(SPACE PROPULSION AND RESEARCH COMMUNITY)

SERS-I

DESIGN DOCUMENT

S P A R C

ABOUT US

The Space Propulsion and Research Community (SPARC) is an autonomous group of students. Our team is composed of dedicated individuals with a shared vision of accomplishing an objective that is viewed as ambitious by many. However, we firmly believe that with the appropriate mindset and unwavering dedication, anything is possible. Our primary objective is to become the first student community in India to independently reach space, i.e., by constructing a rocket that can ascend to the Karman line, 100 km above sea level. If successful, this feat would make them the only team in India to have achieved such a milestone and leave an indelible mark on the country's history of space exploration. We have meticulously planned our journey, with the next crucial step being building a rocket to reach 5km in altitude. SPARC's commitment to this challenging endeavour reflects our dedication to inspire peers interested in rocketry, potentially shaping future career choices. Our motto: "We do this because it's hard, not because it's easy," underscores our serious commitment to achieving our space exploration dream. The primary purpose of this launch is to conduct design validation, perform comprehensive analyses, and ultimately certify that our mission has successfully reached an altitude exceeding 14,000ft. This critical phase represents a significant milestone in our project, as it allows us to thoroughly evaluate the performance and integrity of our systems, equipment, and technologies under real-world conditions at high altitudes. This launch serves as a pivotal step in ensuring the reliability and readiness of our systems as we move closer to achieving our ultimate objectives.

SERS-1 Rocket

WHAT IS OUR ROCKET?

SERS-1 (Sparc Experimental Rocket Series - 1) is a solid fuel powered passive stabilized rocket aiming for an apogee of 5km. The rocket is powered with a solid motor with a propellant mass of 7 kgs and a total ISP of 166s. The rocket also has the ability to carry and deploy a payload at the designated height. The rocket also contains an avionics stack with redundant systems, data logging and live telemetry. For recovery of the rocket after the flight, there is a dual redundant system to deploy parachutes and recover the vehicle safely.

SUB-SYSTEMS

1. Propulsion
2. Avionics
3. Structure
4. Ground System

PROPULSION: ROCKET MOTOR

Type: Core burning solid rocket motor

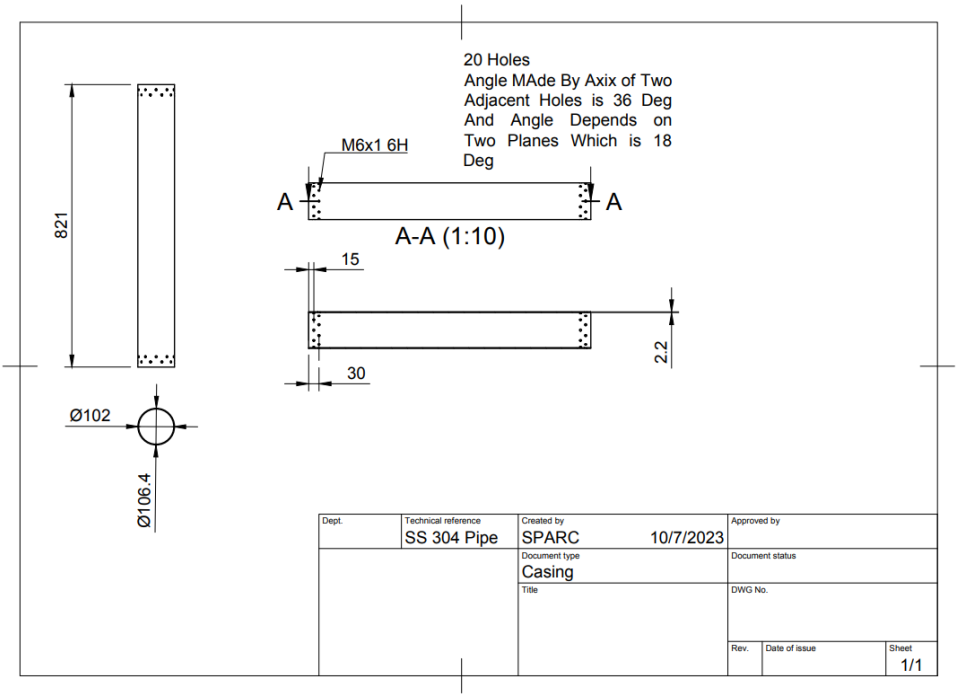
Fuel: KNSu (Potassium nitrate and sucrose)

