Design Portfolio

Orion Racing India (2014-2017):

Orion Racing India is a formula student team of K. J. Somaiya College of Engineering. It develops and manufacture a prototype formula-1 race car and takes part in international design competitions organized by Formula SAE.

(Website: http://orion-racing.com)

Roles and Responsibilities:

- Worked in Bodywork and Aerodynamics System for two years 2014-2016. System head of Bodyworks and Aerodynamics in final year (2017).
- Member of cost report team for two years 2016-2017.
- Presented Design Report and Cost Report at Formula Student Germany 2017 and Formula Society of Automotive Engineers Italy 2017.

Design Portfolio

Projects:

1. **Molds design and manufacturing**:

Aim: To design and manufacture cost-effective molds which can be used for manufacturing carbon fiber parts by resin infusion process and autoclave curing process.

Approach:

- The final finished product is a replica of the corresponding mold and thus, any imperfections, deformities or voids in it will transfer to the parts. With this in mind; the best mold type was a female mold, which would yield the smoothest surface on the outside of the race-car. Based on the draft analysis of the mold designs, modifications were made. The draft analysis of every mold was done using SolidWorks. The example of the seat mold is shown below.

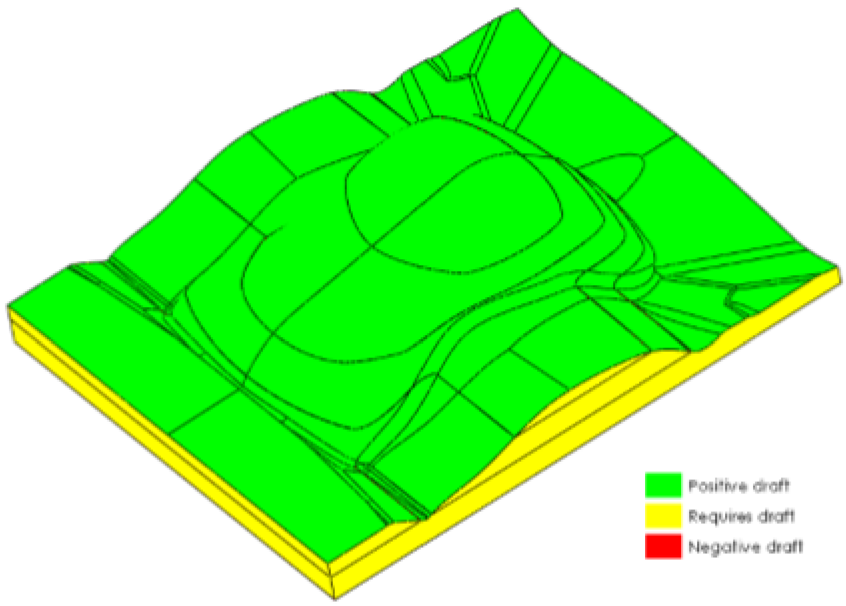


Figure: Draft analysis of seat mould

- The molds had to be rigid enough to hold its shape at high temperature and pressure, inside the autoclave. Thus, after comparing the behavior of various materials, exterior grade medium density fiber (mdf) was selected taking into consideration the required life (single use) and cost.
- The complex design of bodyworks made it difficult and expensive to machine the molds from complete blocks of mdf. Thus, the mdf sheets were machined using mdf milling machine present in the college and were stacked together to form complete molds (aligned using dowel pins).

Design Portfolio

Figure: Stacking of Side Panel Mould

- The primer and high gloss coats were applied to the molds to cover the inherent pores in the mdf and to reduce the efforts to obtain smooth finish on the final carbon fiber part.

Figure: Nose Cone Mould

Figure: Side Panel Mould

Figure: Side Pod Mould

Figure: Dashboard Mould

Figure: Seat Mould

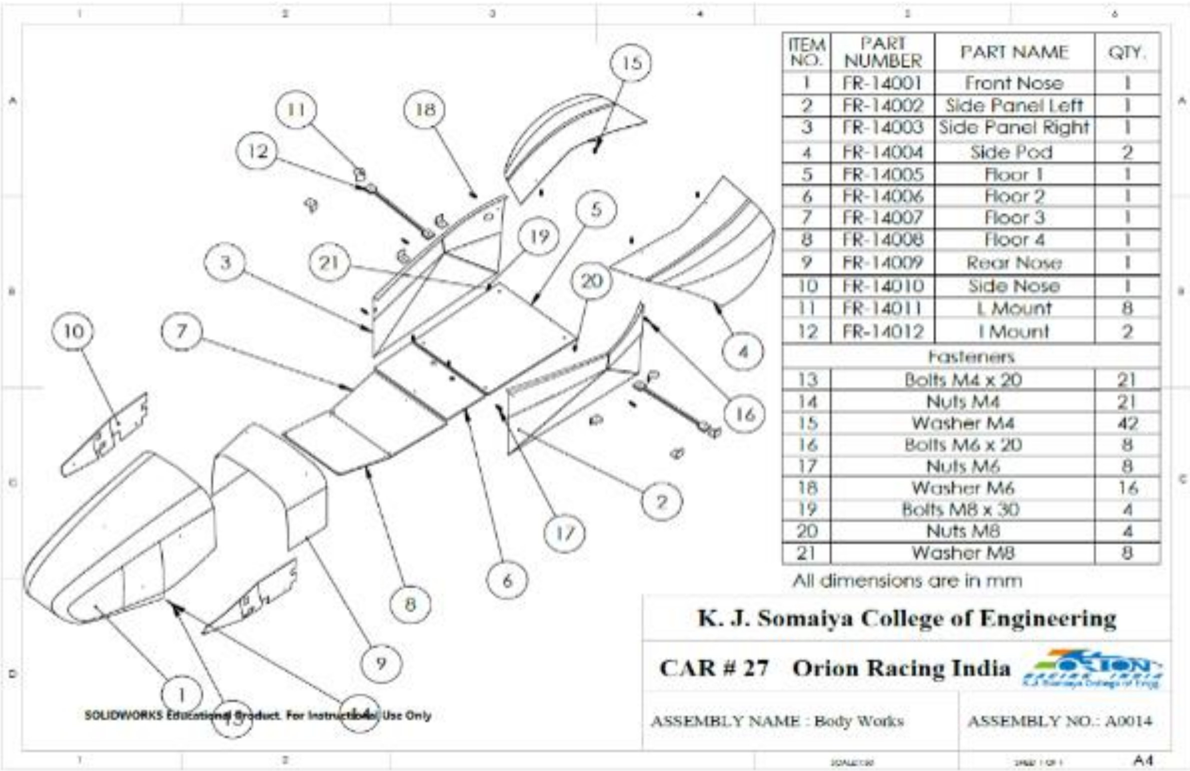
2. **Bodyworks design, analysis and manufacturing**:

Aim:

- To increase strength to weight ratio in structural composite parts.
- Achieving finest finish to reflect the aerodynamic considerations and aesthetics.
- To reduce weight by achieving optimum fiber to weight ratio.

