Debris Mitigation Competition

Space Fan2 : A Mechanical De-Orbiting Device System for Satellites

Presenters:
Barış DERGİN
Istanbul Technical University

Muzaffer DUYSAL
Bülent Ecevit University

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Our Team

- (Phd. Student) Boğaç KARABULUT
  (Undergraduent Student)Barış DERGİN
  Istanbul Technical University

- (Associate degree Student) Barışcan KAHRİMAN,
  (Associate degree Student) Fatih BEBE,
  (Associate degree Student) Esra SAĞLAM,
  Marmara University

- (Undergraduent Student) Salih YETİŞEN
  Karadeniz Technical University

- (Undergraduent Student) Muzaffer DUYSAL
  Bülent Ecevit University

Content

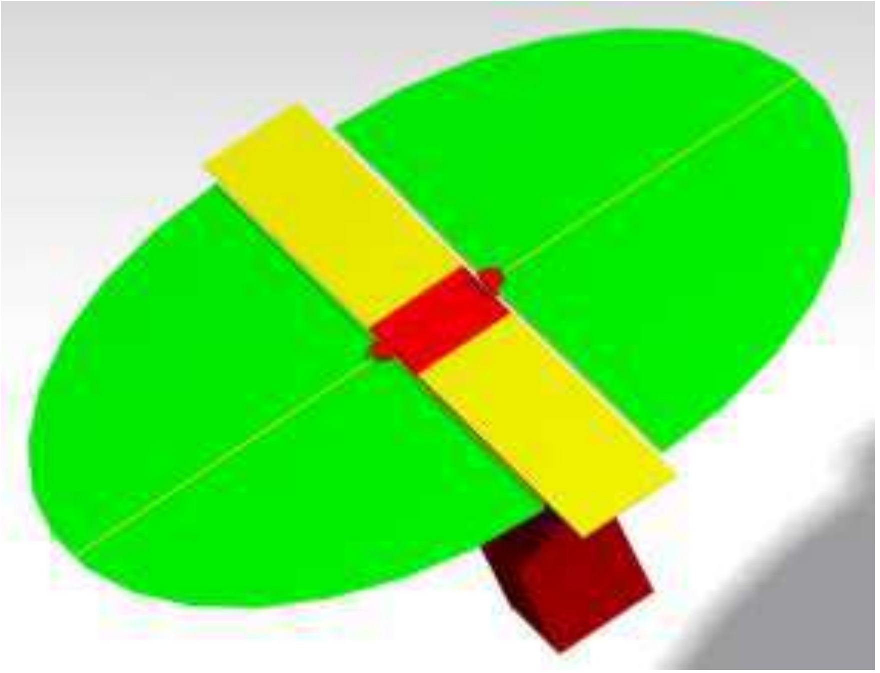
Competition Requirements

- The device must be designed for the removal of a potentially non-cooperative lean satellite of 50 kg mass and maximum dimension of 1 meter. Total mass of a satellite and device can exceed 50 kg.
- The device will enable the satellite to re-entry within 11 years (i.e. one solar cycle) after activating. You can use any systems such as thruster, tether, membrane or electric propulsion.
- The device will be activated at 00:00:00 UTC, January 1, 2020 with the following orbit element:

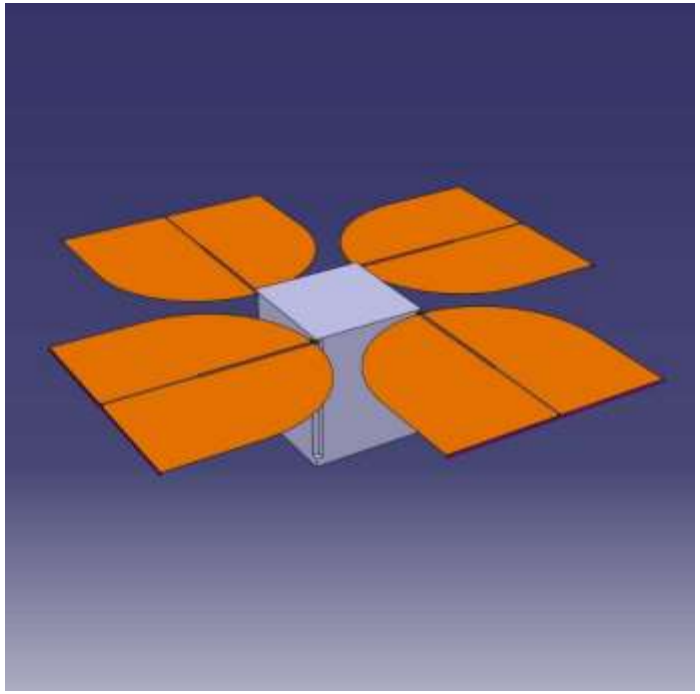
Semi Major Axis	7128 km
Inclination	98.4 degree
R.A.A.N	30 degree
Argument pf Perigee	210 degree
Mean Anomaly	190 degree
Atmosphere model	Jacchia-Roberts

Mission Overview

Space Fan 2 is based on last year's design Space Fan.



