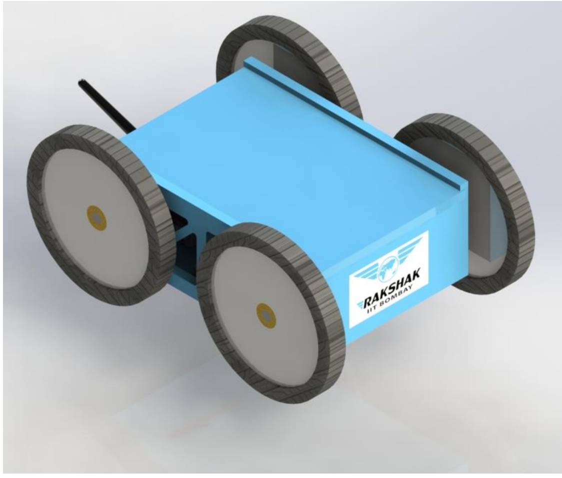
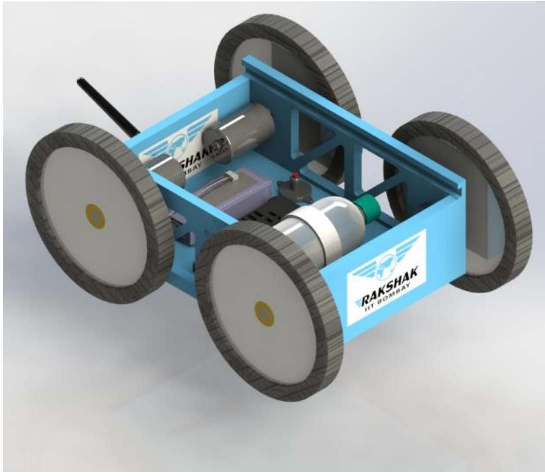
Air Delivery Design Report

