Internship Report on

NOVA-0B110

At STAR – Space Technology and Aeronautical Rocketry

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Jaypee Institute of Information Technology

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NOVA-0B11O

What is NOVA-1B110?

It is a design of a Rocket Motor Static Test Pad for testing and acquiring the required data for the performance analysis of the high-powered rocket motors. Through its stable design and adjustable clamps, it can hold of variable diameter of motor and of any length. And it achieves its stability through its adjustable stands so as it can get a sturdy position in an unlevelled ground too. And the avionics of the Static Test Pad is also made in such a way so that it can be held easily in the avionics bay.

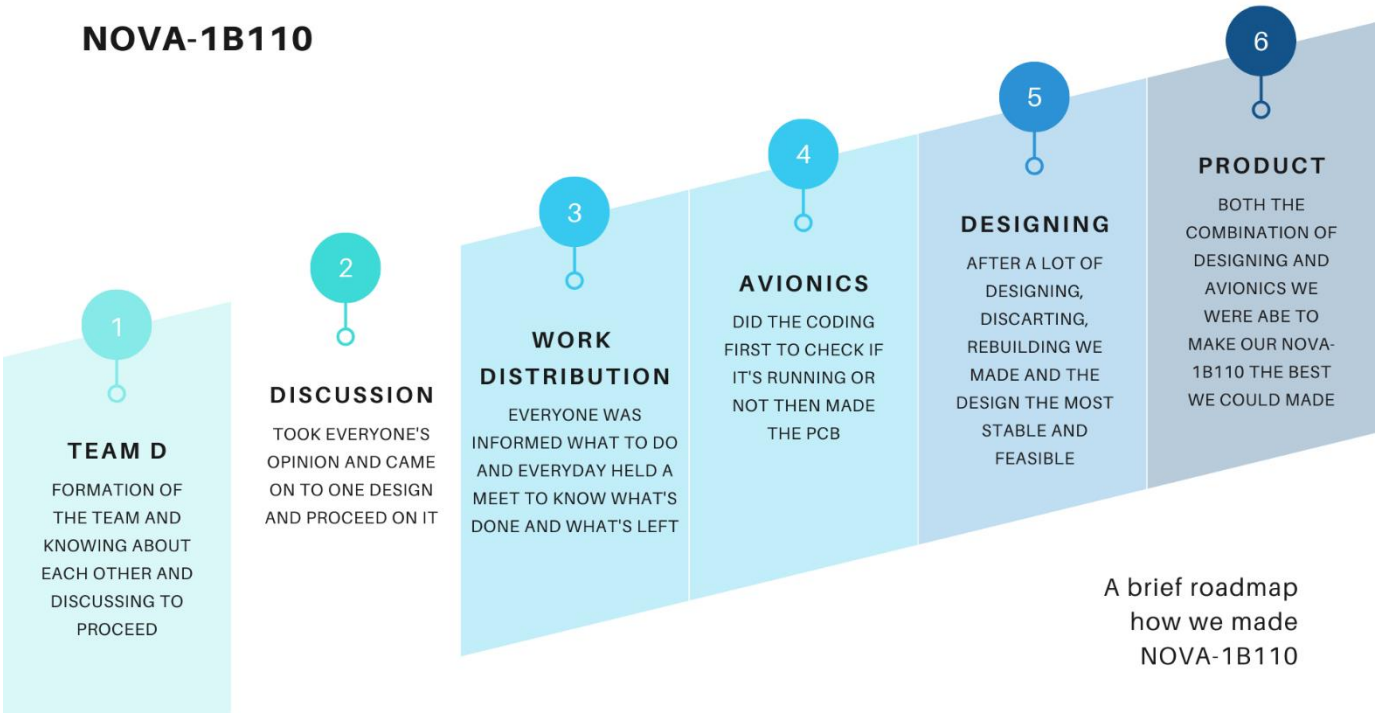
Basic working principle of NOVA-1B110:

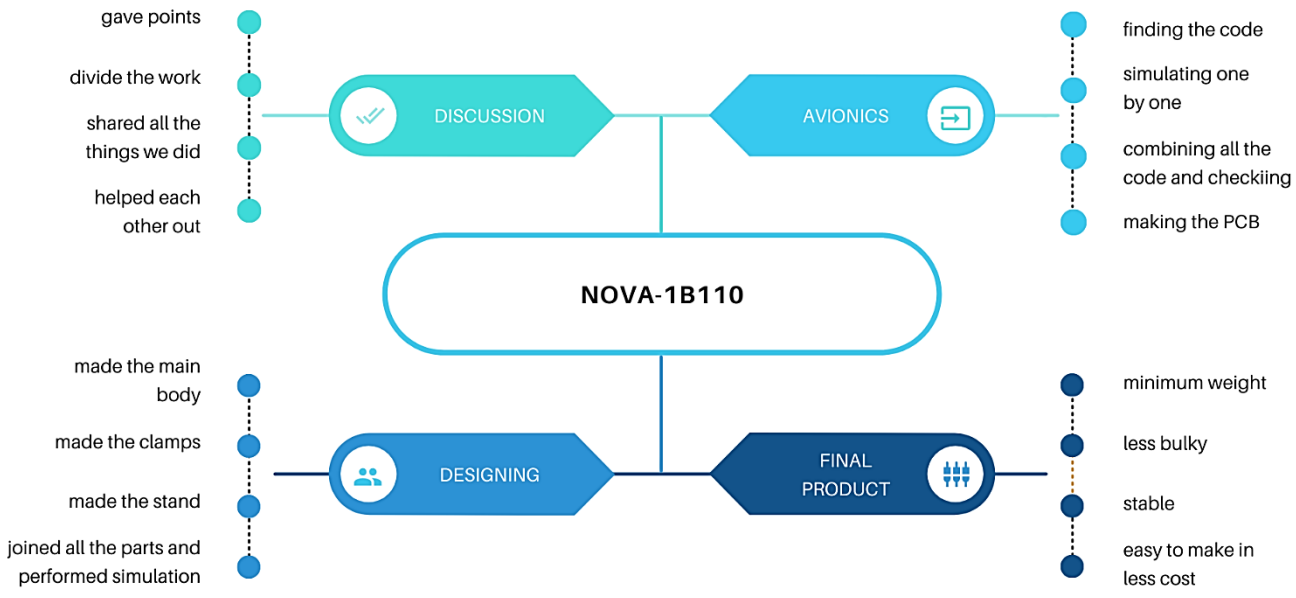
- The design we built is a lot stable as for the un even ground it has adjustable stand where you can adjust the test pad as required.
- The clamps are also adjustable in holding the motor of variable length and of variable diameter.
- Avionics of the STP is kept away from the test pad connected through a wire to the load cell in the STP.
- Make the STP levelled on the ground with the help of adjustable stand.
- Then place the motor between the clamps and tighten them accordingly and also take the height accordingly.
- Make sure the avionics bay is away from the STP at least 20 m.
- Connect the load cell to the avionics bay through the wires.
- Then ignite the motor from the avionics bay and check for the result in SD card.
- In the avionics bay:
    - The code is pre uploaded in the PCB.
    - The load cell would tell the load applied by the motor and the temperature sensor will tell the temperature of the flame.
    - If there is any error or something went wrong there is a LED to alert us.
    - And to get the result we will see the SD card.