1. KNO_3 ⟶ Oxidizer
2. $C_{12}H_{22}O_{11}$ ⟶ Fuel

- Its theoretical maximum specific impulse is 166.
- Chamber Temperature Is 1720k 14460 c @1000 psi.
- 3-grain with external diameter 97.30 mm, core diameter 35mm and height 200mm each for a total height of 600 mm.
- Each grain weighs around 2.292kg for a total propellant mass of 6.87kg.

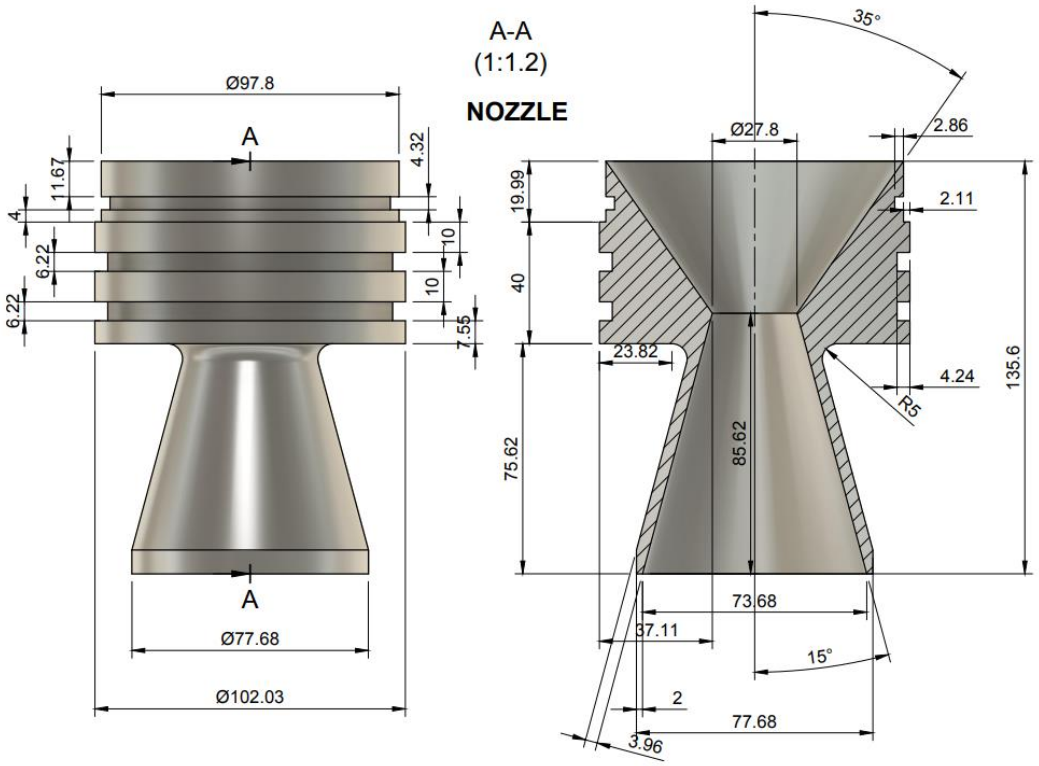
MOTOR CASING

- Material: Stainless steel (304)
- External diameter: 106.4 mm
- Internal diameter: 102 mm
- Height: 821mm