Unmanned Ground Vehicle Design



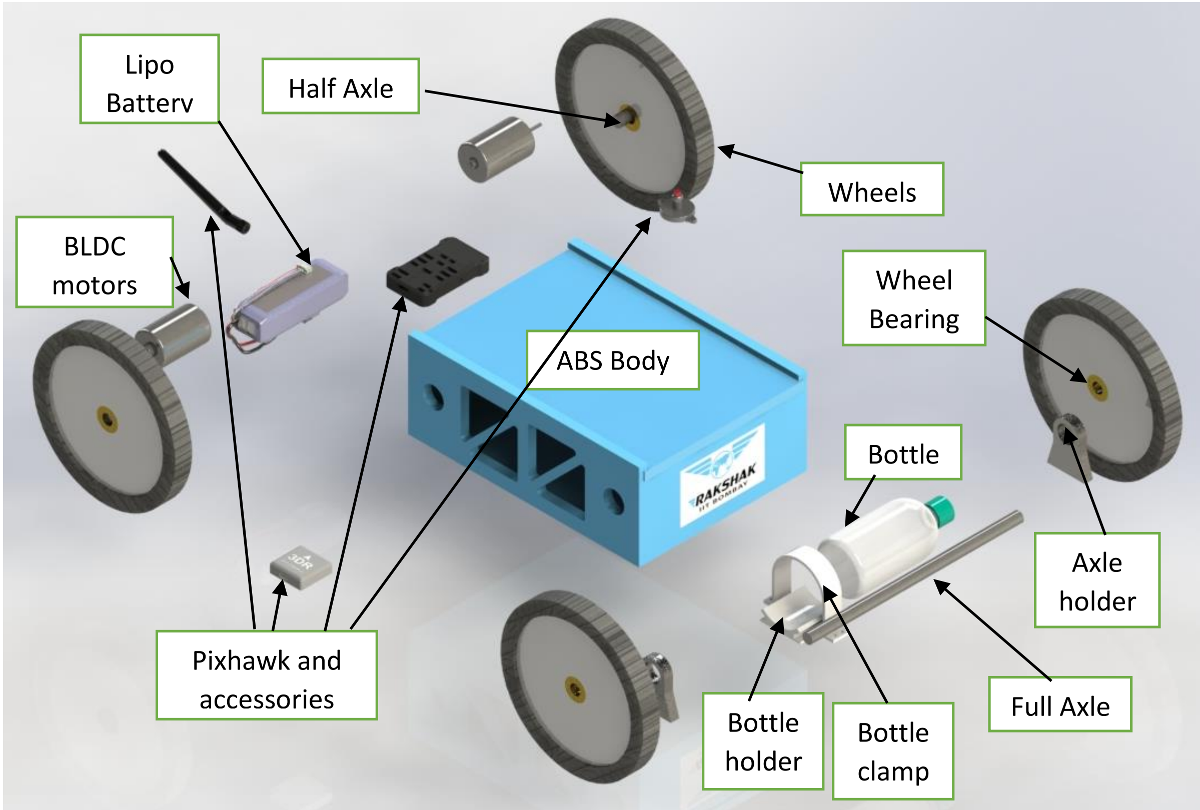


The team considered various possible UGV layouts. Considering the two wheeler and three wheeler UGV models, various uncertainties of toppling and improper landing came out through the flight calculations. So the team decided to opt for a compact 4 wheel, Pixhawk Controlled Forward Drive UGV model. With various iterations and design considerations, the team came up with the above Solid Works rendered model of UGV. The enclosing dimensions of the UGV are 275 mm x 200 mm x 103 mm. The overall weight of the UGV will be 1.2 kg. The unique ability of this UGV model involves waving off the toppling and improper landing uncertainties by a larger wheel (170 mm) which protects the UGV from top and bottom side impact. The UGV body will be in-house manufactured by 3D printing method. The material for the body will be ABS. To reduce the weight of the ABS body, the infill density will be optimized and adjusted. The material selection and process planning for the UGV parts is as follows:

Sr. No.	Part Name	Material	Mfg. Process
1	UGV Body	ABS	3D Printing
2	Wheel Rim	ABS	3D Printing
3	Wheel Tyre	Butadiene rubber	Standard Part
4	Bottle Holder	ABS	3D Printing
5	Bottle Clamp	ABS	3D Printing
6	Motor Mounting	ABS	3D Printing
7	Full Axle	Annealed Stainless Steel	Machining
8	Half Axles	Annealed Stainless Steel	Machining
9	Wheel Bearing	Brass	Standard Part
10	Axle Holder	ABS	3D printing
11	All Electronic Components	Standard	Standard Part

Considering the electronic components cooling via natural convection, vents in form of truss structure is provided. This has double-fold benefit. First, it allows for material reduction and weight optimization. Second, it allows for efficient signal transmission and reception to the Pixhawk via GPS module connected. All the electronic components will be cushioned from a light weight sponge material as an internal packing, to provide extra impact protection for the circuitry. An easy slider roof-top is provided for quick access to the internal UGV components.

Exploded view



UGV Transmission System

UGV is powered by a 12 V, 8000 mAh, rechargeable Lipo Battery. To reduce the power and the weight load, the team chose to opt for a Front Wheel drive UGV, which will include 2 BLDC motors for front wheels. As per the target location, UGV will receive instructions from the ground station via GPS and Pixhawk. The trailing wheels are supported using a Full Axle, acting as a Simply Supported structure between two Axle holders, then to Wheel Bearings. This will also help in taking the impact energy of the structure, as demonstrated below in the Drop test Simulation.

Drop Test Simulation

A Drop Test Simulation and Analysis was performed using SolidWorks to evaluate the Design model. The setup conditions put for the simulation are as follows:

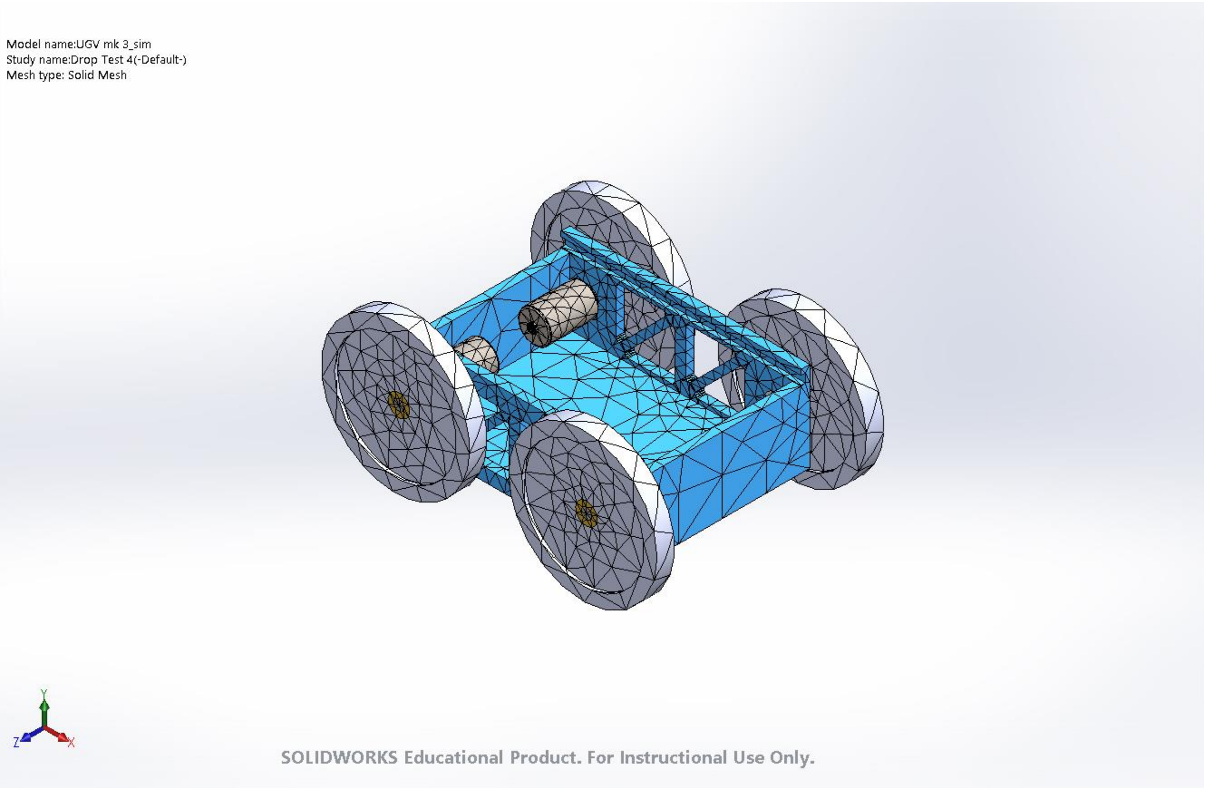
Type	Velocity at impact
Velocity Magnitude	3 m/sec
Gravity	9.81 m/s^2
Friction Coefficient	0
Target Stiffness	Rigid target
Critical Damping Ratio	0