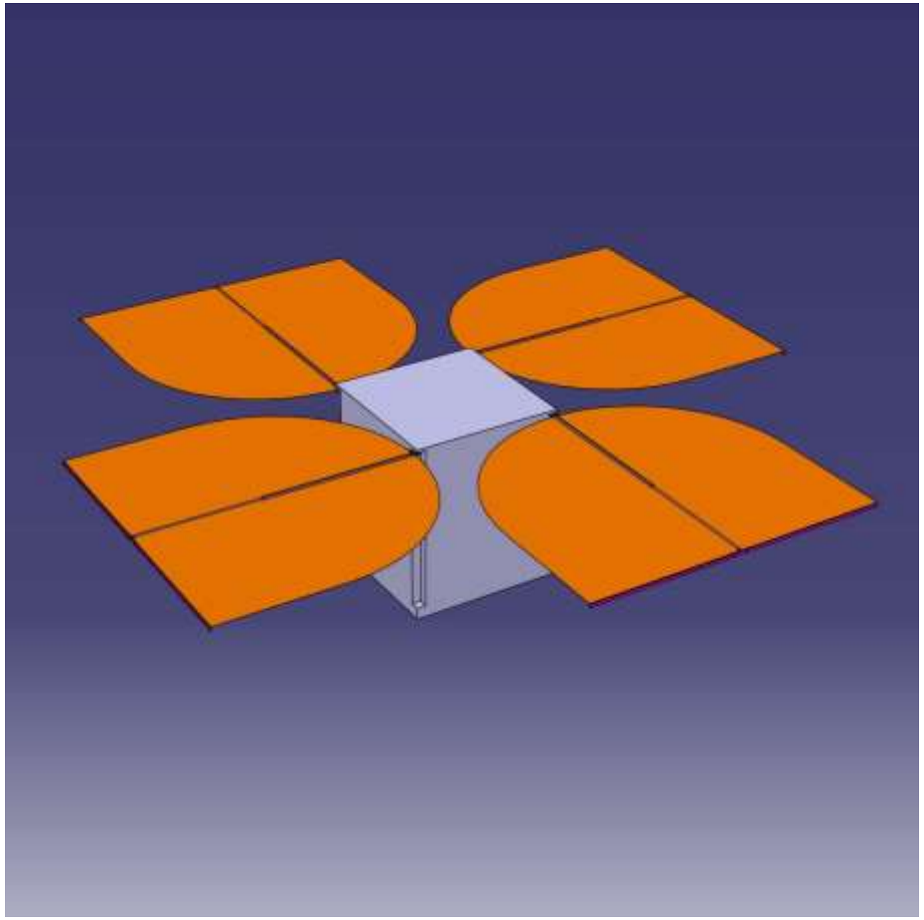
Space Fan



Space Fan 2

Space Fan 1 Available in UNİSEC-GLOBAL website

Mission Overview and Physical Layout



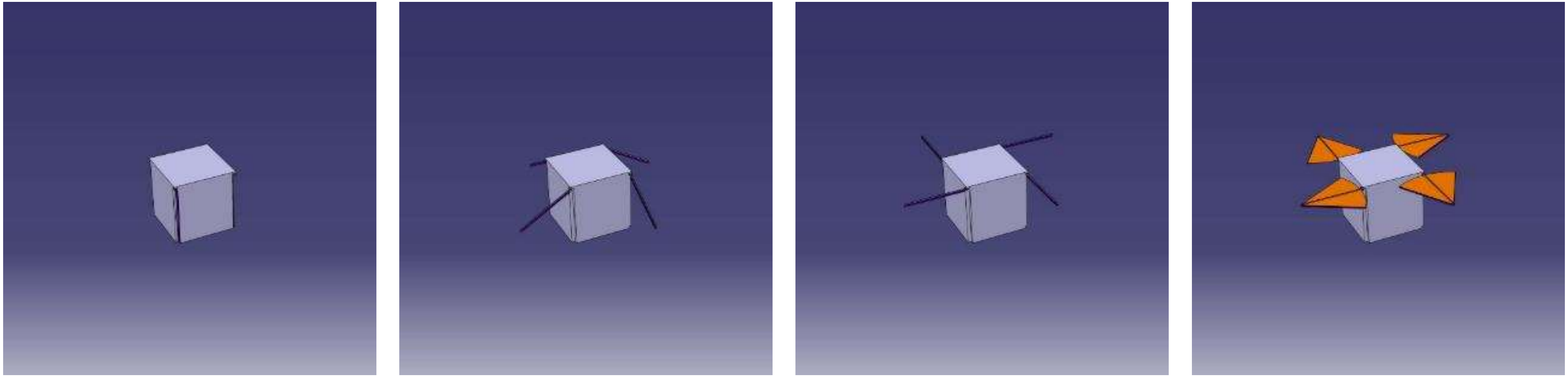
- İncreasing drag area to decrease de - orbiting time
- Consist of 4 fans

Dimensions of satellite : 100 cm x 100 cm x 100 cm

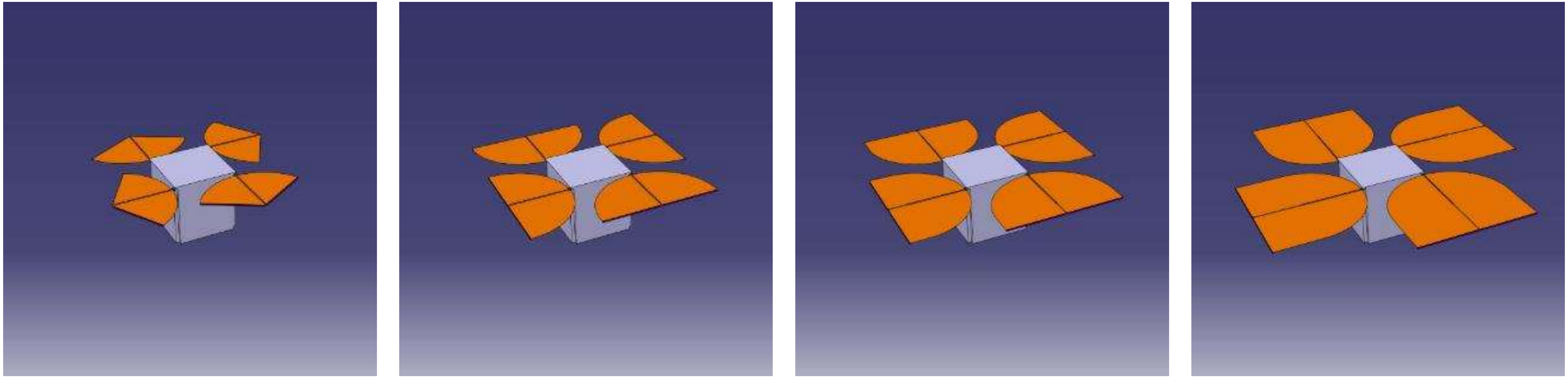
Total surface area of the sail is 10.804 m^2.