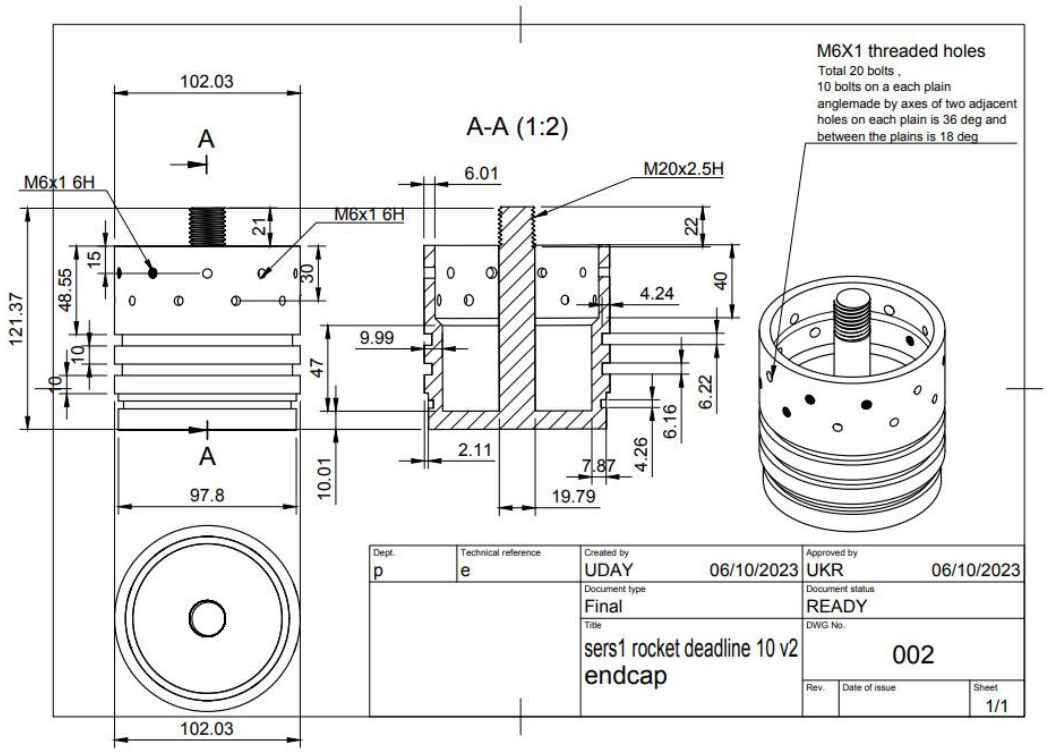
NOZZLE

Material: Stainless Steel 304



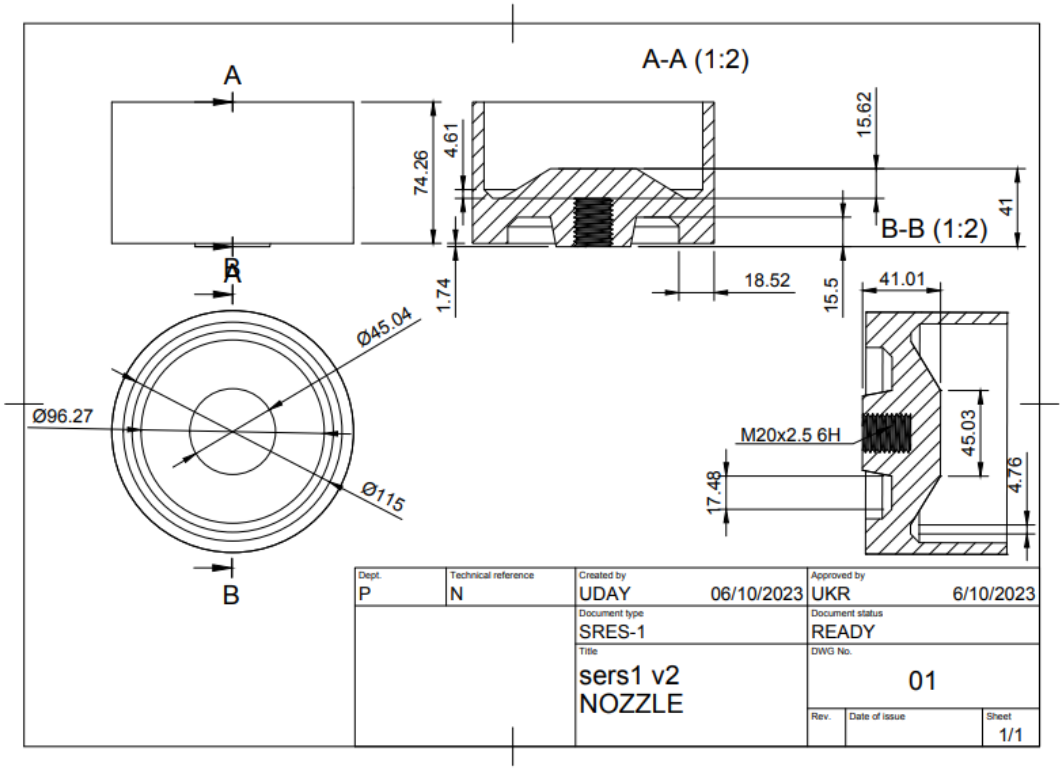
END CAP

Material: Stainless Steel 304



COUPLER

- Material: Aluminium



MOTOR SPECIFICATION

- ISP: 143.30s
- Total impulse: 9661.15 Ns
- Peak thrust: 7700 N
- Burn Time: 2.43s
- Average pressure: 620.82 psi
- Peak pressure: 1136.45 psi
- Initial kn: 108.69
- Peak kn: 301.52
- Motor designation: M3927

AVIONICS

We have designed custom boards to suite our needs. We are using a stacked multilayer board in our avionics bay.