Why to make NOVA-1B110?

As we have seen test pads very heavy, non-adjustable, high building costs. So, we made the NOVA-1B110 to make the testing of the motors easier and in a very stable manner with a low cost to build. As the whole system is in screw and nut mechanism it is very easy to carry it.

How did we proceed?

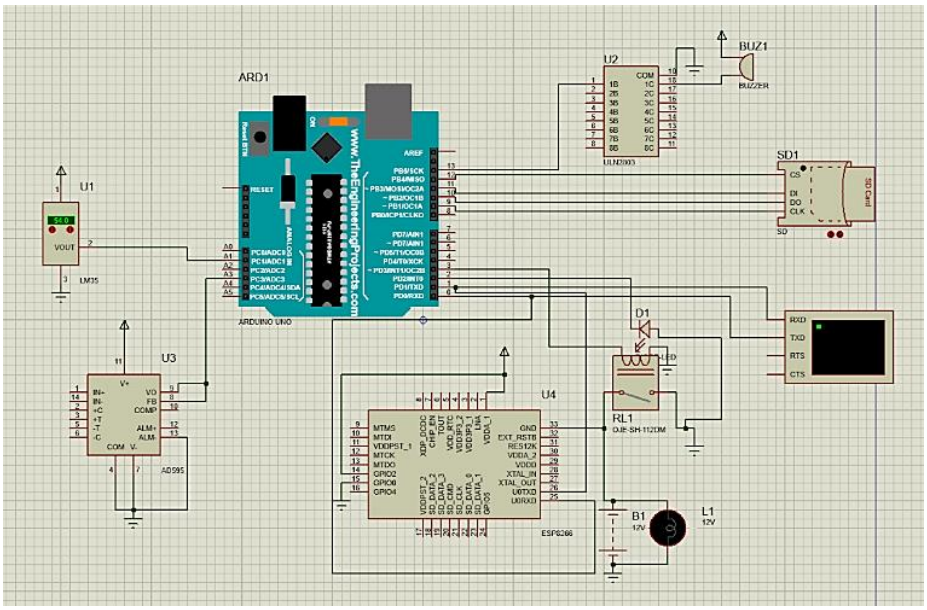


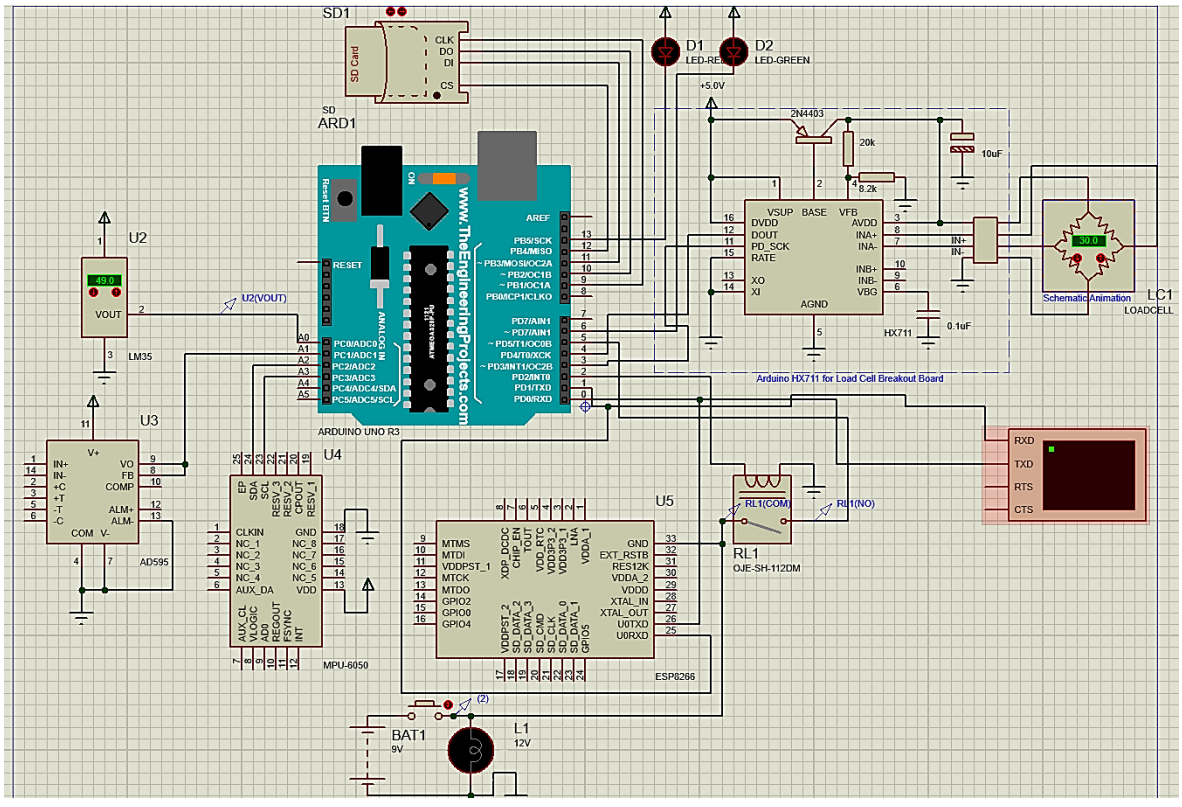


AVIONICS:

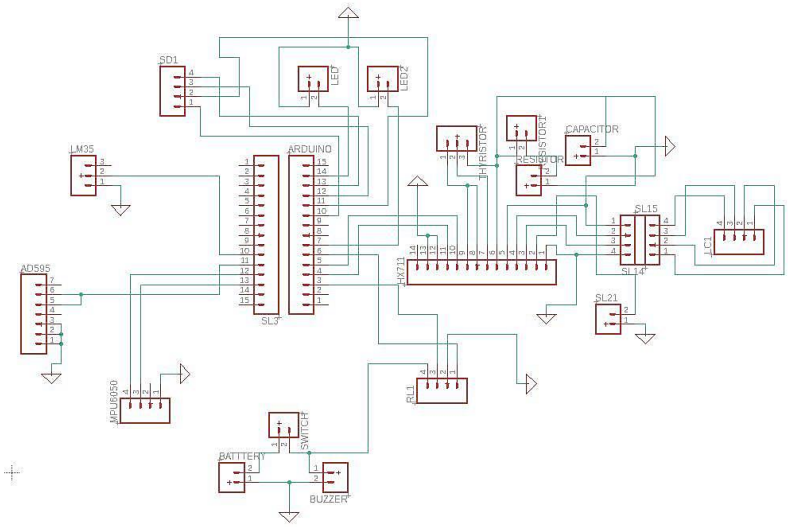
Architecture:

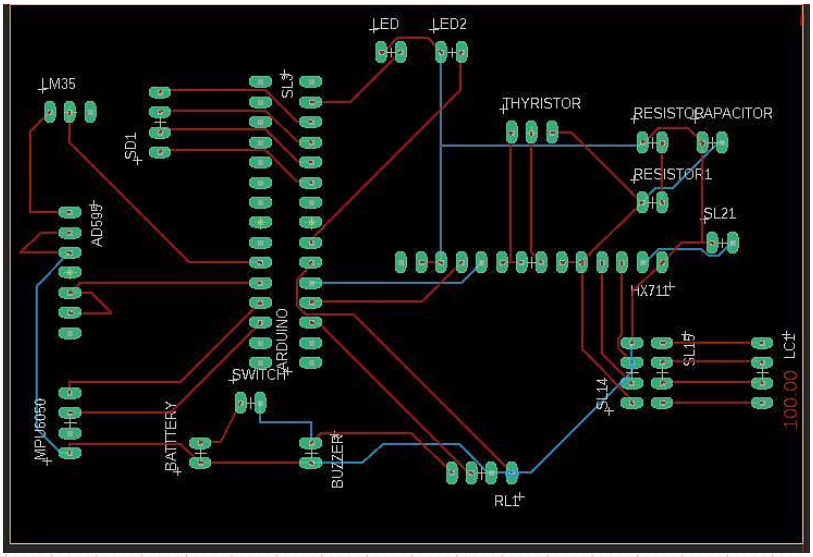
- For our avionics we faced many difficulties but, in the end, we were able to make it through.