Further the UGV was meshed using the inbuilt Curvature-based Mesher in SW. Following were the Mesh inputs (No. of Nodes and Element size).

Meshing Information:

Mesh type	Solid Mesh
Mesher Used:	Curvature-based mesh
Jacobian points	4 Points
Maximum element size	51.4101 mm
Minimum element size	10.282 mm
Mesh Quality Plot	High
Remesh failed parts with incompatible mesh	Off

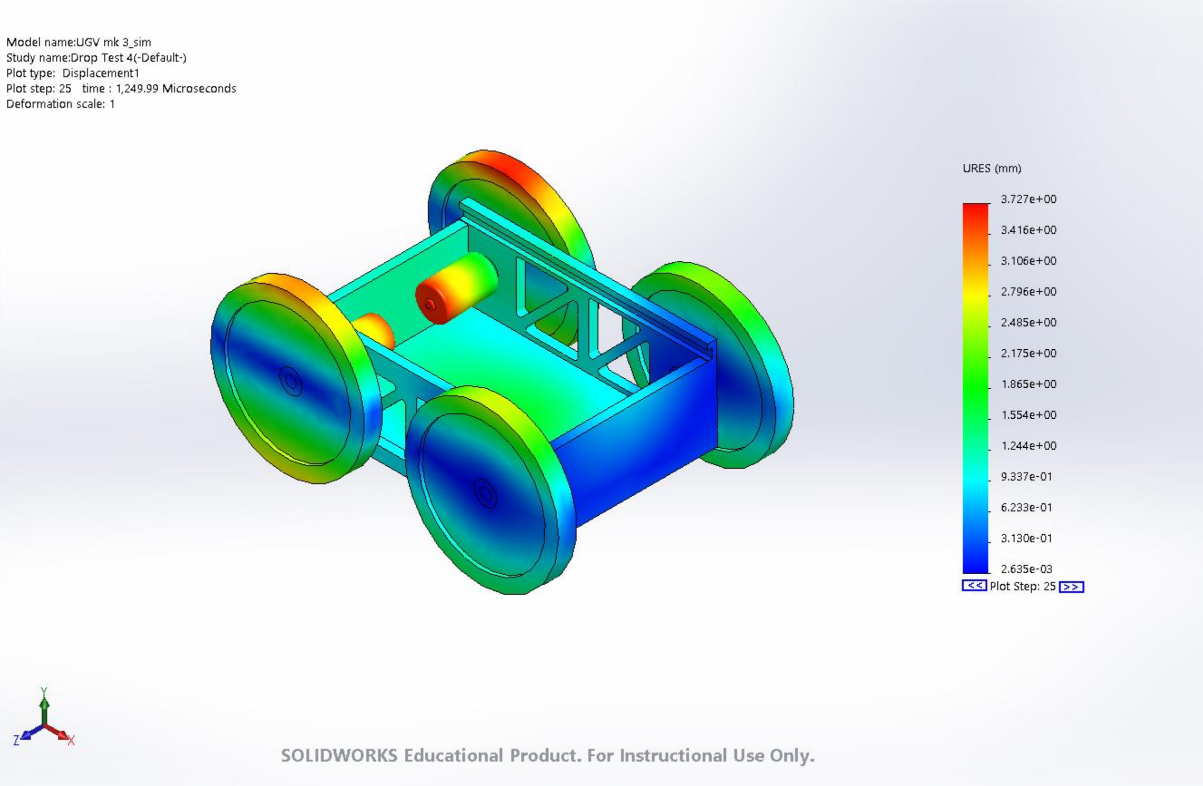
Total Nodes	18077
Total Elements	20661
Maximum Aspect Ratio	27.26
% of elements with Aspect Ratio < 3	61.5
% of elements with Aspect Ratio > 10	1.24
% of distorted elements(Jacobian)	0