FUNCTIONS

- Data Logging
- Parachute deployment
- Telemetry transmission
- GPS

COMPONENTS

- Triple Flight Computer setup
- We have a dual redundant, triple micro controller, Avionics system with onboard data storage
- Telemetry
- GPS, GPRS and GSM
- 3 dual redundant pyro channels
- On board cameras
- Triple altimeter set up for reliability

STRUCTURE

1. BODY TUBE

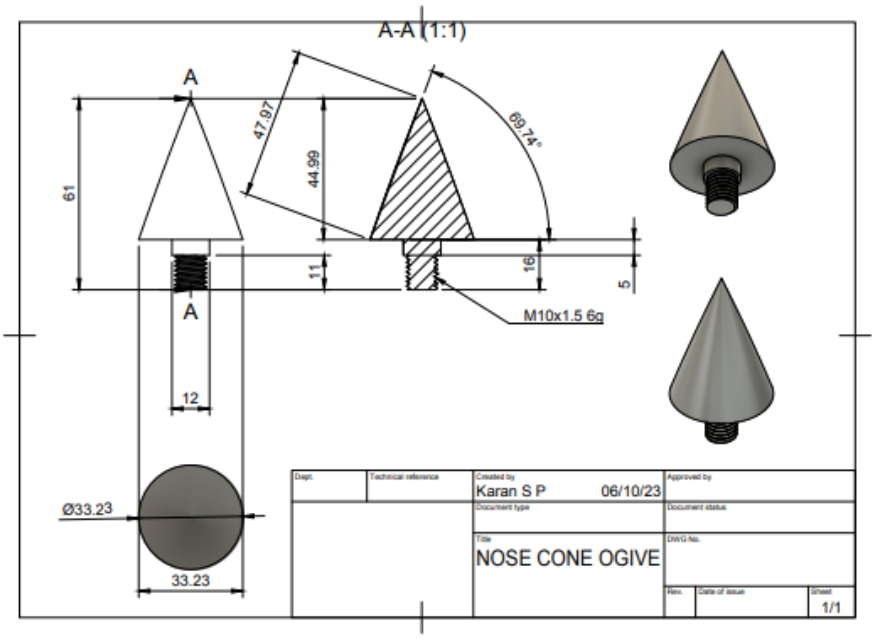
- Material: Fiber Glass
- Height: 160cm
- Inner diameter: 12.8cm
- Outer diameter: 13.8cm

