

Design and Analysis of MAV (Manned Aerial Vehicle)

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Abstract - When considering the MAV, it grabs the thought of air of airplanes. Even there are many low-cost airplanes, where there must be licensed pilot under certified agency. The maintenance cost for those small airplanes is always high and on a major point airplane requires airstrip high and on a major point airplane require airstrip or particular area for take-off and landing. It is not an easy task for maneuvering an aircraft for required turn and hover. On top of these problems the helicopter, which can have easy turn and hover capabilities but always required a safety diameter of space concerning its blades. Our project is based on the flying machine which uses vertical motion for the lift and capable of allowing a pilot to fly and hover with a simple design structure. This vehicle is powered by two electric motors with twin ducted propellers intended to provide lift and thrust. The model created in this project will be able to prove the electric motor can produce the required lift and thrust. The model created in this project will be able to prove the electric motor can produce the required lift and thrust, which is very safer and easier for the air travel, this model can give an instant start and applicable in any emergency situation.

Key Words: Manned Aerial Vehicle (MAV), Electric Jetpack, Structural Analysis.

1. INTRODUCTION

This MAV (Manned Aerial Vehicle), the concept of man flying is always is a fiction. Electric jetpack is a simple vehicle where it can be easily rechargeable and is better version of a convection jetpack which uses gasoline as its fuel. A pilot flying a machine is an adventures and enthusiastic mode of people activity. The term aeronautical in engineering field teaches us how flying machine works at all atmospheric conditions with having concern of its weight to lift ratio. The concept of MAV has been in our history and heard in many epics. On making it realistic, there are many requirements and applications of flying machine, where a pilot can fit in and make desire flying activity. We take this opportunity for applying all our structural designing knowledge on this project to make it lift worthy. This vehicle uses vertical take-off and landing for its motion and allows the pilot to fly and hover. In these vehicles electric motors are used for its propulsion. The ducted propeller is used to decide its lift as

well as thrust. There is various types old propeller used in different aircraft, here in the MAV we are considering fixed pitch propeller.

1.1 Manned Aerial Vehicle

When considering the MAV, it grabs the thought of airplanes. Even there are many low-cost airplanes, where there must be licensed pilot under certified agency. The maintenance cost for the small airplane requires airstrip or particular area for take-off and landing. It is not an easy task for maneuvering an aircraft for required turn and hover.

The model created in this project will be able to prove the electric motor can produce the required lift and thrust, which is very safe and easier for the air travel, this model can give an instant start and applicable in any emergency situation. A pilot flying a machine is an adventure and enthusiastic activity. The term aeronautical in engineering field teaches us how flying machine works at all atmospheric conditions with having the concern of its weight to lift ratio.

1.2 Advantages and Disadvantages

The various advantages of MAV are described below: To reach some areas inaccessible to road vehicles and helicopters. The jetpack has the ability can hover. The fuel consumption is less compared to the other aircrafts. It improves the way of transport. It is can be used for reconnaissance purpose. The MAV in our project will work on electric power rather than aviation fuel. It can land on any terrain without the need of an airstrip or a helipad. The design is compact in nature. It can be used in disaster management crisis, search and rescue operation.

The disadvantages of the MAV are the following. Only 1 person can at a time. No crew members and passengers are allowed. Flying time is limited. Cannot fly on high altitude. Cannot withstand turbulence and rough weather. Not convenient for long distant travel.

1.2. OBEJCTIVES AND PROBLEM STATEMENT

OBEJCTIVES

To design and fabricate the MAV (Manned Aerial Vehicle) with the combination of electric motors and batteries.

To ensure flying capabilities through simple design.

Ensuring proper torque delivery from the motor to the propellers, using belt drive with differential ratios of pulley diameter.

Powering two motors from a single battery using appropriate motor controller.

PROBLEM STATEMENT

When considering the MAV, it grabs the thought of an aircraft, even there are many low-cost aircrafts but there is must for all pilot should be trained under certified agency. The maintenance for the small aircraft is also a huge in amount. It always required an airstrip or particular area to land and takeoff. It is not an easy task in maneuverability an aircraft for required turn and hover, by this consideration the helicopter which can have easy turn and hover capability but always required a safety diameter on concern to its blade the efforts of human activity on desirable altitude but these is always a deny. Because of cost for maintenance for these air vehicles.

1.3 METHODOLOGY

Design: The Concept of making simple design using CATIA

V5.

Spinal cord: It is the main structural support, here we design and analyses the basic structure, and find the suitable material to withstand the estimated loads.