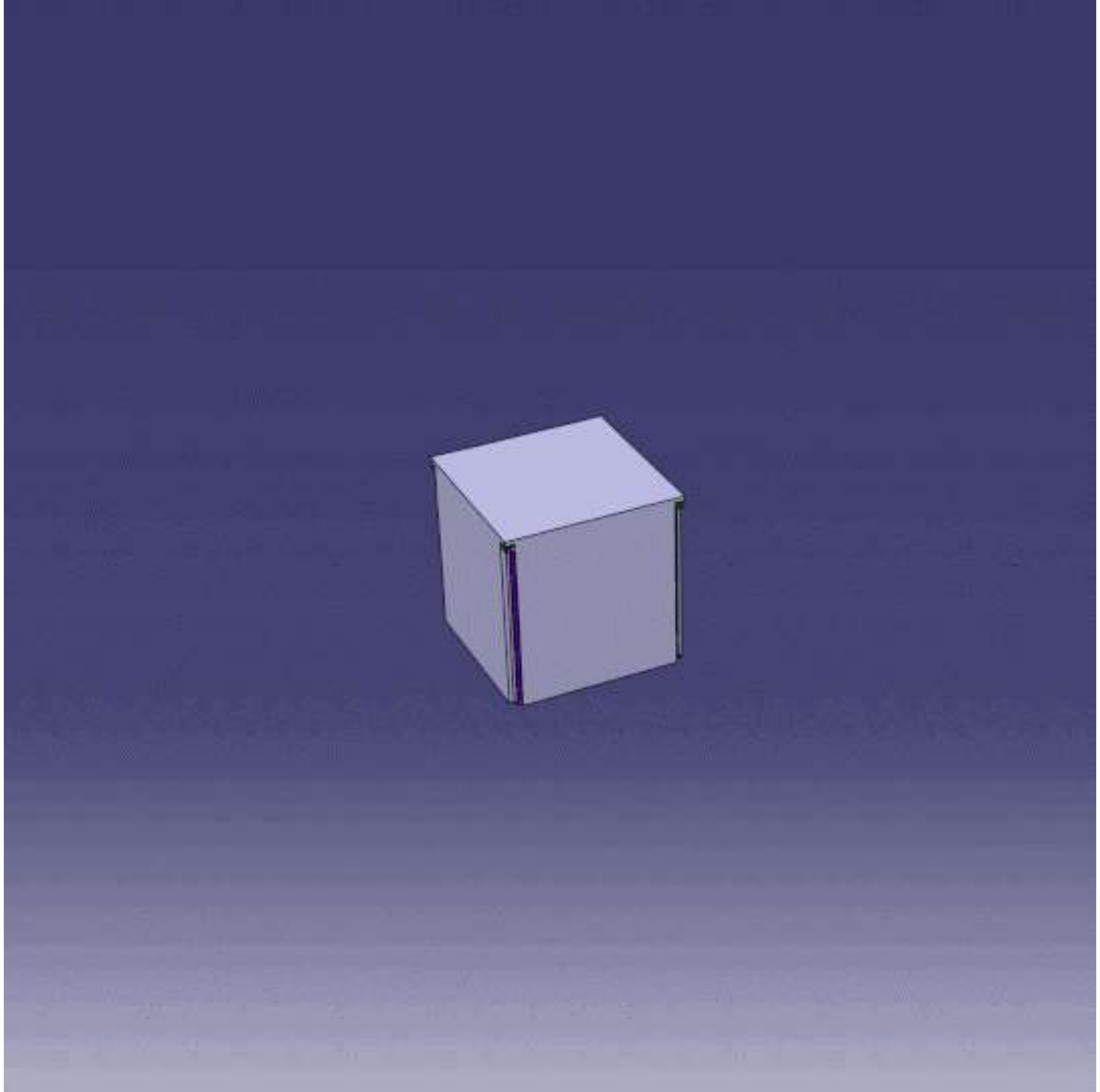
Total Mass : 50 kg (İnclude de-orbit system)

Mechanical Deployment Design



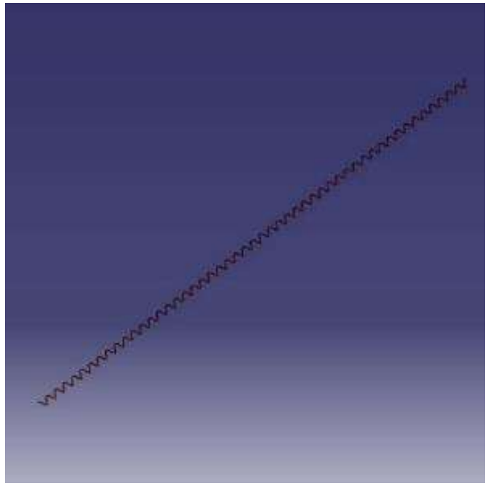
Mechanical Deployment Design



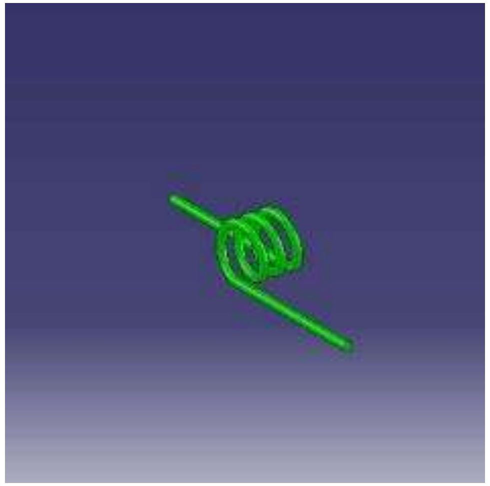


Components

- **Compression Springs**

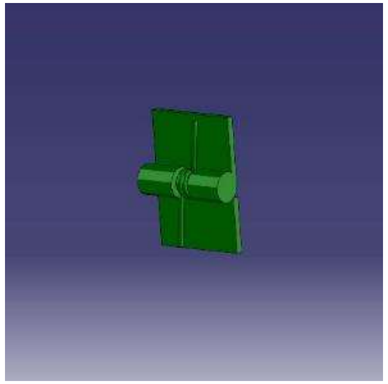
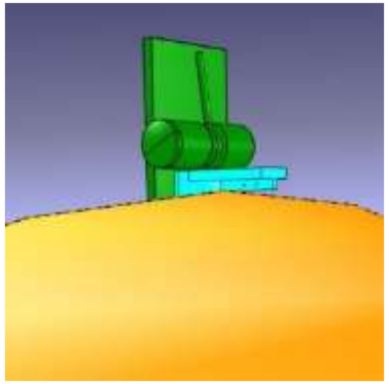