2. FINS

- Material: Fiber Glass

3. NOSE CONE

- Material: Fiber Glass Nose Cone with Stainless Steel Tip



PAYLOAD

The payload is being flown in this flight as a demonstration of the rocket's capabilities to launch and eject a payload of certain mass at the specified altitude. The payload being flown contains the following sensors:

- BMP 280 – Altitude, pressure & temperature
- Quectel L89 – GNSS
- MPU6050 – Accelerometer, gyro meter
- UART Optical communication module
- LoRa – communication module

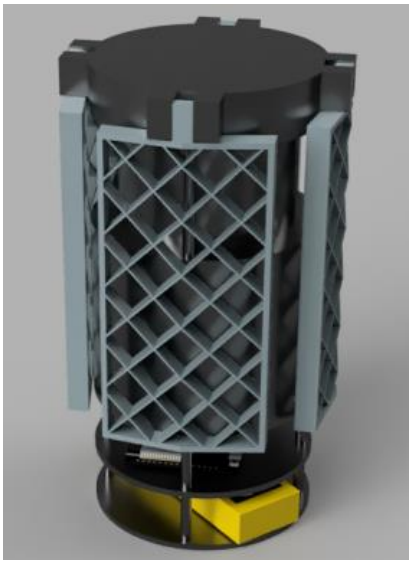
The payload will be ejected at apogee and will be recovered under a parachute. On the initial part of the descent the payload will stabilized by the use of grid fins. At a lower altitude of 1000m – 800m, the parachute will be deployed to achieve a soft landing. On descent the payload will record all parameters and send the data in a real time manner. This payload will help evaluate and confirm the abilities of the launcher to carry such a payload and deploy as required. The structure of the payload is composed of threaded bolts and lateral plates. The parachute is attached via a eyebolt and a shock chord.

PAYLOAD DIMENSIONS

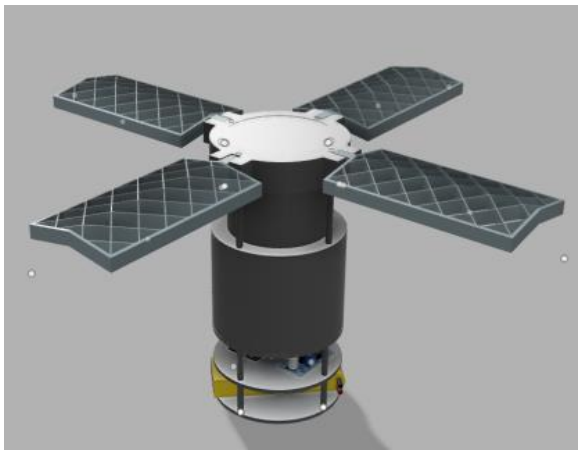
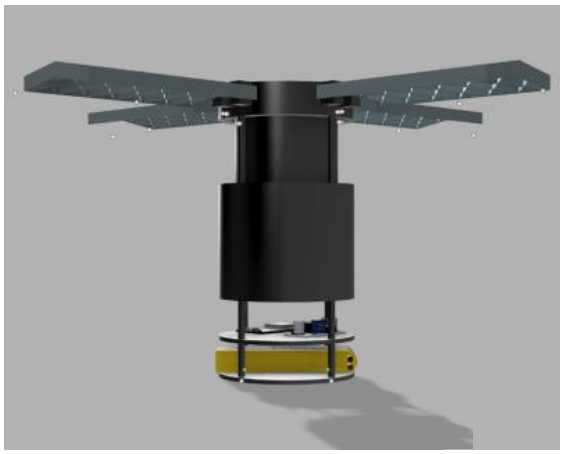
No.	Dimensions	Value
1.	Length	200mm
2.	Diameter	120mm
3.	Grid Fin Length	170mm
4.	Parachute Diameter	2000mm