- You can see below our transition from day 1 to the day we completed our avionics part on proteus

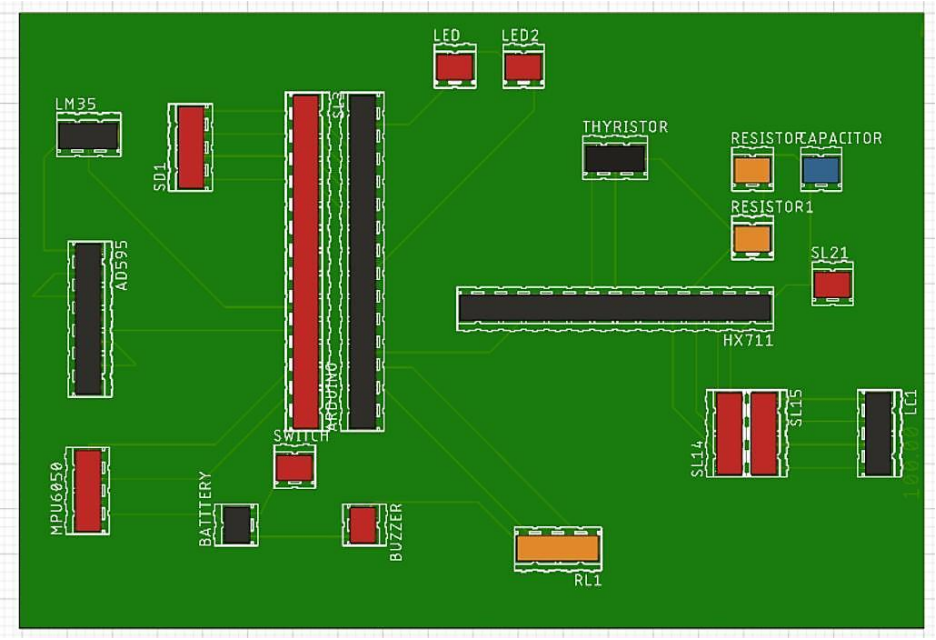




- So firstly, our approach was to find the code of individual sensor and then test it in the proteus one by one after the compilation of the code in Arduino IDE.
- After the compilation of every sensor and required component individually we combined them one by one the keep testing as we were adding the new component in the proteus.
- After whole completion of the code we then went for the designing the PCB for the avionics bay.