- **Torsion Spring**

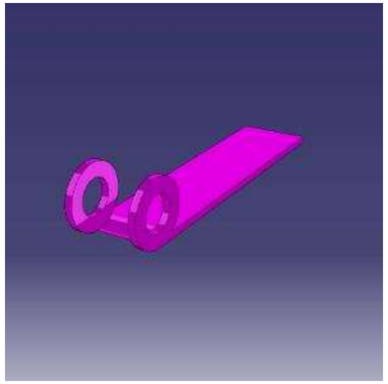
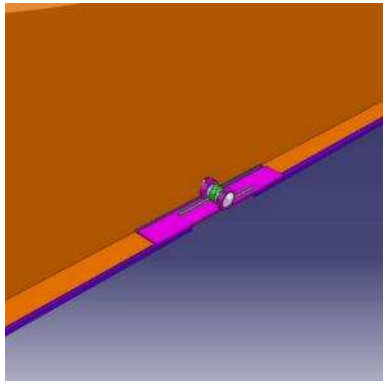


Components

- Body Hinge

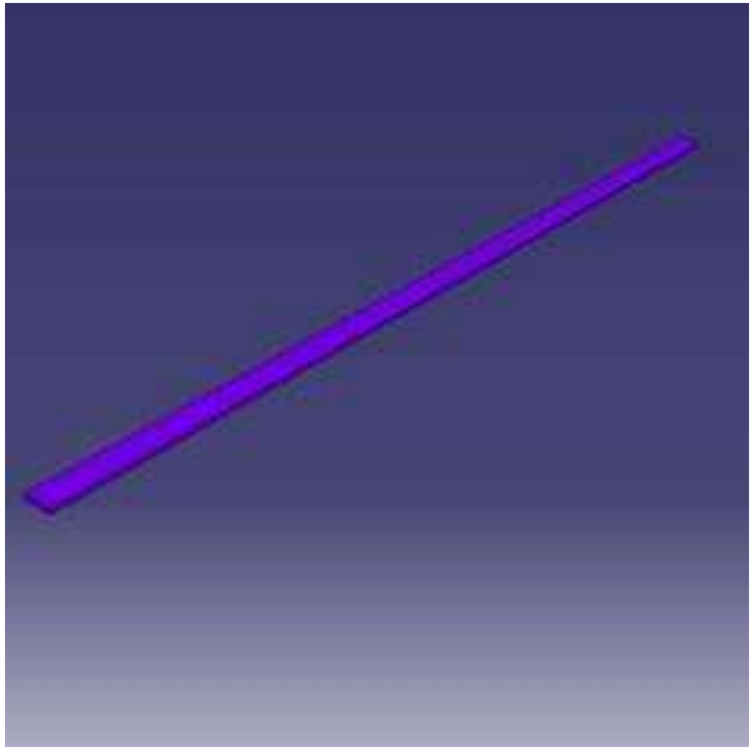



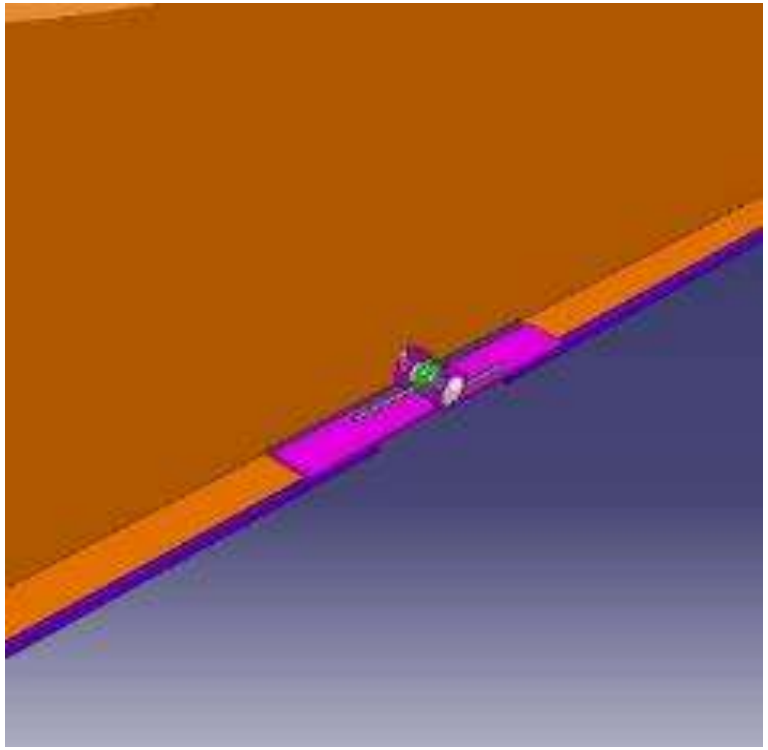

- Sail Hinge


Components

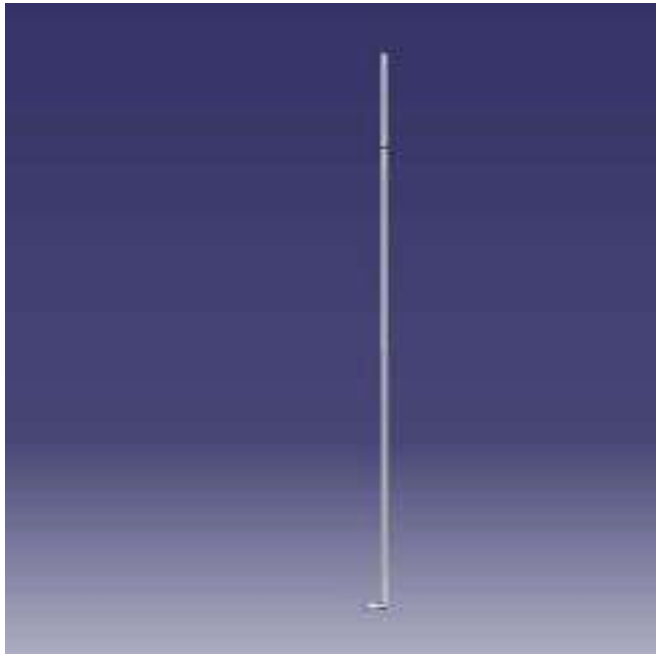
- **Sail Wing**

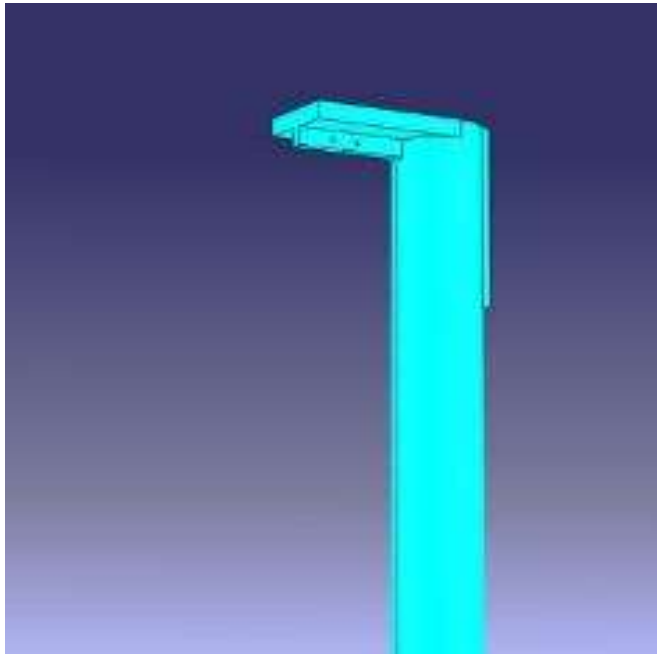


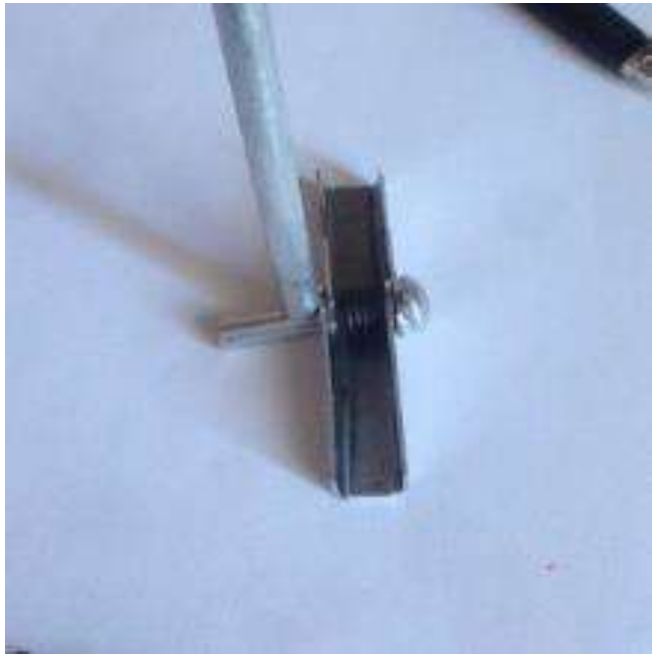


Components