Approach:

- The exploded view along with the bill of material is shown below:



ITEM NO.	PART NUMBER	PART NAME	QTY.
1	FR-14001	Front Nose	1
2	FR-14002	Side Panel Left	1
3	FR-14003	Side Panel Right	1
4	FR-14004	Side Pod	2
5	FR-14005	Floor 1	1
6	FR-14006	Floor 2	1
7	FR-14007	Floor 3	1
8	FR-14008	Floor 4	1
9	FR-14009	Rear Nose	1
10	FR-14010	Side Nose	1
11	FR-14011	L Mount	8
12	FR-14012	I Mount	2
	Fasteners		
13	Bolts M4 x 20		21
14	Nuts M4		21
15	Washer M4		42
16	Bolts M6 x 20		8
17	Nuts M6		8
18	Washer M6		16
19	Bolts M8 x 30		4
20	Nuts M8		4
21	Washer M8		8

- The floors are the structural composite parts, whereas the nose cone, side panel and side pods are major parts in non-structural category.
- The non-structural parts were designed by taking into consideration the aesthetics and their cumulative effect on drag and lift of the car.

3. **Aerodynamic package design, CFD simulation and manufacturing**:

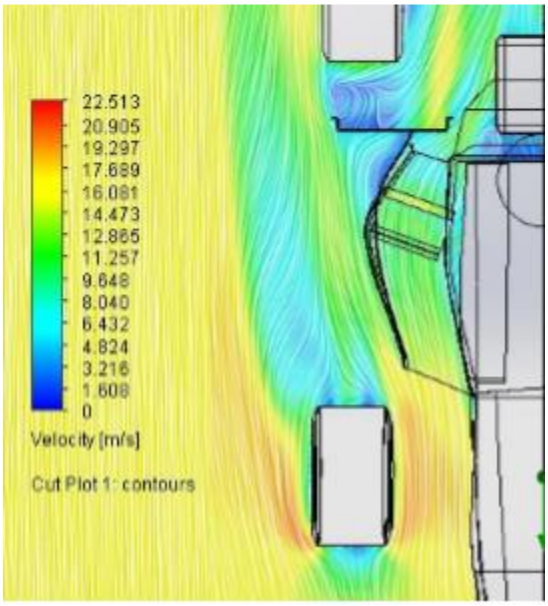
Aim:

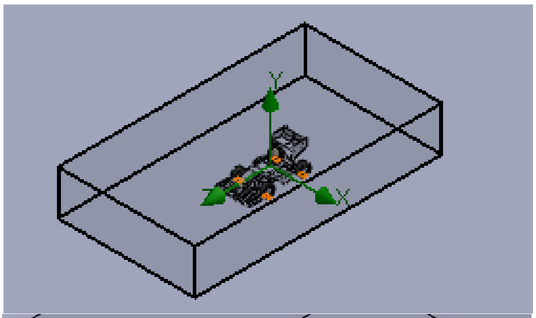
- With a powerful twin cylinder 650cc engine, the purpose of aerodynamic package was to create downforce thereby improving traction and reducing lap times.
- The design should ensure sufficient amount of downforce in order to overcome the weight penalty of the added components and reduce lap times substantially.

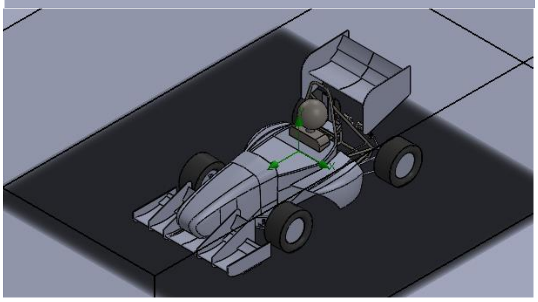
Approach:

- SolidWorks CFD Package was used to simulate different vehicle configurations as shown below.
- The CAD model geometry was simplified to reduce the computational power required as the cell count reduces in the final mesh

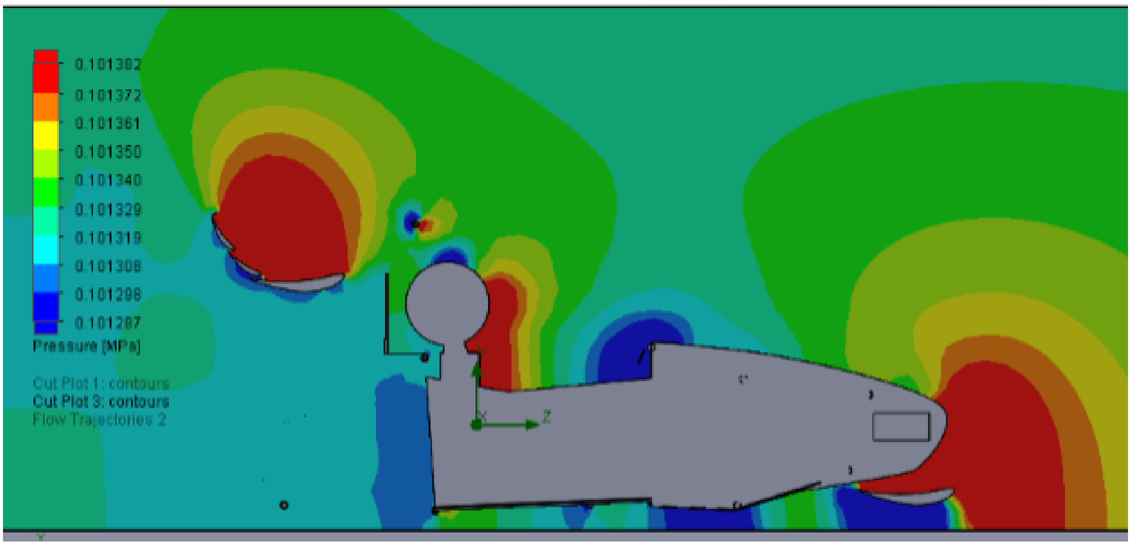
Flow Setup	
Ground Plane	Moving wall at - 60 kmph Z direction global
Front Wheel, Rear Wheel	Rotating wall at 72.9 rpm about their respective Z-axis