Basic components, software required to build a NOVA-1B110:

- List of Components:
    - Arduino UNO
    - Thermocouple sensor
    - LM35
    - Wi-Fi module
    - SD card
    - LEDS
    - Battery
    - Load cell
    - Amplifier
    - Gyroscopic sensor
    - Relay

- List of Soft wares:
    - Autodesk Eagle EDA
    - Arduino IDE
    - Proteus

Pre-making knowledge to do the coding of a NOVA-1B110:

- Things to know about the components used in avionics bay
    - Arduino UNO – it is microcontroller board used to give all the commands to all the sensors and it is kind of the brain of the PCB which we will build
    - Thermocouple sensor – it is a sensor being used for checking the temperature of the flame produced by the motor while testing.
    - LM-35 – it the sensor to check the temperature of the avionics bay to see it is not getting over heat which can damage our PCB.
    - ESP8266 (Wi-Fi Module) – we thought of making the avionics wireless. So, this is to get all the data on our phone and we could ignite the motor wirelessly.
    - SD card – it is going to be a micro SD card to store all the data we get through the tests and through our sensors.
    - LEDs – to get alerts if some connection are wrong or something went wrong like (LM-35 if senses high temperature in avionics bay we can get alert through the LEDs).
    - Battery – to power up the modules and controllers and to ignite the motor.
    - Load cell- to get the force which motor can exert so as to see what should be the weight of the whole rocket.
    - Amplifier – it is used to amplify the signal of the Wi-Fi module when needed.

    - Gyroscopic sensor – to check the angular velocity motor is exerting during the test.
    - Relay – main purpose of it is to using it as switch.
- As knowing the components and it's uses then it's just about the coding and connection to the right ports of one sensor to the controller/other sensor.
- While designing the PCB it's very typical to connect but we got through.

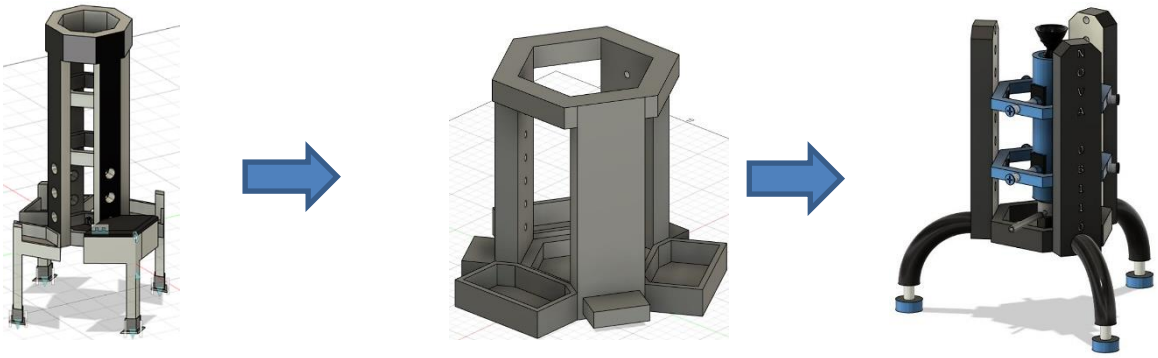
Procedure of building a NOVA-1B110:

- So now the procedure of making avionics and coding for NOVA-1B110 is very simple.
- Firstly, for avionics check all the codes of every components you are taking and combine them with the components itself using proteus.
- After checking of all the code combine all the codes and all the components in the proteus and then check.
- Then after the combine code is running properly make the PCB using Autodesk Eagle EDA and after completion export it to Fusion 360.

DESIGNING:

Architecture:

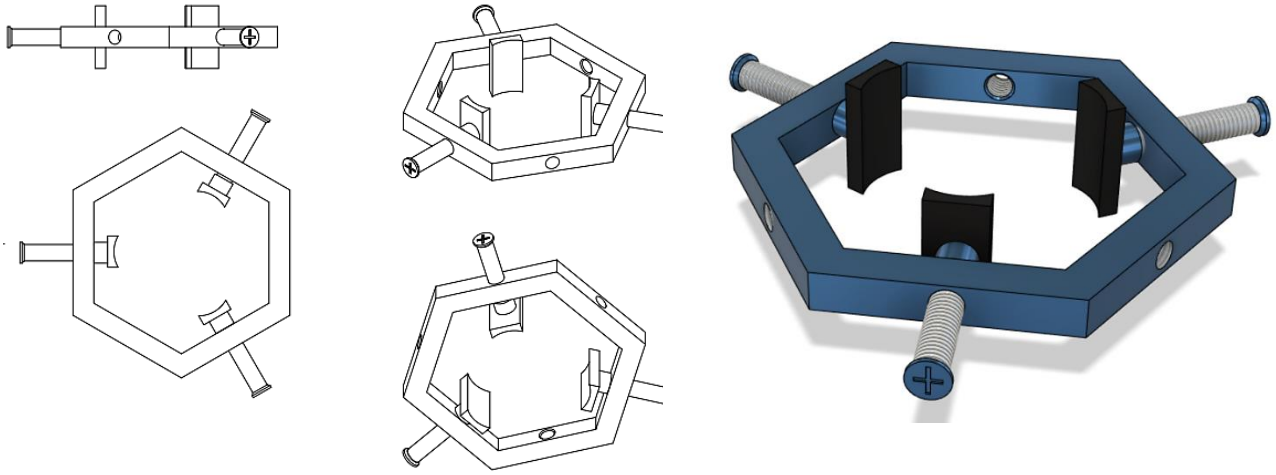
- Firstly, our design was really bulky and less stable but after a lot of discussions and review presentations we improved our design for the STP.