Arm and Arm Housing

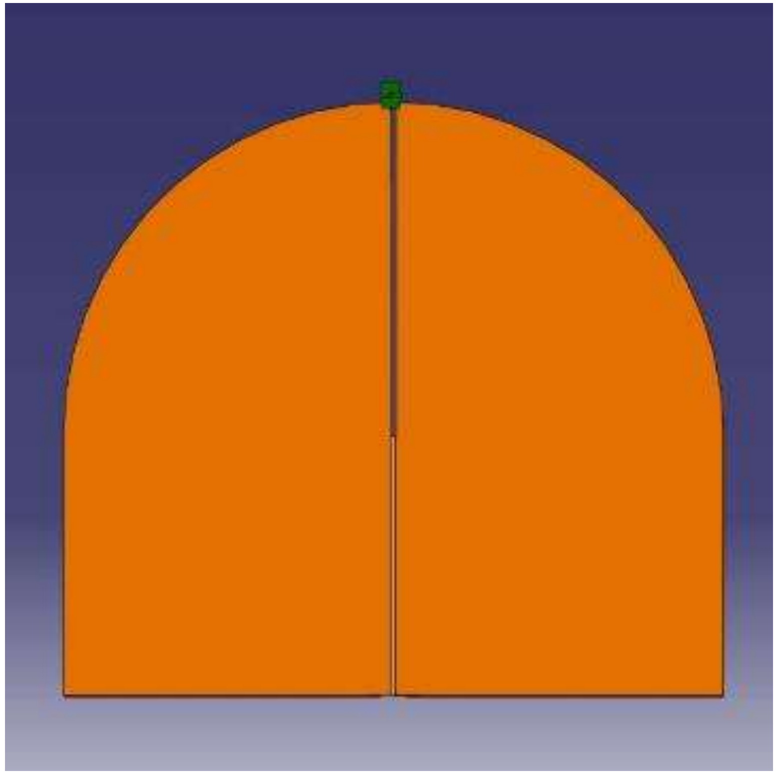






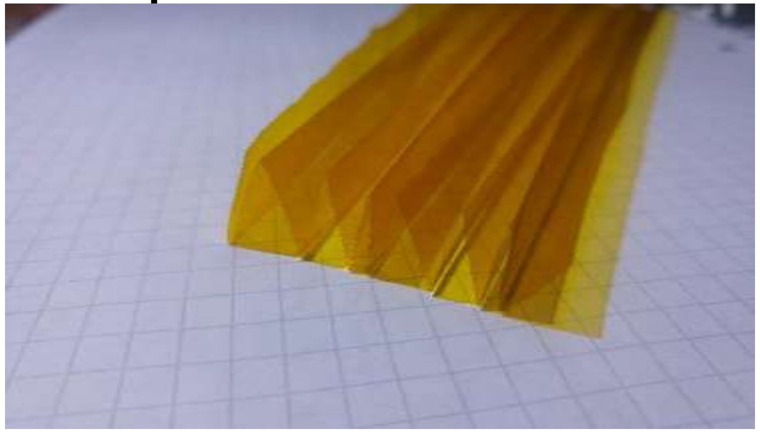
Components

- **Fan**



Sail Material Selection

- Kapton



Property	Unit	75µm	125µm
Ultimate Tensile Strenght at 23°C, (73°F) at 200°C (392°F)	psi (MPa)	33,500(231) 20,000(139)	33,500(231) 20,000(139)
Density	g/cc	1.42	1.42
Tear Strength, Initial (Graves), N (lbf)		26.3 (1.6)	46.9 (1.6)