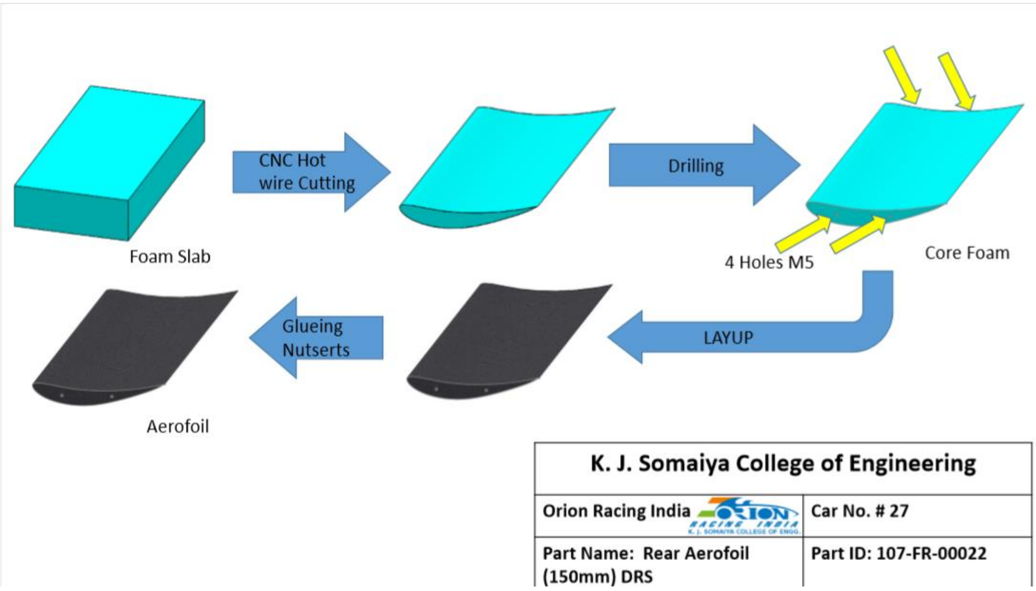




- The simulation results were used to modify the design of bodyworks to guide the flow as required. The above figure shows design of the sidepod to optimize the cooling at radiator and directing the airflow towards the engine.
- The following pressure plots and flow trajectories flow were observed.



Pressure plot at the midplane of the car



Topology Optimization of Rear Wing Mount

4. **Cost and manufacturing report**:

Aim:

- In the cost analysis event, the teams must grapple with the calculative size of the vehicle, its components, and the necessary manufacturing steps and record all of this in a written cost report.
- The students must then answer questions from the judges relating to the cost report on their prototype. In addition to considering the thoroughness of the written report, the students' understanding of the manufacturing process and the total cost calculation will be assessed.

Approach:

- The Bill of Materials and corresponding exploded assembly drawings for each assembly were created.
- The cost effectiveness of each manufacturing technique was considered during the manufacturing phase of the prototype.
- In order to shift to large scale production, the suitable setup cost as well as processing costs were determined as follows:

3 Axis CNC Milling		
Machine Cost		
Machine Cost	€23,600	Total investment on purchasing of the machine
Machine Insurance	€1,440	€120 per month
Depreciation Value	€1,061	18 Years
Salvage Value	€4,500	Value after 18 Years
Fixed Cost		
Labour Cost	€6,500.00	Programmer, Operator Wages
Maintenance Cost	€300.00	4 times a Year
Initial Setup Inventory Cost (One time Cost)	€6,906	Includes Measuring instruments, Software, Computers, Safety Equipment
Inventory Cost	€1,160.00	Includes End mills, Collets, Ball Cutter
Administration Cost	€2,003.50	Includes Stationary, Admin Necessities
Variable cost		
Repair Cost	€100.00	Other than Insurance
Electricity Consumption Cost	€4,368.00	€0.07 per kWH x Usage x 25KW
Machine Hours	2496	52 weeks, 6 days a week, 10 hrs a day, 80% Efficiency
Machine Hourly Rate	€6.94	Cost/Hr of machine operation
Final Hourly Rate	€7.80	Rounding off, Includes 10% Profit

Table 2.3: 3 Axis CNC Milling Machine Hourly Rate

We secured third place in Formula Student 2017 in the cost and manufacturing event.

U-farm (April – June 2018):

U-farm is a startup company from 2018, producing IoT powered modular indoor vertical farming equipment for Hotels, Restaurants and Cafes.

(Website: https://www.theufarm.com)

Roles and Responsibilities:

- I joined U-farm while they were in their early stages.
- I was responsible for CAD modeling, material selection and manufacturing the pilot vertical farming equipment.
- I held the position of Project Design Engineer for three months, gaining hands-on experience using the 3-axis milling machine, laser printer and 3d printer (from the university's maker lab) to create custom parts for our machine.

Aim:

- To design a chassis for a vertical farm that can create and control the environment best suited to grow microgreens and other herbs.

Approach:

- Solid works was used for 3D CAD modelling, validation and to prepare 2D drawings.
- In order to make the project cost-effective, modular and easy to assemble, aluminum extrusions were selected.
- Acrylic sheets were used to improve aesthetics of the overall equipment. These acrylic sheets were trimmed using laser cutting.
- To manufacture custom sized trays for growing herbs, wooden sheets were milled to our requirement.


Divide by Zero Technologies (2018-2019):

Divide by Zero Technologies is 3D printing Original Equipment Manufacturer in India. It is one of the pioneer companies to take 3D printing technology to SME sector in India purely because the machines are professional, affordable and adhere to international quality standards.

(Website: https://www.divbyz.com)

Roles and Responsibilities:

- I joined Divide by Zero Technologies as Design Intern in Research and Development Department.
- I was responsible for CAD modeling, material selection and preparing Bill of Materials and corresponding drawings.
- In addition, I was also part of the team for manufacturing the beta prototype of these machines.
- I held the position of Design Consultant (Engineer) in the same department for six months after finishing my internship.

Projects:

1. **Fused Filament Fabrication 3D printer**:

   Aim:

   - My first project was to design a Fused Filament Fabrication 3D printer which had increased bed size and functionality than its predecessor.

   Approach:

   - Solid works was used for 3D CAD modelling and assembly, since the former model was present in the same format.
   - In order to make the project cost-effective, the material study was performed to determine the best-suited material for the structure.
   - The material selection was determined by trade-off between parameters such as cost, ease of machining and the life of material.
   - For efficient handling of the machine, the weight was a criterion which was settled using topology optimization.
   - Heat simulation was performed for optimizing and validating the extruder assembly.
   - I was able to develop a beta prototype for the same within 4 months.

2. **Laser-based 3D printer**:
   Aim:
   - My second project was to design and manufacture Optics Assembly, water cooling and gas purging systems of a prototype laser-based 3D printer.

   Approach:
   - This project was also modelled using Solid works.
   - Since, this was a novel prototype project, the design was based on the research and results from the simulation.
   - The fundamentally different parts needed specific vendors for manufacturing the components required for the prototype.
   - The modular design approach was used, to rectify and improve particular modules rather than the whole assembly.
   - Modular design also helped in checking and approving certain sub-assembly, when there was unanticipated delay in remaining components.
   - A working beta prototype was successfully manufactured and testing was performed for improving the parameters.