Hub: The hub is made hexagonal so that it holds the spinal and also holds the center of gravity of the entire structure.

Landing section: It is one of the main structures where it helps in landing activity, and resting on ground.

Transmission Mechanism: It helps in the movement of the duct; the movement of the ducts mostly used the maneuvering.

Propeller section: It consists of duct housing the propellers. The propeller rods will be attached by pulleys for the belt drive.

Linkages: This is drawn from the pilot's actuator to the motor bay, the motion of the actuator produce the motion for the duct.

2. DESIGN

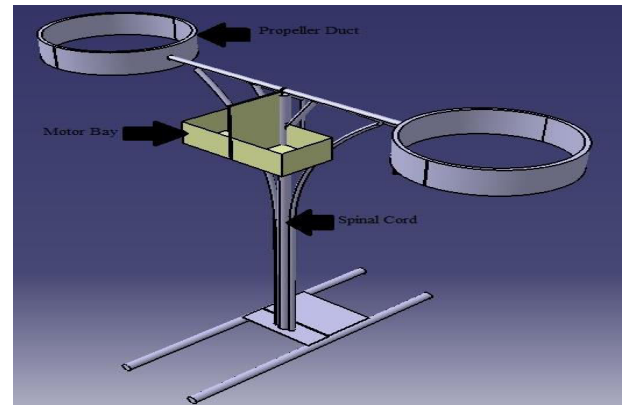


Fig 1: Design of the MAV

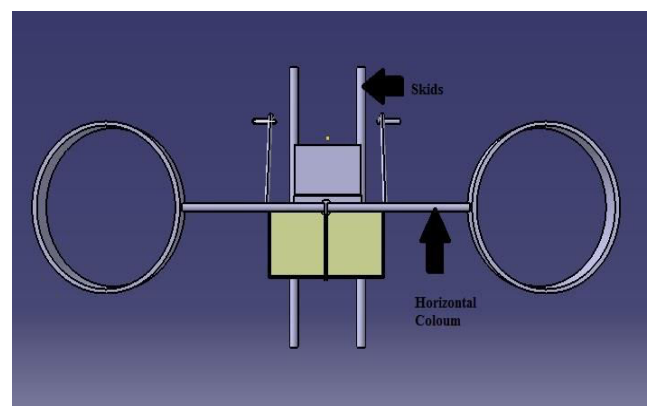


Fig 2: Design of the MAV (Top View)

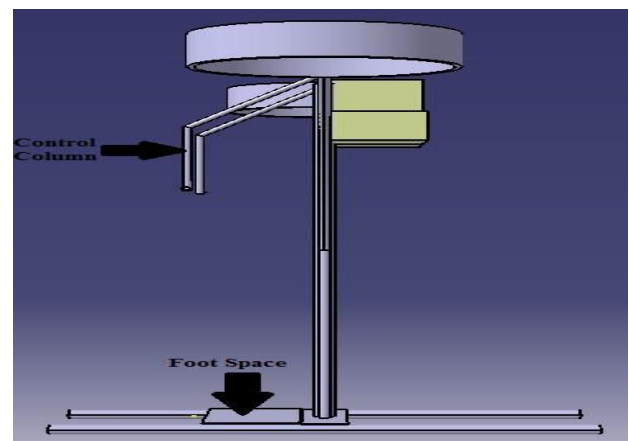


Fig 3: Design of the MAV (Side View)

The design of the MAV is designed in CATIA V5. The MAV is sub divide into the following parts

- 1) Spinal cord which is the part which is responsible for giving support and strength to the MAV.
- 2) Propeller duct: The region where the propellers will be assembled.
- 3) Motor bay: The place where the motor will be placed.
- 4) Foot Support: The part of the MAV where the person will stand.

- 5) Control Column: It is the control to operate the MAV.
- 6) Horizontal Column: It is connected with the propeller duct and the motors.

During designing we need to decide the type of the material which will be acquired by the model. The material used in the model is an alloy of Aluminum i.e. Aluminum 6061, this alloy was selected by comparing various other material which was convenient for the project. The model is joined together by using a welding process known as Tig Welding.

3 ANALYSIS

3.1 ANALYSIS FOR THE COMPARISON BETWEEN STEEL AND ALUMINIUM

The explicit dynamic analysis is done by using the software ANSYS R18.1 by using Ansys workbench design modeler. The explicit dynamic analysis of the entire model is done by giving suitable boundary conditions and the results are obtained for the tests.