Property	Typical Value	Test Condition
Thermal Coefficient of Linear Expansion	20 ppm/°C (11 ppm/°F)	-14 to 38°C (7 to 100°F)
Specific Heat, J/g•K (cal/g·°C)	1.09 (0.261)	
Shrinkage, % 30 min at 150°C 120 min at 400°C	 0.17 1.25	

- Mylar Film

Property	Unit	142µm
Tensile Strenght MD	kpsi	28
Tensile Strenght TD	kpsi	34
Elongation at Break MD	%	125
Elongation at Break TD	%	100

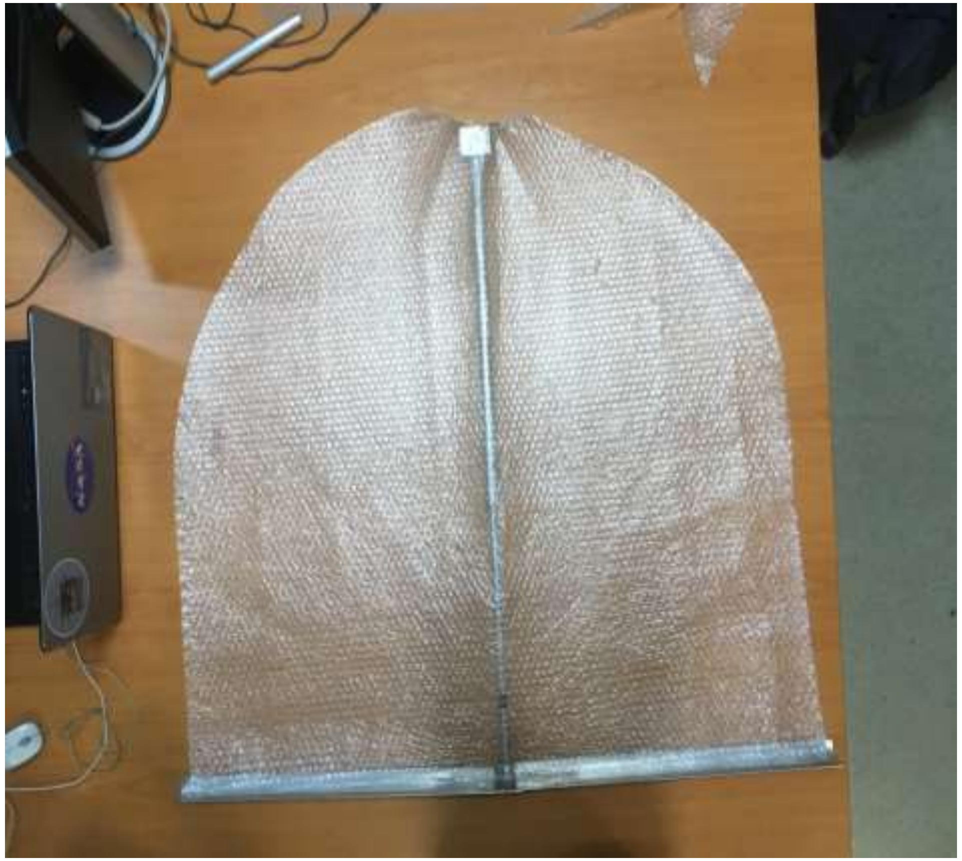
Property	Unit	142µm
Shrinkage MD (150°C)	%	1.5
Shrinkage TD (150°C)	%	1.0

Sail Material Selection

- The values given in the tables are the results of the tests made by the manufacturer and the film features presented to the user. If we consider the characteristics of both films: Using 125μm Kapton HN Film will be more advantageous because although it is thin,
- Tensile strength more than Mylar,
- The amount of elongation is less than Mylar,
- It shrinks less with temperature regarding to Mylar,
- When we take into consideration that it is thin, the time we fold will fit easily between the wings in our design.