Skills and Knowledge gained:
- During this time, I was able to imbibe practical knowledge and exposure from my seniors and head of the department.
- Both of the Internet of Things enabled printers required good interaction and understanding between designer and embedder.
- The procurement of materials and quality control of the same demanded an inter-departmental rapport.
- These interactions helped me develop teamwork and cooperation at an industrial level.

Please find the letter of recommendation here:
https://drive.google.com/open?id=113haEz2b0-aT0gmH6yx-JjmJSRt2OEZ8

CAD and Digital Manufacturing Specialization (2019):

CAD and Digital Manufacturing Specialization is an offered online on Coursera by Autodesk. Through this specialization, we can learn the foundations of product innovation and digital manufacturing while developing the technical skills within Autodesk® Fusion 360™.
(Website: https://www.coursera.org/specializations/cad-design-digital-manufacturing)

Project:
Designing and analyzing an Unmanned Aerial Vehicle (UAV) using Autodesk Fusion

Aim:

- To design the chassis of an unmanned aerial vehicle (UAV), selecting the appropriate components as per requirement and performing simulated tests and analysis to validate the design. The specialization consisted of two different type of UAVs: Agile & Search and Rescue

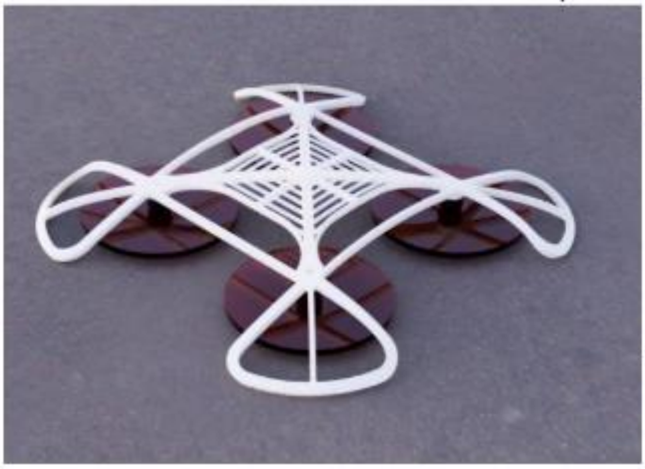
Approach:

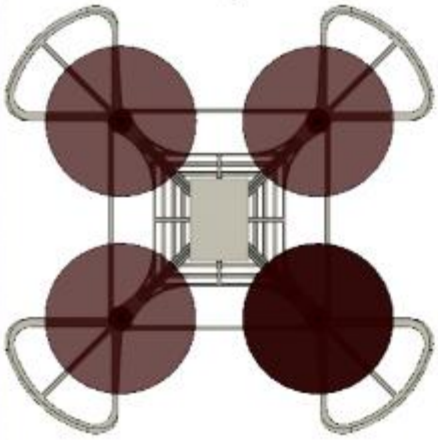
- This project was modelled and analyzed using Autodesk Fusion.
  For agile design:
- The frame was selected to have convex shape so as to protrude and form stand of the quadcopter.
- The electronics are mounted on lower side to protect them in case of impact.
- The battery is mounted on the top side of quadcopter to move the center of gravity closer to thrust plane thereby making it more agile.
- The propellers are unprotected to keep frame compact and quadcopter lightweight.

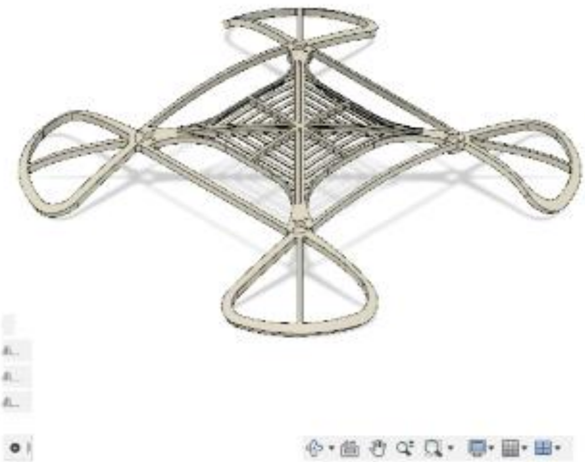
Design Portfolio

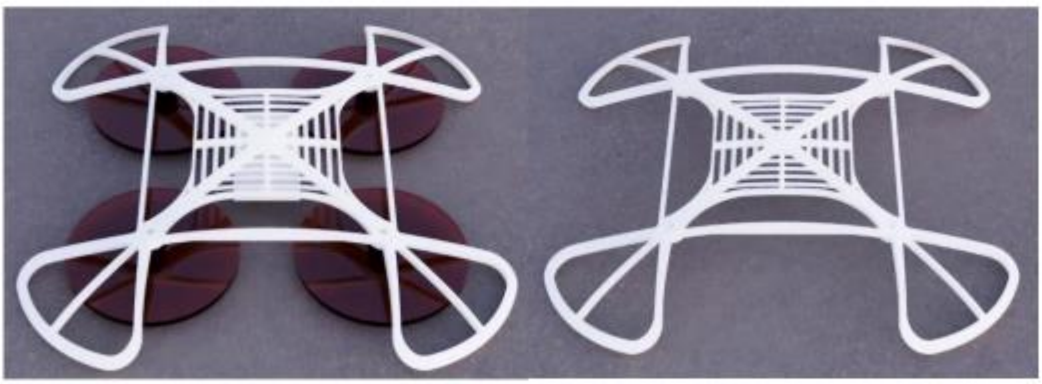
For Search and Rescue design:

- The frame was selected to have convex shape so as to protrude and form protective covering for propellers of the quadcopter.
- The battery is mounted on the bottom side of quadcopter to move the center of gravity below thrust plane thereby making it more stable.
- The electronics are mounted on lower side to protect them in case of impact.









