Solidworks used to hold a Vertical stand, Electronic box, Angular actuator and a Hydraulic linear actuator made up of a truss bridge which will give very high strength so that it will be able to handle the high thrust and rocket weight.
3. Horizontal stand and vertical stand are connected at two positions first at the bottom edge with a linear rod which will allow the vertical rod to rotate about that rod and other is a hydraulic jack which is used as a linear actuator to set rocket in a particular direction and it is connected between the horizontal stand and the vertical vertical stand.
4. Then we connected the **launch rail** (*which will be used to guide the rocket smoothly*) and **flame deflector**(*used to deflect the flame to prevent damage)* to the vertical stand and fixed it on a vertical stand.
5. Then we attach two wheels parallel to the horizontal stand which are parallel to the front side of the vertical stand, they are moving on the semicircular rail to give direction to the rocket in the perpendicular plane
6. We also designed two retractable wheels axle as hydraulic linear actuators they are connected to a horizontal stand and are used to move the launchpad
7. We will use an angular actuator that will rotate the horizontal stand on the semicircular rail

Pls find below the link to the drive folder to find all of our prepared CAD designs for the launch pad.

https://drive.google.com/drive/folders/1QZ9nUw2DnAqUoK19cxwWAmSiLD2GgDgt?usp=sharing