Prototype Development Phase

Prototype Development Phase



Prototype Development Phase

Mass Budget

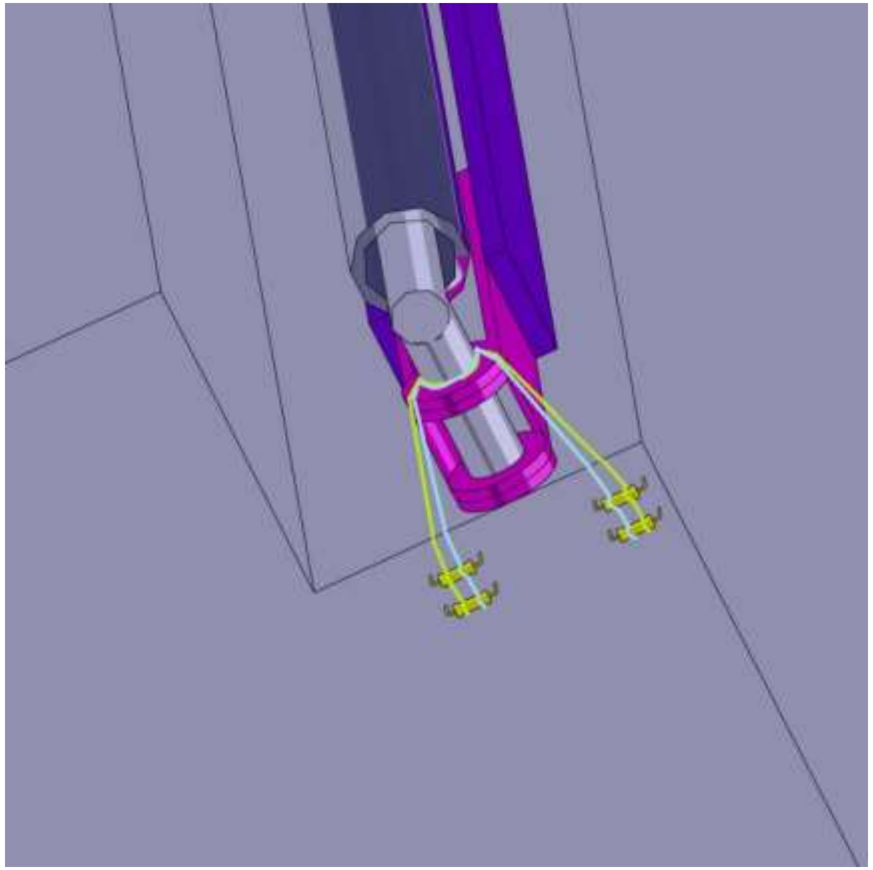
Components	Mass(g)	%20 margin (g)	Predicted Mass (g)
Longbow(steel)	17.0316	3.40632	20.43792
Tube(aluminum)	170.1108	34.02216	204.133
Inner arm(aluminum)	112.062	22.4124	134.4744
Wing x 2 (aluminum)	109.8276	21.96552	131.7931
180 degree opening hinge part (aluminum)	5.358	1.0716	6.4296
180 degree opening bow (steel)	2.508	0.5016	3.0096
First hinge (steel)	121.1136	24.22272	145.3363
Kapton	5.0616	1.01232	6.07392
TOTAL 4 Parts	2172.2928	434.4584	2606.75

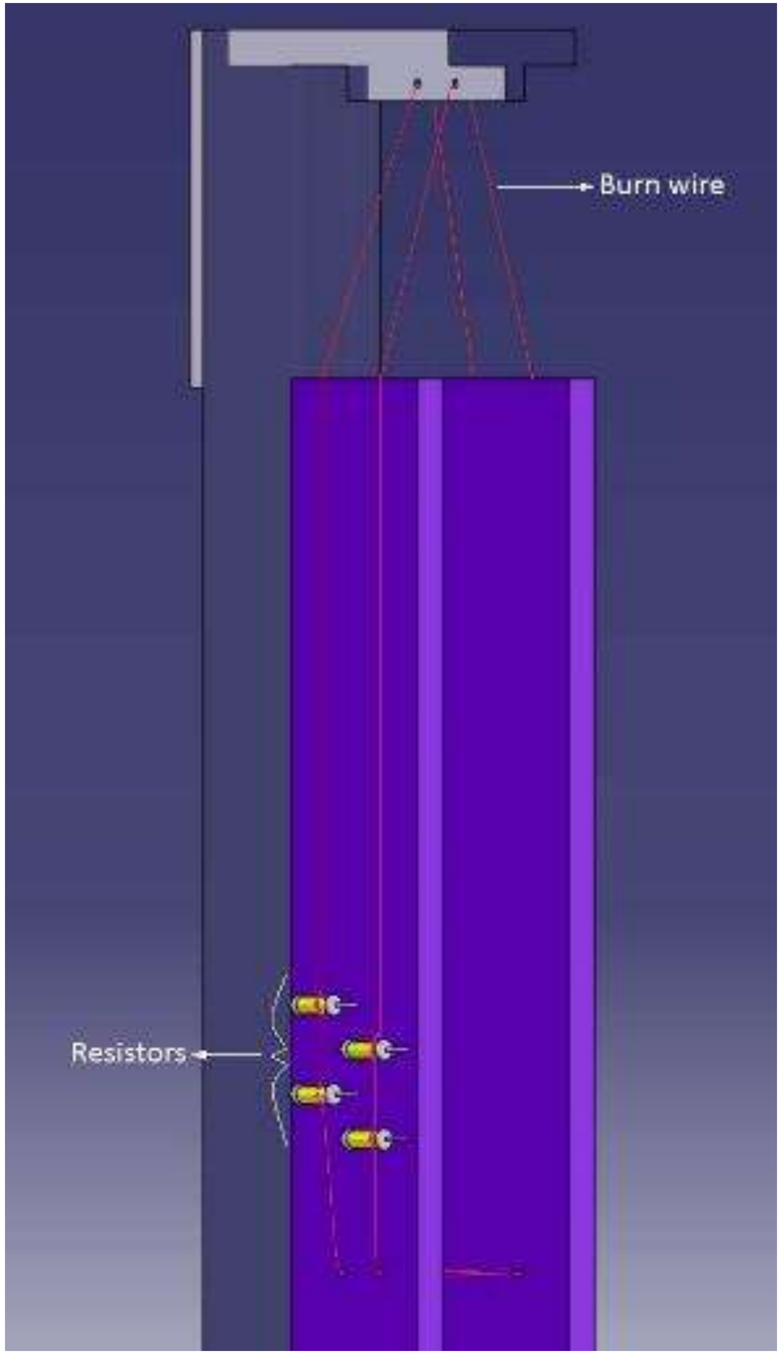
Cost Budget

Components	Unit	Cost	Total
Springs	4 pieces	$3	$12
Spring hinge	8 pieces	$2.5	$20
Frame	4 pieces	$5	$20
Kapton/ Aluminum	11 m2	$16.06	$225
Screws	16 pieces	$0.3	$4.8
Fish line	8m	$1	$1
Total			$282.8