Our first design **Our second design** **Our final design**

- It was a 4 beam and 4-legged structure but then we went to a 3 beam and 3-legged structure.
- But there too it was a lot bulky so we removed the weight pans and removed the upper ring.
- For the legs firstly legs weren't not feasible adjusting legs for an un even ground so we came up with the L curved shaped structure which has a screw mechanism at the bottom.

- For holding the motor in the main body is the main thing only. So, for the first design there were 8 faces so we were going with 2 pentagonal rings.
- But after making the 3-beam structure we went for the 2 hexagonal rings.
- So, to hold the motor we came up with using 2 clamps in each ring for holding the rocket
- But for making it stable we gone with the 3 clamps in each ring.



- Made the avionics bay with a mind set that is has to be carried away from the STP during the test.

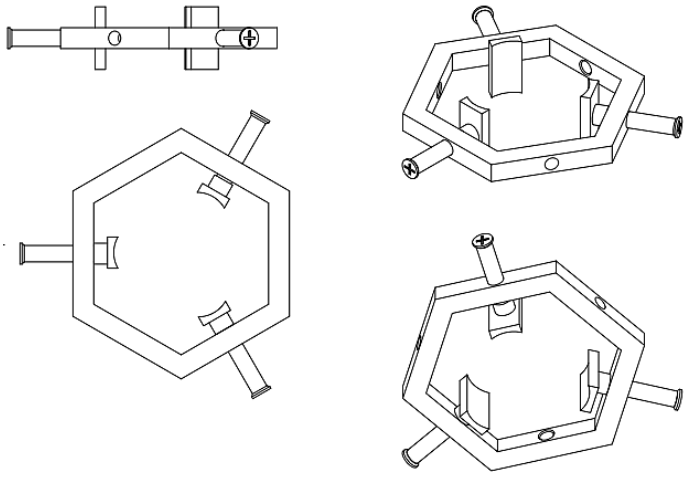
Basic components, software required to build a NOVA-1B110:

- List of Components:
  - Steel (for making all the things except avionics bay and clamp holder)
  - Aluminium (for making avionics bay)
  - Silicon (for making clamp holders)
  - Stationary
  - Fevicol or any adhesive

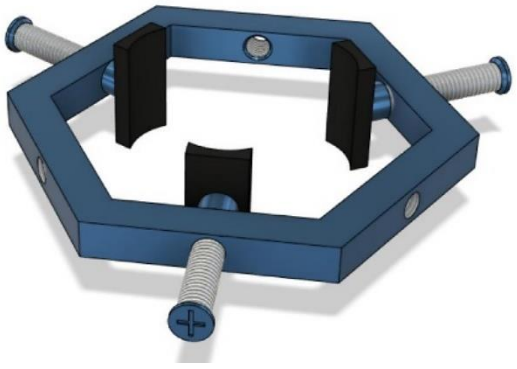
- List of Soft wares:
  - Autodesk Fusion 360
  - Paint

Pre-making knowledge to build a NOVA-1B110:

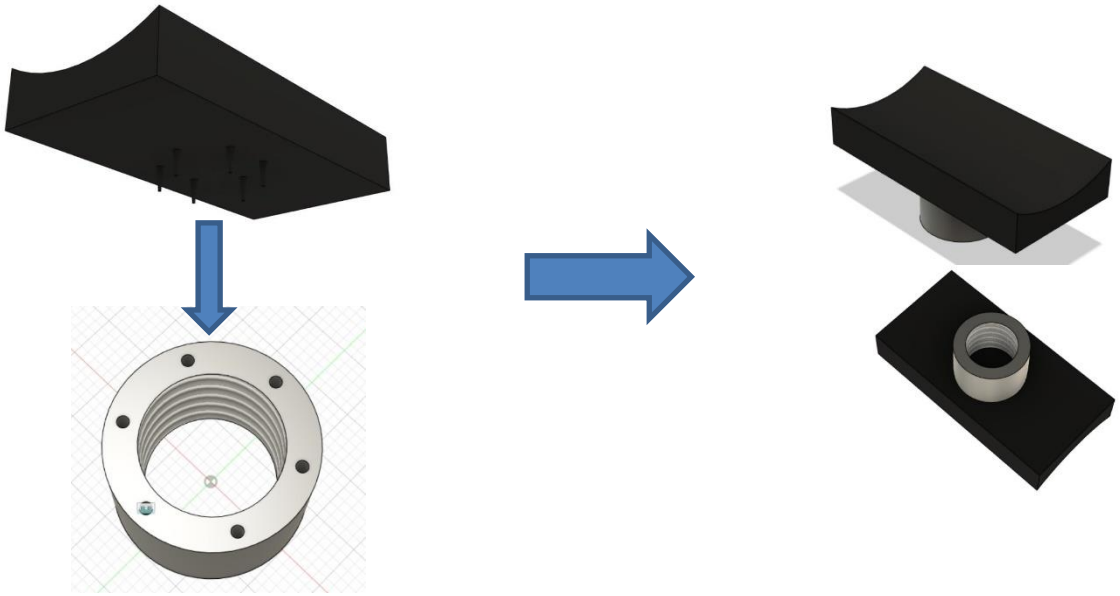
- After the review of everyone's design in the team, we took one design and to go further with it as our main design.
- As for first the main design was a lot bulky so we discussed and reduced its bulkiness and from 4 pillars we went for 3 pillars for gaining for stability.
- But we also had made some sacrifices as to reduce bulkiness we removed the weight pans which would have increased stability but in future we came up with more suitable design for the stand of the STP so it evened out.
- So, aim was to make the holding system of the STP as adjustable as possible and being an Iron Man fan, we took inspiration from it and came up the clamp holding system in the STP like he holds the triangular thing in iron man 2, making the element.
- As from the image you can see that for better grip, we placed 3 clamps and all three are in a nut and screw mechanism.