Please find the detailed report with component selection here:
https://drive.google.com/drive/folders/196YS0k2-lDR7KSbZix0bYxD-02sz9OBm

Clemson University - Academic Group Projects (Aug 2019 - Present):

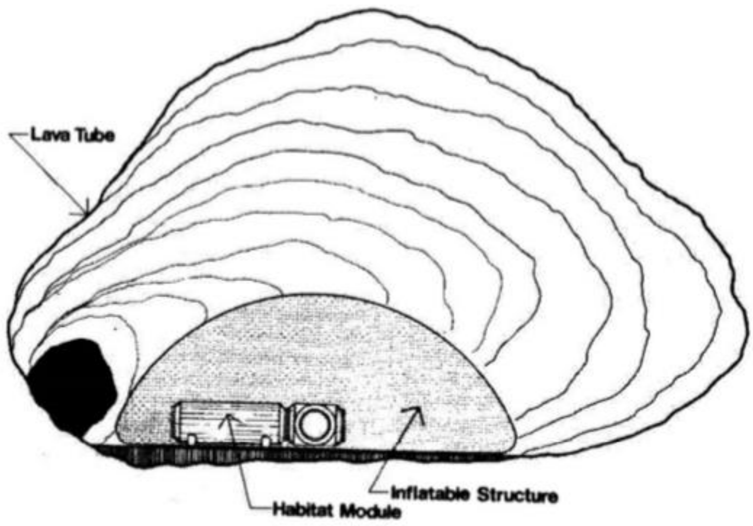
1. Lunar Regolith processing module (Aug - Dec 2019)

Aim:

- To design a lunar regolith processing module for processing mined regolith to extract and store hydrogen, oxygen and He-3 for inter-terrestrial use.
- Being part of structures team, our aim was to minimize the risk to human life and to shield all other systems of the module from extreme temperatures, radiation, regolith and impacts from the micrometeoroids.

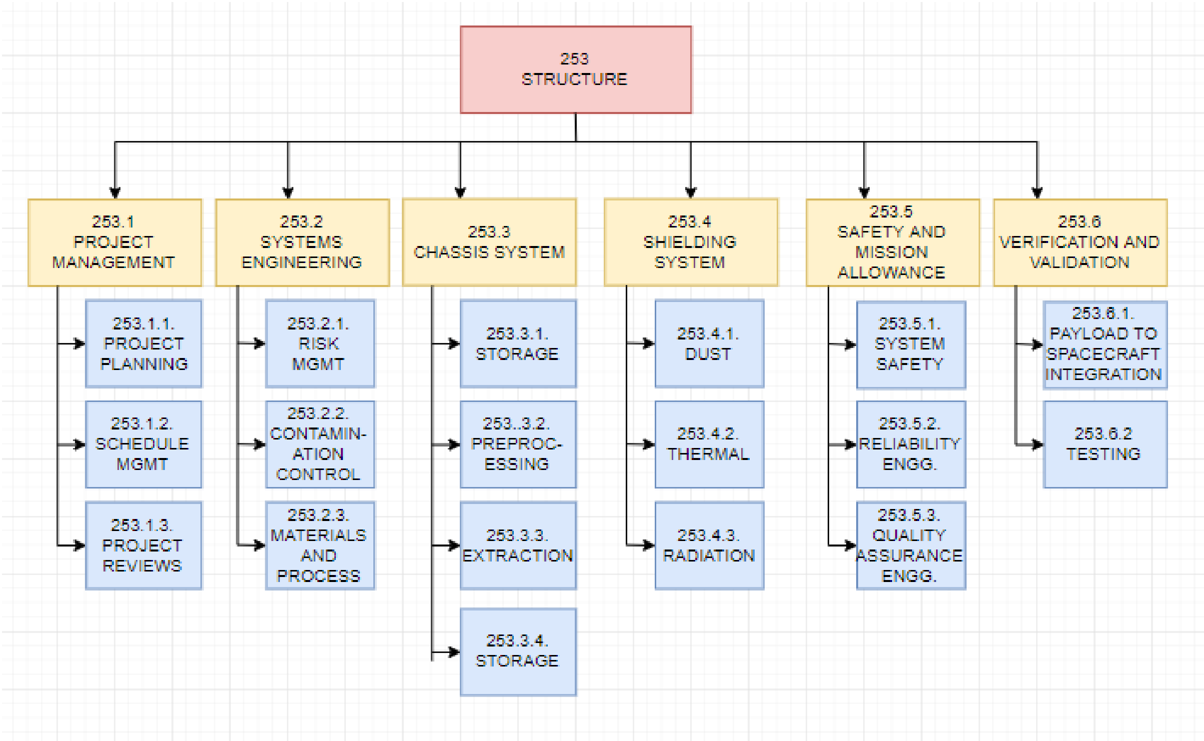
Approach:

- A modular design was preferred to incorporate modifications or upgrades easily as well as for ease of maintenance.
- The module was designed to be fully autonomous and unmanned for minimizing risk to human life.
- The module was designed to be a standalone inter-galactic station capable of withstanding long-term exposure to an adverse lunar environment.
- Due to absence of atmosphere, lunar surface receives about 100 times of cosmic radiation on earth surface as well as impacts from micrometeoroids. Lunar surface also has extreme temperatures (125 °C to -183 °C). Thus, if the module is present on the lunar surface it needs to be overdesigned as none of these conditions are present on the earth.
- We came up with a creative solution to place the module in a lunar lava tube, the environment in lava tube is less harsh as compared to lunar surface. The roof of lava tube protects the module from micrometeoroids and cosmic radiation. The temperature inside the lava tube is also constant around -120 °C as the roof acts as an insulator reducing creep.

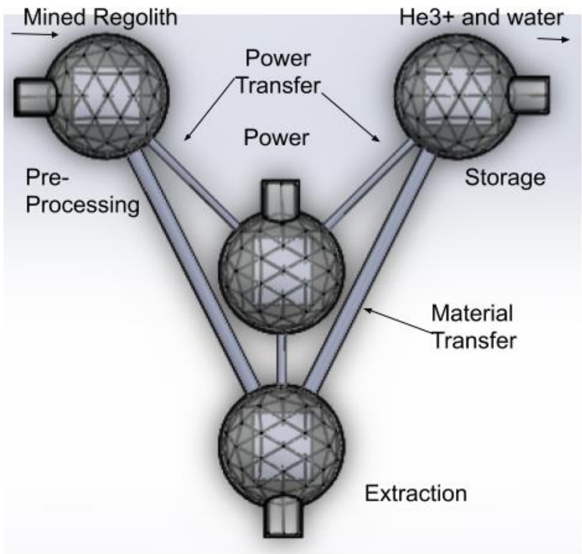


Inflatable Structure Habitat in a Lunar lava tube.