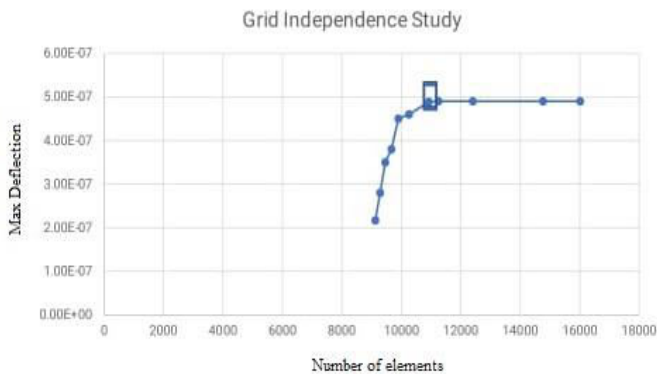


Fig.3.1: Grid Independence Study

<input type="checkbox"/> Nodes	6818
<input type="checkbox"/> Elements	10924

Fig.3.2: Values for nodes and elements

A structured mesh of the entire design of the MAV is developed by using triangular meshes. The mesh size was set by defining the number of divisions.

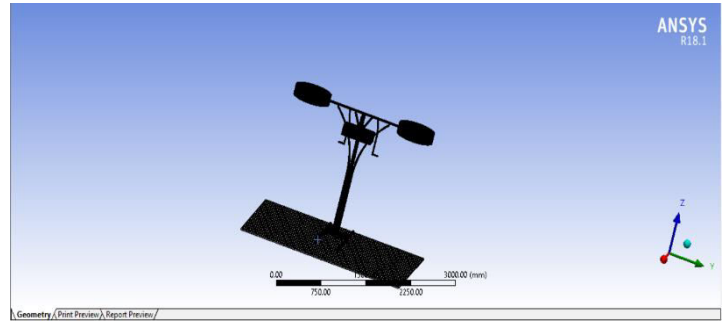


Fig.3.3: Mesh Model of the MAV

Model (E4) > Mesh > Mesh Controls

Object Name	Body Sizing 2
State	Fully Defined
Scope	
Scoping Method	Geometry Selection
Geometry	4 Bodies
Definition	
Suppressed	No
Type	Element Size
Element Size	Default (60.949 mm)
Advanced	
Deeature Size	Default
Behavior	Soft

Fig.3.4: Mesh details.

The mesh details of the MAV provide the information about the various parameters as described in the fig: 5.4

Model (F4) > Explicit Dynamics (F5) > Loads

Object Name	Fixed Support	Force
State	Fully Defined	
Scope		
Scoping Method	Geometry Selection	
Geometry	1 Face	88 Faces
Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By	Components	
Coordinate System	Global Coordinate System	
X Component	0. N (step applied)	
Y Component	0. N (step applied)	
Z Component	-60. N (step applied)	

Fig 3.5: Boundary conditions used for the analysis for total deformation.

The boundary conditions used for the analysis are vertically downwards.

3.1.1 ANALYSIS OF THE MAV (STEEL VS ALUMINIUM)

To select a material for the fabrication we understand by the literature review that aluminum and steel are can be used for fabrication but aluminum offers a better property compared to steel with respect to the fabrication of the MAV.

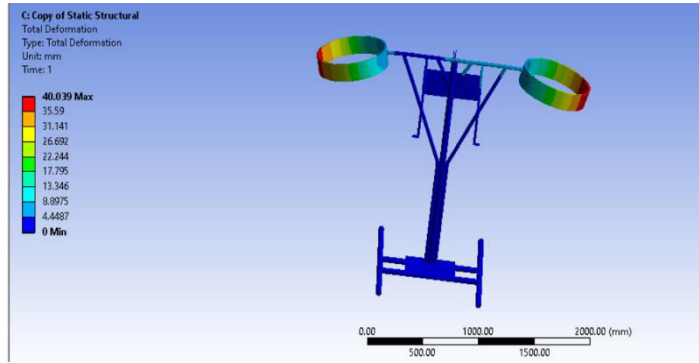


Fig.3.6: Total deformation of the MAV (Steel)

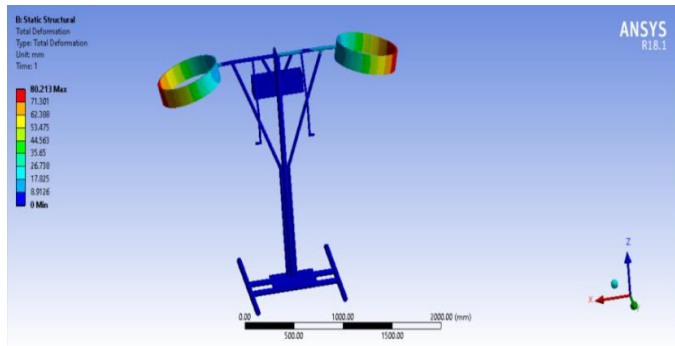


Fig.3.7 Total deformation of the MAV (Aluminum)