Activation System

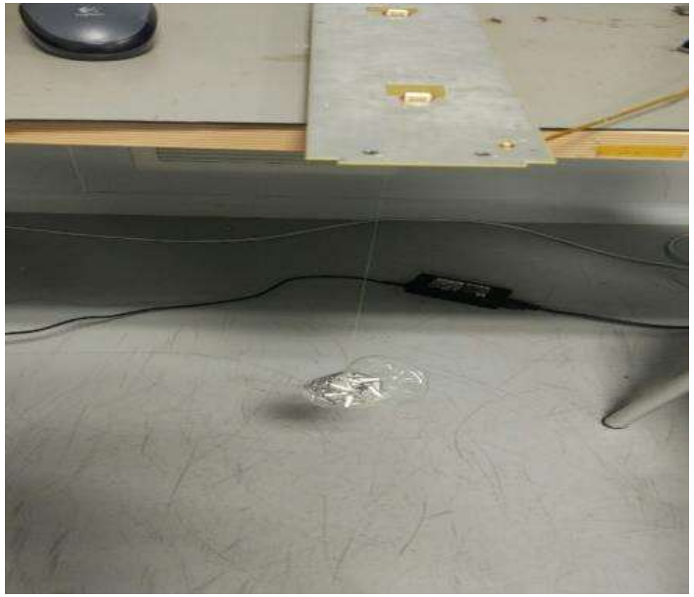
- The opening of the sails will be provided by resistors. 2 fishline and 2 resistors for each fishline is used in every mechanism to ensure safety.





Activation System

- The burn wire used for opening sails can withstand a weight of 37 kg. Since it is not possible to carry out the test for the duration of the task, the test was carried out for 7 days. No stretching or distortion was observed in the tests.



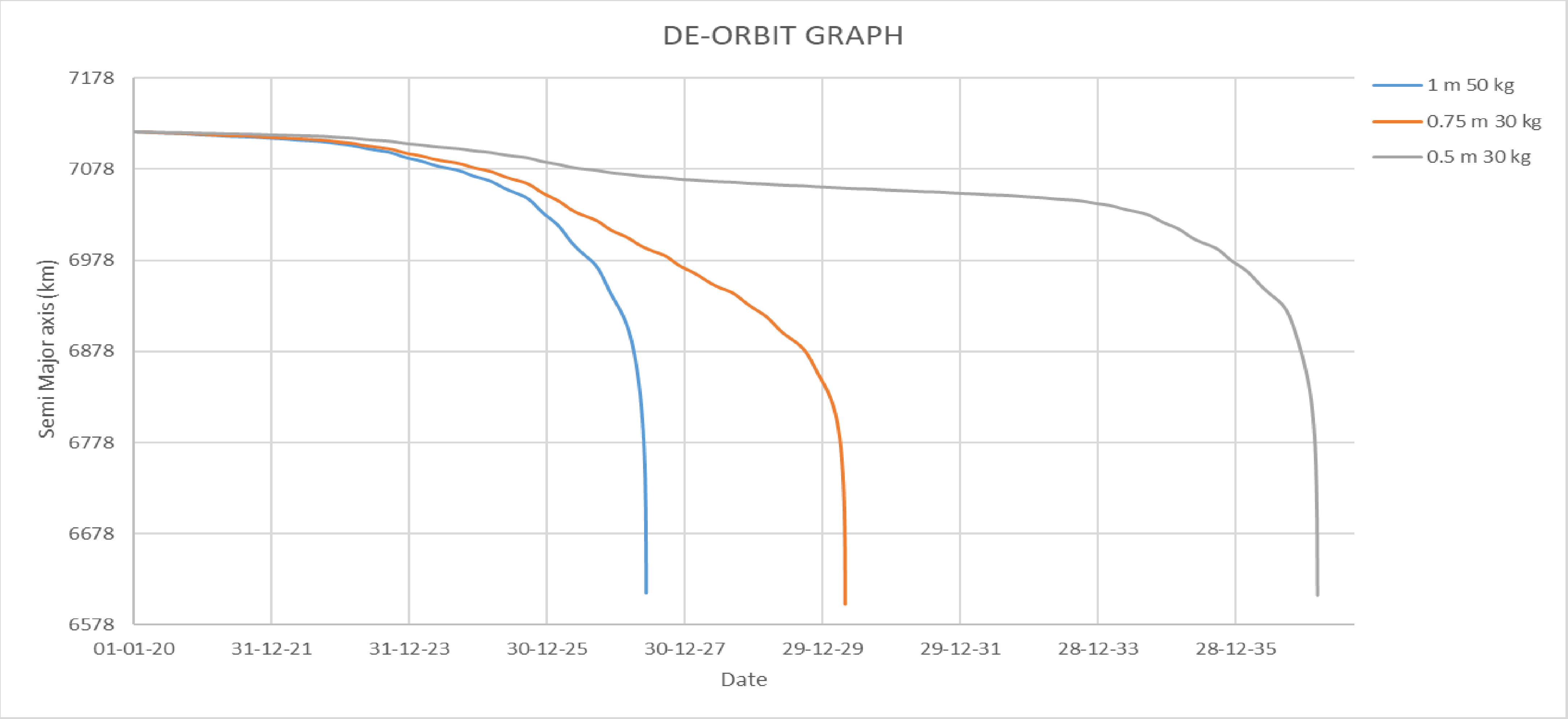
In the room conditions, it was observed that the resistance of the burn wire was burned with resistance at 5V, 10 ohms, 0.48 amperes and 7 seconds. Nichrome wire can be used instead of resistor.

Lifetime Analysis

Case	Height of the Satellite (meter)	Mass of the satellite (kg)	Drag Area of the Solution (m^2)	Total Drag Area with Satellite (m^2)	Lifetime (Days)	Lifetime (Years)
1	1	50	10.804	11.804	2716	7.4
2	1	52	10.804	11.804	2875	7.9
3	1	40	10.804	11.804	2281	6.2
4	0.75	30	6.077	7.077	3772	10.3
5	0.75	50	6.077	7.077	6313	17.3
6	0.5	50	2.701	3.701	16496	45.2
7	0.5	40	2.701	3.701	7524	20.6
8	0.5	30	2.701	3.701	6276	17.2
9	1	50	0	1		340

Lifetime analysis of a cubıc satellite at 750 km altitude. Analysis made with System Tool Kit (STK)

Lifetime Analysis



Conclusion and Future work

- Simple and cheap
- More effective at lower altitudes.

- Future work

- We will integrate a lock system for deployed parts to prevent osccilation of the deployed part with spring force.
- We will design a better prototype

THANK YOU FOR YOUR ATTENTION