Design Portfolio



Work Breakdown Structure



Proposed Layout of the LuRePm module

A Preliminary Design Report was prepared for this project which included:

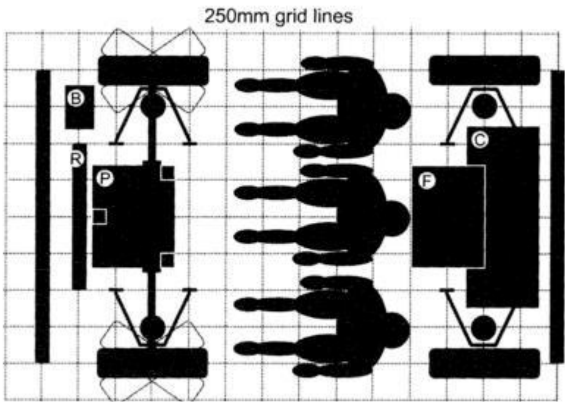
- Users and Stakeholders
- Design Trade-offs
- Mission Justification and Objectives
- Conduct of Operations Plan (ConOps)
- Mission Architecture
- Project Breakdown Structure

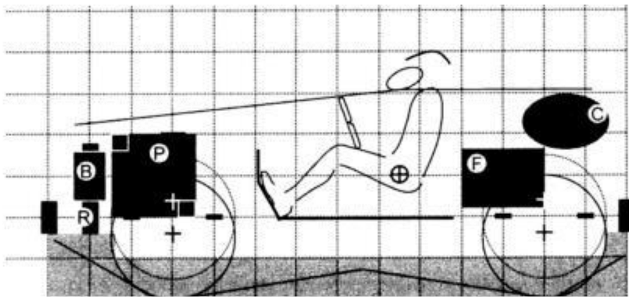
- Work Breakdown Structure
- Feasible Design Concepts
- Concept Evaluation Study (FMEA, Decision Matrix, Severity Ranking Criteria)
- Verification and Validation test plan for subsystem level
- Program project plan
- Program budget proposal
- Proposed technology development program
- Evaluation of the concept with respect to MOE and MOP with engineering analysis

2. Structural & Thermal Analysis of Body in White (Jan - Apr 2020)

Aim:

- To develop the body structure which will meet the bending, torsion and crashworthiness and vibration with minimum possible weight.
- In addition to meeting all the structural requirement, the developed body structure should also satisfy the spatial requirements as per given layout.

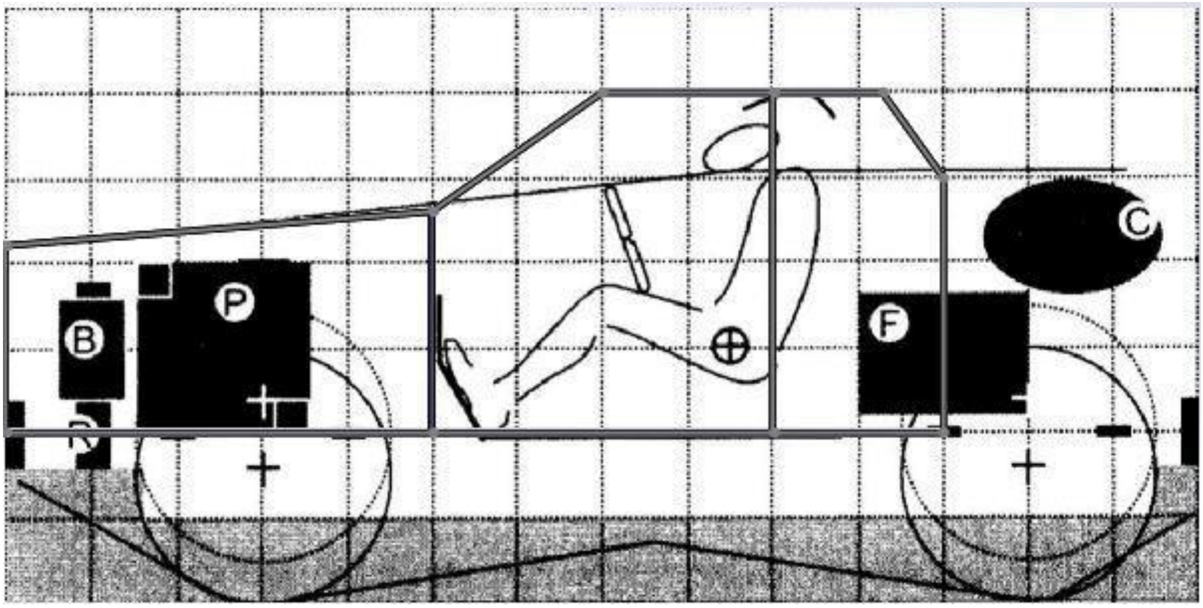


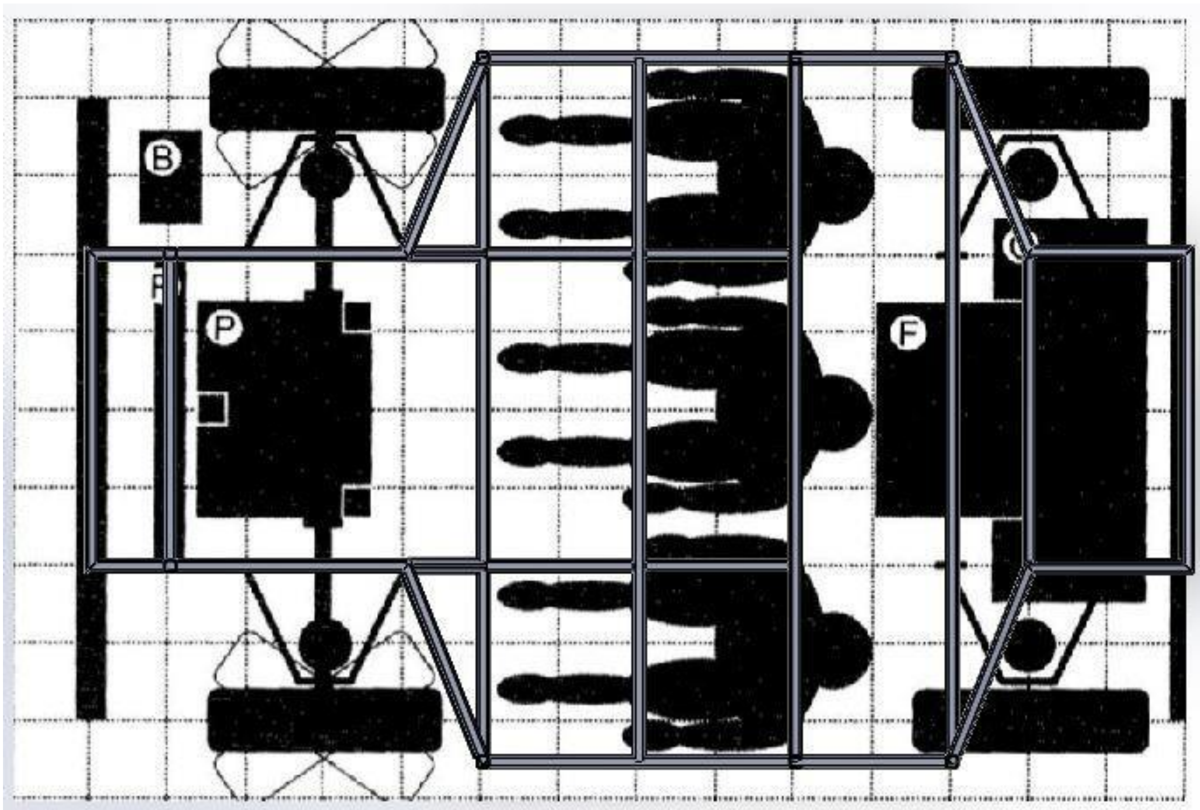


Approach:

- One of the tradeoffs was the body-on-frame vs unibody, while body-on-frame is used for mostly single door cars, we went with unibody for the light weight design, fuel efficiency and better riding comfort which is expected from a mid-range car. Another tradeoff included the B-pillar position for bending stiffness vs ingress and egress timing.
- The joint stiffness was calculated using Hypermesh and the determined value was used in the Donald Malen's Body Structure Advisor. The geometry of the frame and the dimensions of tubes were optimized to minimize the weight.