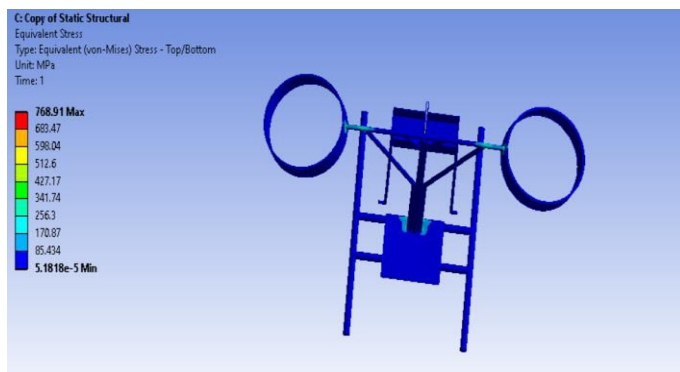


Fig.3.8 Total deformation of the MAV (Steel)

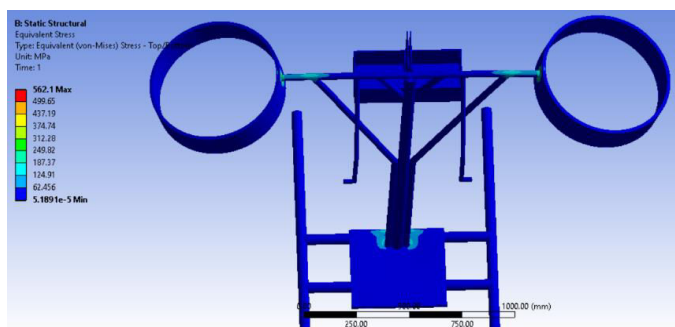


Fig.3.9: Total deformation of the MAV (Aluminum)

	Total deformation (mm)	Equivalent stress (MPa)	Magnitude (N)
Min	0.00000	5.1818×10^{-5}	1962
Max	40.039	768.91	

Fig.3.10: Results for total deformation and equivalent stress (Aluminum)

	Total Deformation (mm)	Equivalent stress (MPa)	Magnitude (N)
Min	0.00000	5.1891×10^{-5}	1570
Max	80.213	562.1	

Fig.3.11: Results for total deformation and equivalent stress (Steel)

The load applied on the MAV having aluminum and steel as the material has different magnitude applied due to the variation of properties between aluminum and steel. As steels weight to density ratio is 2.5 times to that of aluminum.

3.1.2 CONCLUSION FROM THE ANALYSIS FOR METALS

By observing the results from the analysis, we concluded that Aluminum is the best suitable metal due to the fact that it acquires various properties, availability and economically feasible for the project. We observed that aluminum has a high strength to weight ratio compared to steel. Aluminum weighs less than steel, making it a more convenient material for aircrafts. Aluminum is approximately one-third the weight of steel. For aerospace manufacturing companies, the lightweight properties of aluminum allow for the construction of lighter, more efficient airplanes. If an aerospace manufacturing company used steel, its airplanes would be heavier and, therefore, require more fuel to stay in the air. We have considered using Aluminum as the metal for the fabrication of the MAV. The material used in the model is an alloy of Aluminum i.e. Aluminum 6061, this alloy was selected by analyzing and comparing various other material

	Total Deformation (mm)	Equivalent stress (MPa)	Magnitude (N)
Min	0	7.7238×10^{-6}	0
Max	23.7	296.91	1962

which was convenient for the project. The model is joined together by using a welding process known as TIG Welding. Since aluminum 6061 offers decent weld ability.