After setting up the test conditions and the Meshing inputs, a FEM Solver was run to get Displacement and Stress Results.

Study Results

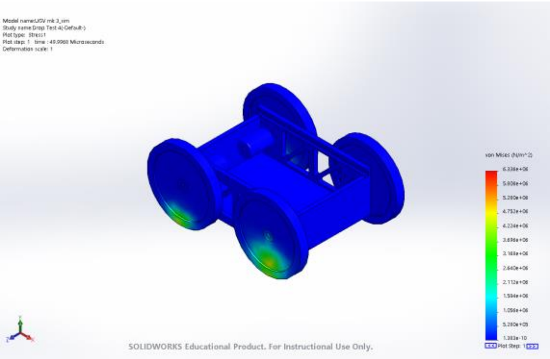
1. Displacement Analysis:



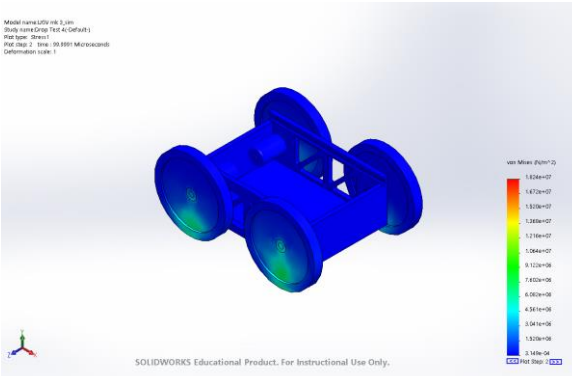
Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	2.635e-03 mm Node: 335	3.727e+00 mm Node: 9957

As per the FEM analysis, the maximum displacement achieved is just 3.27 mm at the top portion of the Front wheels. This is as per the expected situation where the Front wheels, which are supported by the half axle are provided a Bending Moment by the middle body due to Drop Impact, taken by the wheels. Here, the wheel tire is expected to take the impact, acting as a natural suspension for UGV. Since all the displacements throughout are less than 3 mm, the structural integrity of the proposed 3D model of UGV is maintained, even after the impact. This fact gets verified.

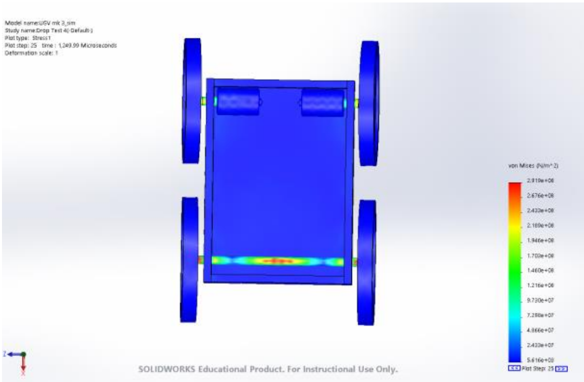
2. Stress Analysis:



Intermediate Time Frame 1



Intermediate Time Frame 2



Final Time Frame 3

Name	Type	Min	Max
Stress1	VON: von Mises Stress	5.616e+03 N/m^2 Node: 10118	2.919e+08 N/m^2 Node: 717

In the Stress Analysis Study, the Von Mises Strain Energy Theory of Failure was selected for simulation. The figures show 3 different instances of the simulation run. In the First Intermediate time frame, we see the stress is first developed at the wheel contact due to impact. Moving further in time, this Stress gets propagated through the wheels to the body, which is eminent from Intermediate Time Frame 2. This impact energy is finally passed on to the wheel Axles (both Front Half Axle and the back Full Axle) where it gets absorbed and contained. The Maximum Stress reached in the Axle is 291.9 MPa. The material used for the Axle, Annealed SS, has Shear Strength of 517 MPa. Thus the induced impact stress is lesser than the Material Strength, and so the Structure does not fail. This fact gets verified.

So, overall the model developed by the team, is safe from Impact as per the FEM Analysis and so it will be used for fabrication.