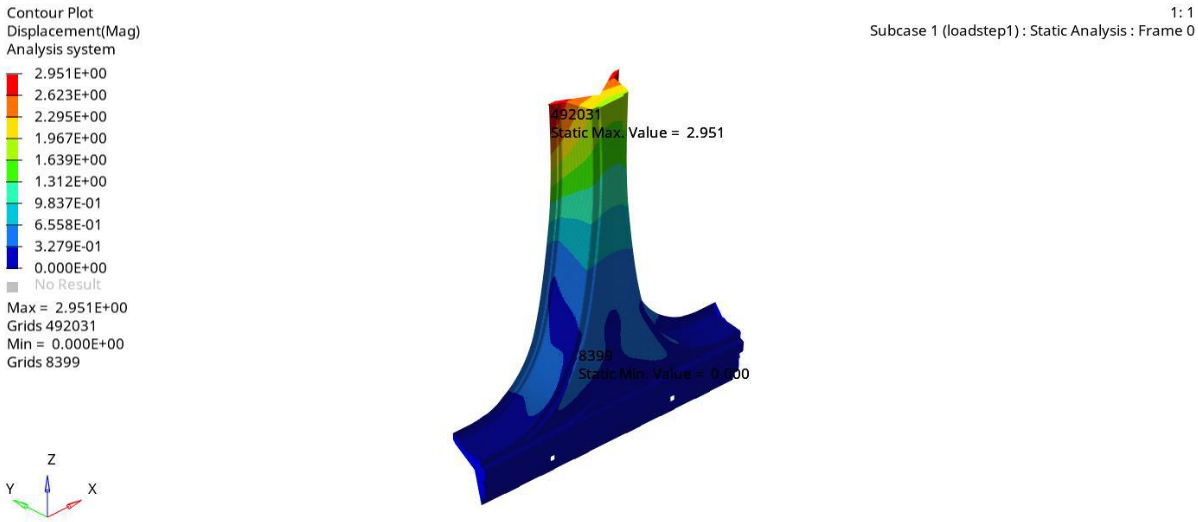
Design Portfolio

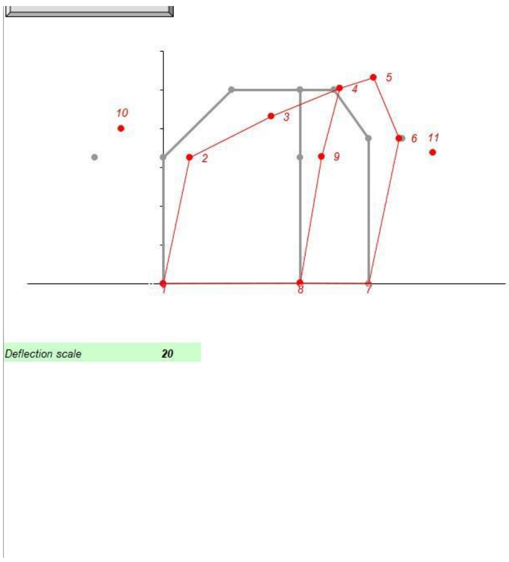




- The design report was prepared for this project containing:
    1. BIW Structural Lay-Out
    2. Body Side-Frame Design for Bending Stiffness
    3. Body Structural Torsional Stiffness Modeling and Development
    4. Design for Crashworthiness
    5. Design of BIW Structural Cross-Members to maintain passenger compartment integrity and to reach crash impact loads
    6. Total Vehicle Mass Compounding Estimate

Design Portfolio





deflections (mm)

	x	y
1	0.00	0.00
2	9.63	0.00
3	14.43	-6.80
4	14.45	0.32
5	14.44	3.22
6	11.19	-0.01
7	0.02	0.00
8	0.02	0.31
9	7.85	0.32
10	9.63	7.47
11	11.19	-3.75

	Bending Energy Nmm	% bending energy %	Bending Stress N/mm^2 end 1	end 2	total stress N/mm^2	Cap buckling stress N/mm^2	Max moment Nmm	Moment of Inertia mm^4
hinge pillar	290.6	1.5%	58	0	59	299	484,602	416,667
A pillar	145.3	0.8%	4	54	60	611	88,471	28,583
roof front	194.9	1.0%	70	73	78	468	87,726	15,104
roof rear	68.1	0.4%	33	70	86	468	84,195	15,104
C upper	44.3	0.2%	24	22	28	1197	89,380	140,625
C lower	686.9	3.6%	23	102	105	299	341,353	83,333
Rocker rear	37.9	0.2%	20	16	21	355	347,018	1,093,359
Rocker front	489.2	2.5%	54	28	58	355	940,769	1,093,359
B lower	4228.3	22.0%	198	56	199	299	1,213,607	245,333
B upper	490.9	2.6%	166	55	167	1197	346,322	52,083
Total beams		34.8%						
hinge-rocker	3407.5	17.8%						
hinge-A	0.3	0.0%						
A-roof	989.4	5.2%						
roof-C	991.4	5.2%						
C up-Clower	115.3	0.6%						
C-rocker	1692.4	8.8%						
B-rocker	3384.9	17.6%						
B-roof	1934.8	10.1%						
front end horiz	0.0	0.0%						
front end diag	0.0	0.0%						
rear end horiz	0.0	0.0%						
rear end diag	0.0	0.0%						
Total joints		65.2%						
Grand total	19192.3	100.0%						

Please find the detailed reports here:

https://drive.google.com/drive/folders/10XUgQ1YZKPZibDcCoXUcw3YqOx13Obrz?usp=sharing

Hackathons:

1. MIT COVID-19 Challenge Beat the Pandemic II (May 2020):

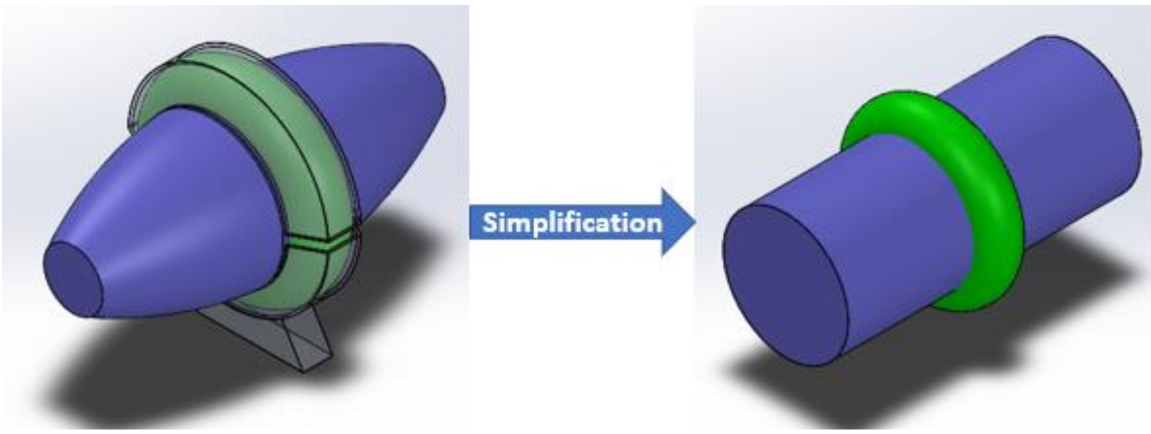
Aim:

- To conceptualize, design a prototype and validate the design using the simple model and initial assumptions.

Approach:

Prototype

- The model was created using the approximate general dimensions of the ambu tube (350 mm length, 150 mm diameter)
- Toroidal tube was considered to be having 50 mm od. (Optimized position for maximum effective displacement)
- For effective conversion of expansion of toroidal tube to ambu tube, designed a clamp to guide the displacement.



Thickness and Volume Calculations:

Simplifications:

- Inflatable cylindrical toroid
- Thin-walled elements
- Cylinder does not expand axially

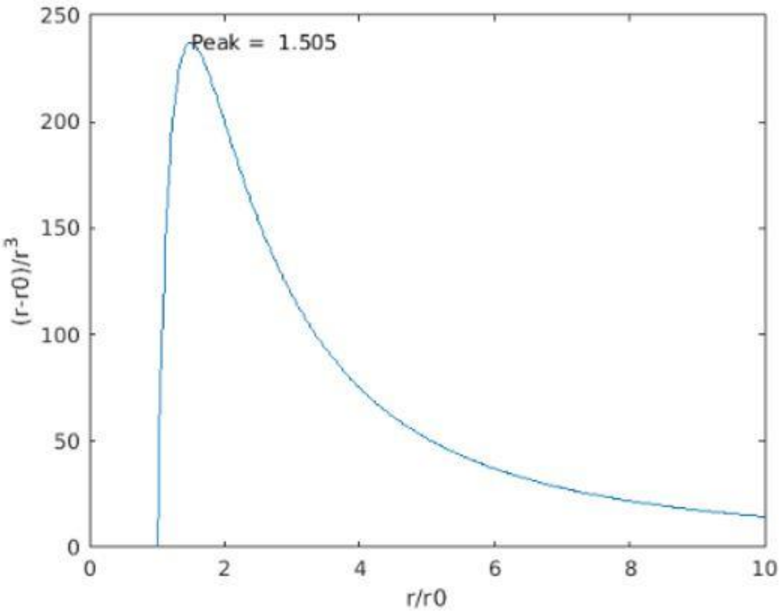
Relation between pressure and radius of toroid (after expansion):

$$P = E_{sbr} * \frac{\Delta r * t0 * r0}{1} * \frac{1}{r^3}$$

Maximum Pressure calculations:

```
r0 = 0.025; %m
e = linspace(1,10,500);
r = e*r0;
m = (r-r0)./r.^3;
plot(e,m)
xlabel('r/r0');
ylabel('(r-r0)/r^3');
[Peak, PeakIdx] = findpe
Pk = e(PeakIdx);
text(e(PeakIdx), Peak, s
```

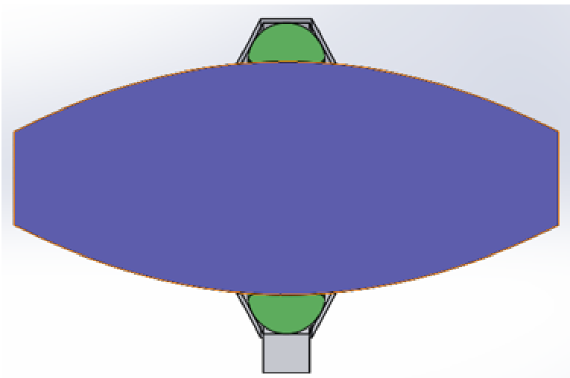
With reference to the graph, there is a maximum pressure after which it becomes easier and easier to inflate the tube.



Validation:

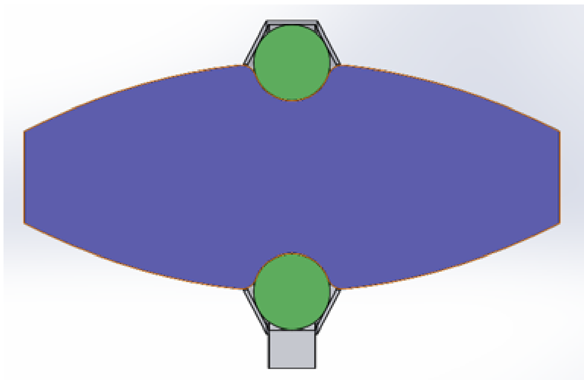
After the maximum pressure was determined, the thickness of toroidal tube was fixed. The expansion of toroidal tube and displaced volume for ambu bag was calculated, after using appropriate factor of safety.

Calculation for size and number of toroidal vents:



The compression cycle of toroidal tube.

- Volume of ambu bag: 4.156 L



The expansion cycle of toroidal tube.

- Volume of compressed ambu bag: 3.753 L

Difference in volume = 0.403 L
Air intake in one breath or Tidal Volume (TV) = 0.5 L

2. Winner of MIT Challenge: India Turning the Tide (Aug 2020):

Aim:

- During the COVID 19 pandemic, an increasing amount of poor quality and counterfeit healthcare products are reaching the customers due to poor quality inspections.
- We proposed a solution to include an intelligent conveyor belt type system with remote inspection capabilities at various stations of the manufacturer site.

Approach:

- We had a multi-disciplinary team consisting of senior quality engineers and strategic experts from medical industries, computer science and machine learning engineers.
- We came up with a way to automate the quality inspection process while maintaining the scalability using the technologies like 3D scanner and virtual reality, RF id tags and Remote visual inspection.