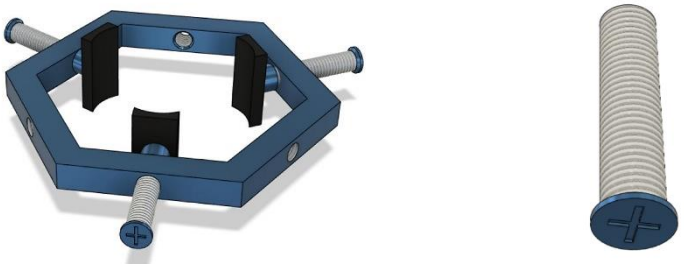
- The front of the clamp is made of silicon and rest is made up of steel.
- You can also see 3 more holes in the figure they are there so as they can be placed anywhere according to the length we need.
- From the below image you will get a clearer visual of how the 3 holes are useful.



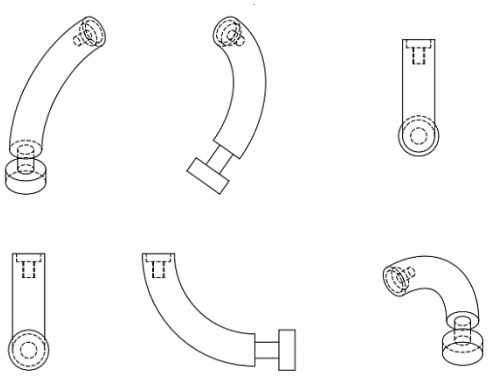
- Below if you see you will understand how we manage to join the silicon piece to the screw



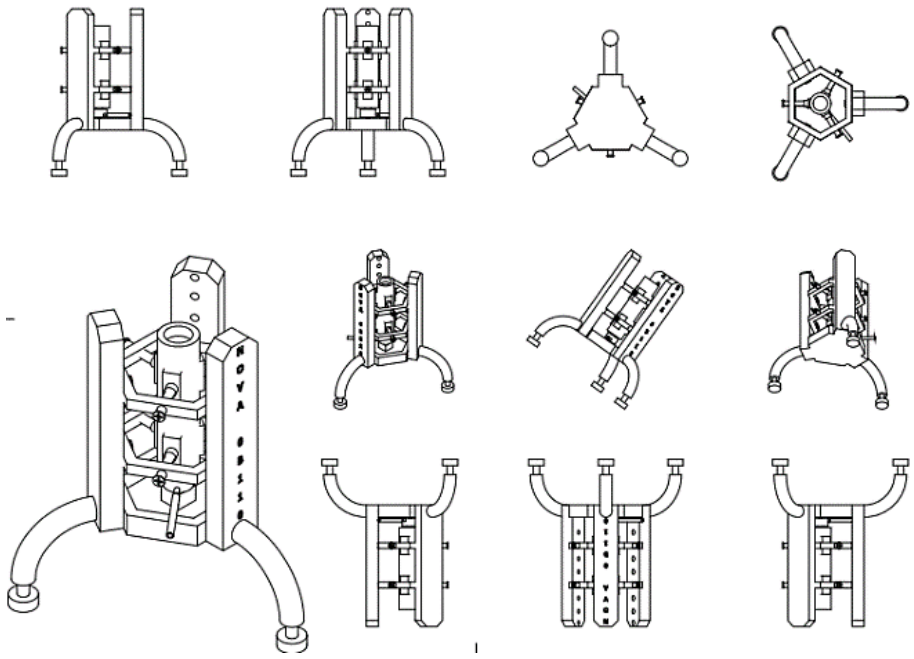
- The spikes in the silicon goes inside the metal ring to keep it intact.
- The metal ring then gets screwed on to the screw as shown above in the picture.
- The ring in which the clamps are screwed are 2 so as to give more stable grip to the motor.
- And the metal ring and the screw were attached while first we inserted the screw in the ring then in the metal ring the screw was inserted giving you this



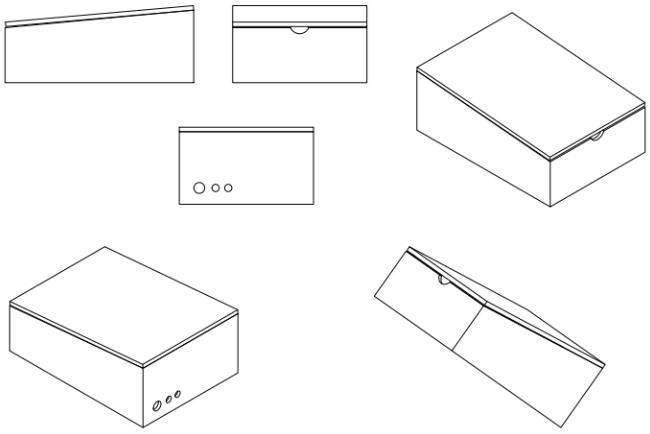
- The screw is used of same length both for attaching ring in main body and for attaching the clamps to the ring
- For the stand of the rocket we made a curved L shaped design for stability.