CAD RENDERINGS OF THE PAYLOAD

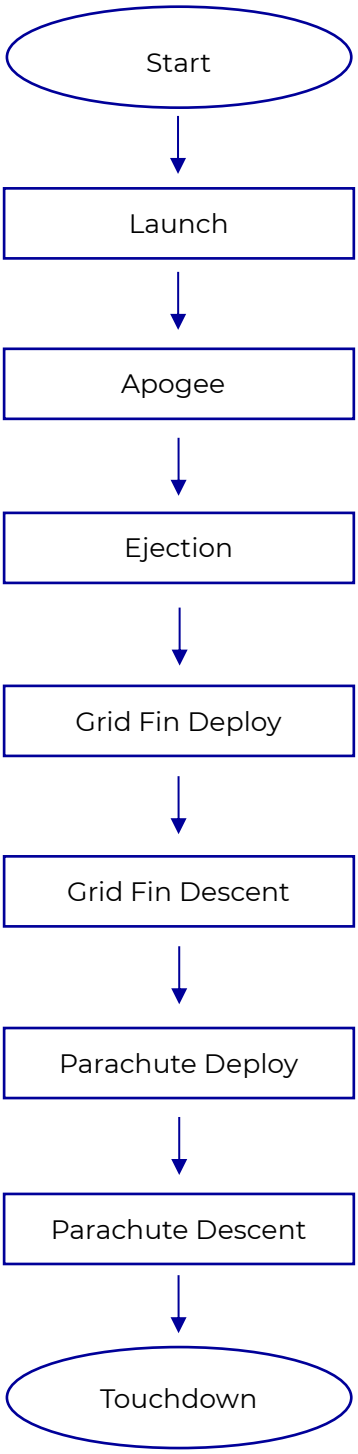
1. Grid Fins Stowed

2. Grid Fins Deployed

SEQUENCE OF FLIGHT EVENTS



sl No.		Motor statistics	SERS -1
			Practical propellant density 1.8
1		motor designation	M3927
2		total impulse	9661.15 Ns
3		impulse	143.30s
4		burn time	2.43s
5		average pressure	620.82psi
6		peak pressure	1136.45psi
7		initial Kn	108.69
8		peak Kn	301.52
9		ideal thrust coefficient	1.56
10		propellant	6.87kg
11		propellant length	60 cm
12		port/throat ratio	1.59
13		peak mass flux	1143.46 kg(m^2*s)
14		delivered thrust coefficient	1.52
15		diameter	13.8 cm
16		mass of rocket	24 kg
17		apogee	5113m
18		max velocity	480 m/s, M=1.43
19		max acceleration	327m/s2
20		stability margin (at Mach 0.90)	1.61 cal
21		centre of gravity (at Mach 0.90)	104cm
22		centre of pressure (at Mach 0.90)	127cm
23		length of rocket	180 cm
24		max drag	3020 N
25		average thrust/weight ratio	13.63
26		coefficient of drag at Mach 1	0.455
27		rocket empty mass	~13 kg
28		rocket motor mass (empty)	~11 kg
29		drogue parachute diameter	0.5 m
30		main parachute diameter	3.83 m
31		primary decent velocity	60-70m/s
32		secondary decent velocity	6m/s
33		no of fins	4
34		fin length	11cm
35		fin root chord	20cm
36		fin tip chord	6.9cm
37		fin sweeping angle	66.8
38		fin sweeping length	25.7cm
39		fineness ratio of nose cone	2.606