- As you can see from the figure to make it stable for un even ground we made here also a screw and nut mechanism so as we can adjust as per the ground and the stability.
- For attaching the stand to test pad we made incursions in all the beams of the test pad so the stand can me attached in it.
- For the main body of the test pad we made the base and constructed 3 solid beams to make it rigid enough.
- From below figure you will get a better visual.



- For building the avionics bay we kept in mind that it has to be both big enough to set our PCB and rigid and hard enough to handle the heat from both the motor and the PCB.
- So, we made this design which is easy to carry and light weight.



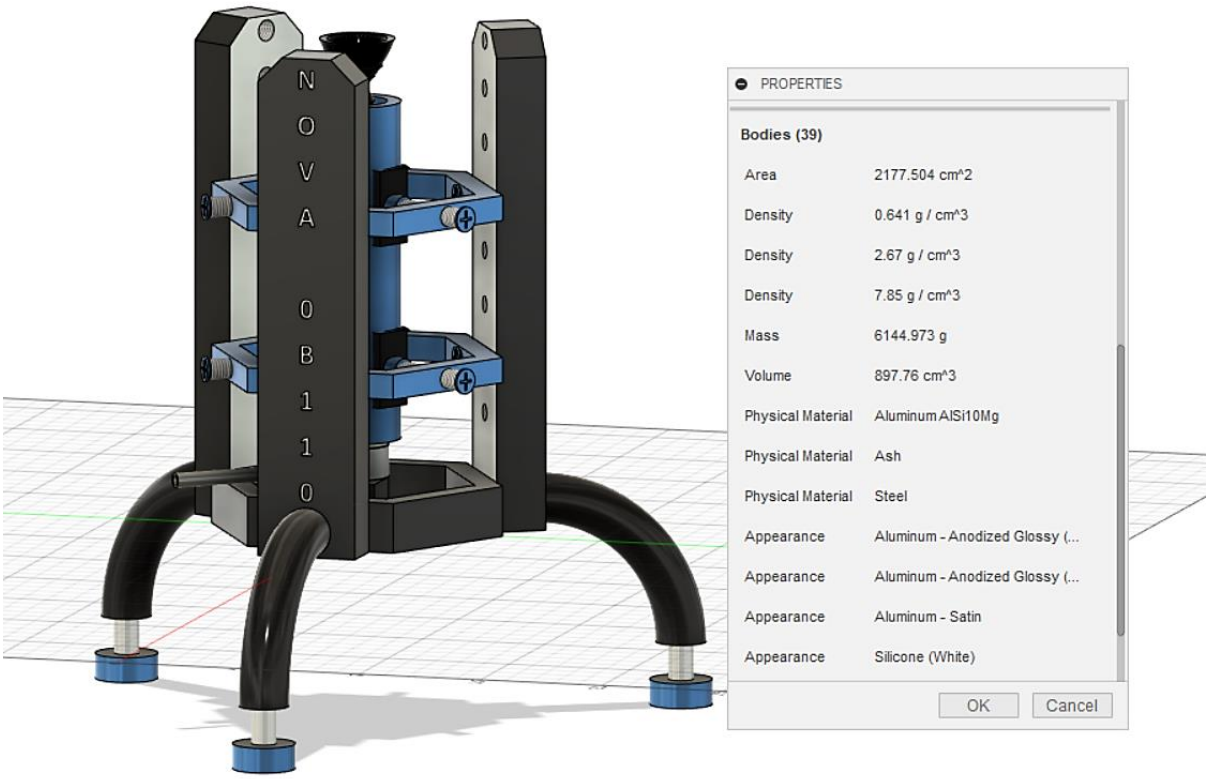
- As you can see is also has a lid to cover the PCB with 3 holes for wires and LEDs.

Procedure of building a NOVA-1B110:

- So now the procedure for designing is very simple of building a NOVA-1B110
- Firstly, create a base and make 3 beams attached to the base.
- Create screw holes in the beam.
- Make 2 rings for the clamp mechanism.
    - Each ring consists of 6 nut holes.
    - 3 for the clamps
    - 3 for attaching the ring to the main body of STP.
- Make 6 clamps 3 for each ring
    - Make the silicon part of the clamp with spikes to join it the nut.
    - Make the nut with holes for spikes at one end of the surface to connect the screw and silicon part.
    - Make the screw of desirable length.
- Make small incursions outer side of all the beams in the STP
- Make the stand of L shape with one side a screw and nut mechanism for the adjustment of the stability and on the other with the hole of the same size as the incursions created to attach it to the beam.
- Make the avionics bay with a lid mechanism.
- Make holes as necessary.

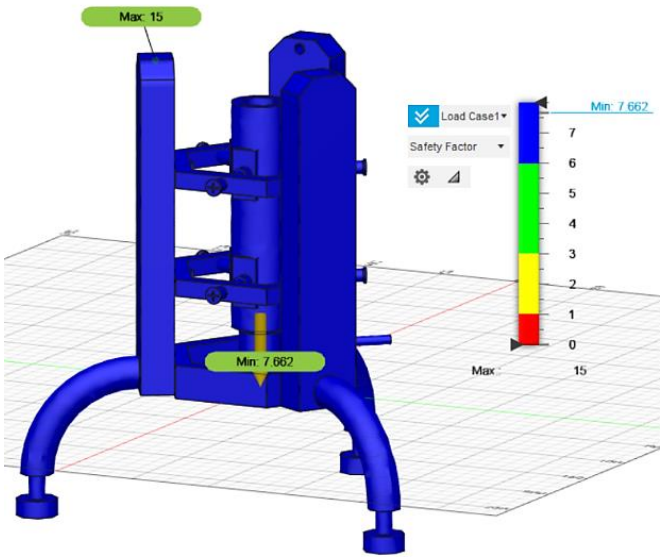
Observation:

- Total weight of our model is around 7kg.
- We have used a Wi-Fi module in the avionics bay with the Arduino to remotely activate relay, hence reducing the risk of being near to the test pad.
- Wi-Fi module that helps us control the calibration and relay wirelessly, while buzzer and LEDs for emergencies and updates.
- The design we made is both light weight and easy to carry.
- Our design is highly stable.
- Properties of our STP are below in the image.

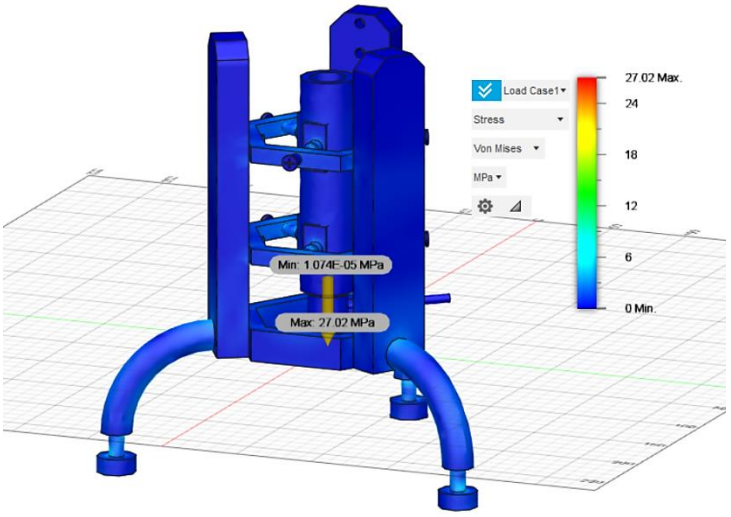


Results:

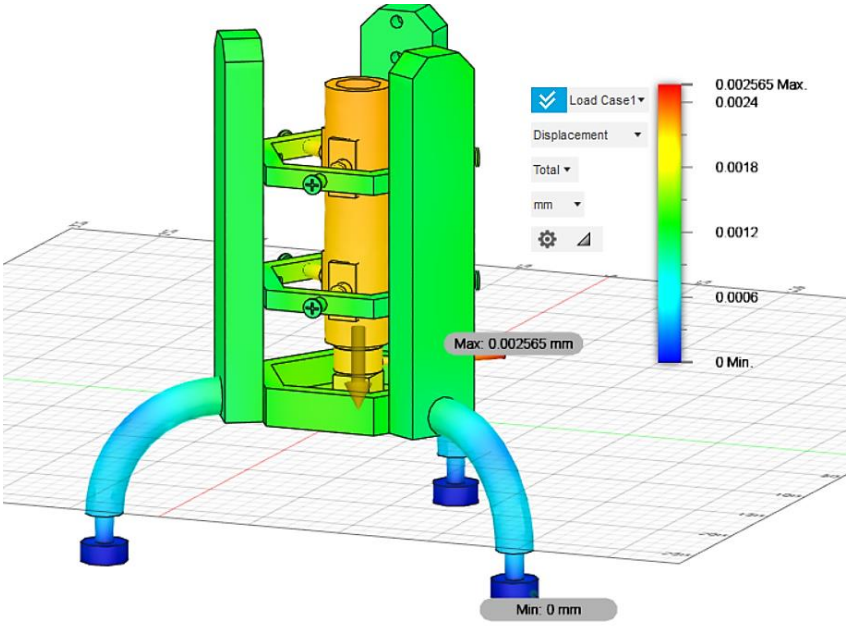
- Simulation results when the force applied is 150N.
  - Minimum safety factor achieve is 7.662.
  - maximum stress obtained is 27.02 MPa and minimum is 1.074 MPa.
  - Maximum displacement got is 0.0002565 mmm.
- Below are the screenshots of the simulations.
- PCB is working with all the components.



Safety factor



Stress on the STP



Displacement

Cost analysis:

- AVIONICS

S.NO	NAME	QUANTITY	PRICE(INR)
1	ARDUINO UNO	1	370/-
2	HX711MODULE + LOAD CELL	1	3300/-
3	LM 35 SENSOR	1	60/-
4	SD CAR MODULE	1	150/-
5	K-TYPE THERMOCOUPLE & AMPLIFIER	1	1410/-
6	GYRO/ACCELEROMETER (MPU6050)	1	220/-
7	LED	5	20/-
8	BUZZER	2	30/-
9	RELAY	1	100/-
10	BATTERY 12V	1	200/-
TOTAL COST			**5,860/-**

- DESIGNING

S.NO	NAME	QUANTITY	PRICE(INR)
1	DOUBLE SIDED BOLTS	----	250/-KG
2	LONG BOLTS	----	100/-KG
3	MEDIUM LENGTH BOLTS	----	60/-KG
4	SILICON	----	300/-KG
5	ALUMINIUM PLATE	3	1390/-
6	STEEL CYLINDER	----	220/-KG
7	STEEL RECTANGULAR BARS (2m x 12m x 3m)	2	3500/-
8	STEEL SQUARE TUBE	----	1900/-
9	MACHINING COST	----	6000/-
10	OTHER COSTS	----	2000/-
TOTAL COST			**15,720/-**

Conclusion:

So, from this report I conclude that we have built a lot stable and feasible design with low cost. The total price of the STP with avionics is 21,580/-. With wireless control it has safety for the people testing and with adjustable stand it can be placed on any surface. And with the help of the adjusting clamps it is capable of holding motor of any length or diameter.

Precautions:

- Maintain a proper distance while conducting the test.
- Double check all the codes and the wirings.
- Be sure that the STP is fully stable and holding the rocket motor with right amount of force.
- Keep a fire extinguisher in case of a fire.