3.2 ANALYSIS OF THE MAV

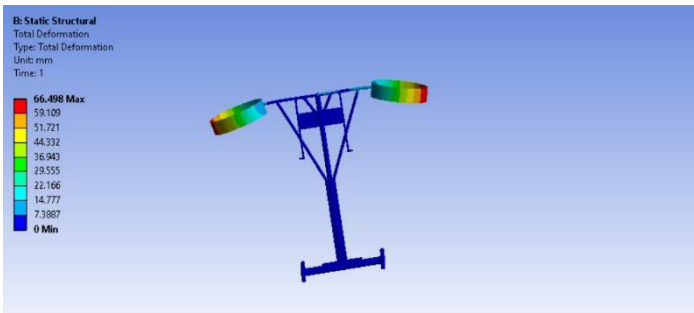


Fig.3.1: Analysis of Total Deformation

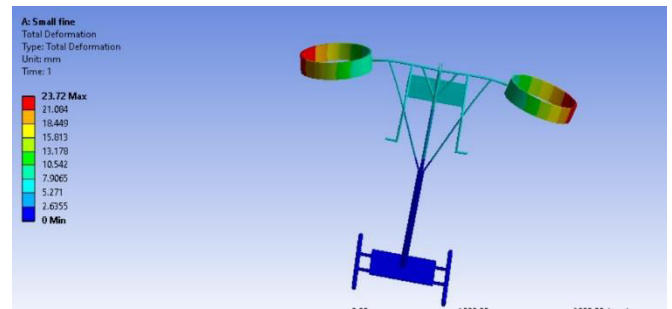


Fig.3.3.1: Results for total deformation

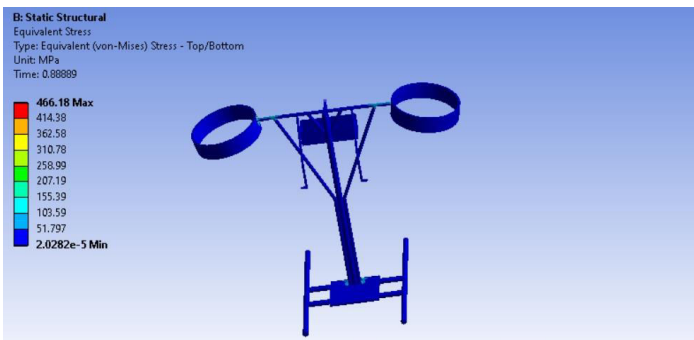


Fig.3.2: Analysis of Equivalent stress

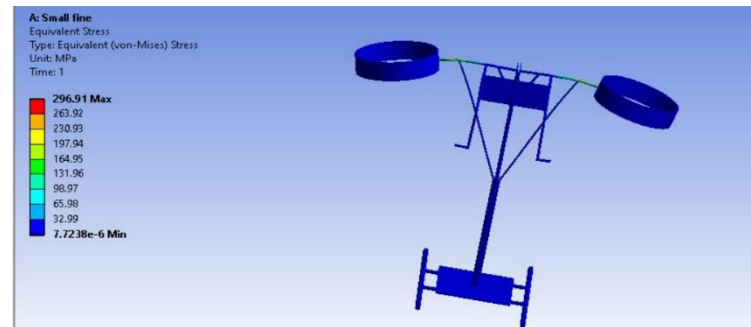


Fig.3.3.2: Results for equivalent stress (Aluminum)

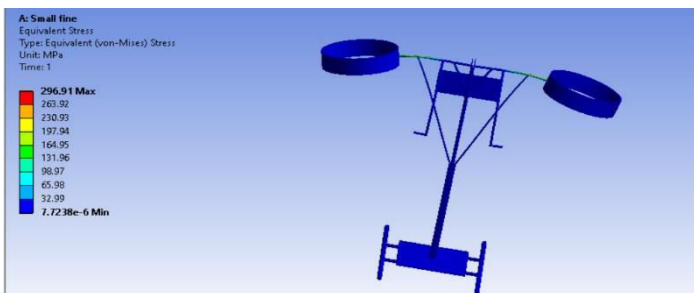


Fig.3.3: Analysis of Safety Factor

3.3.1 ANALYSIS OF THE MAV FOR DOWN SCALED DESIGN

The design which is scaled down from the original model has the following dimension:

- Spinal cord has a diameter of 20 mm.
- Support column of the spinal cord has a diameter of 20 mm.
- The duct has the thickness of 15 mm.
- Horizontal column has the diameter of 15 mm.
- The propeller duct has a diameter of 26 inches which is 660.4 mm.
- The skids have the diameter of 30mm.

Fig.3.2 Results of the analysis

3.3.2 ANALYSIS OF THE MAV FOR THE UP SCALED DESIGN

Dimension of the up-scaled MAV

The design which is scaled up from the original model has the following dimension:

- Spinal cord has a diameter of 60 mm.
- Support column of the spinal cord has a diameter of 40 mm.
- The duct has the thickness of 15 mm.
- Horizontal column has the diameter of 35 mm.
- The propeller duct has a diameter of 26 inches which is 660.4 mm.
- The skids have the diameter of 60mm.

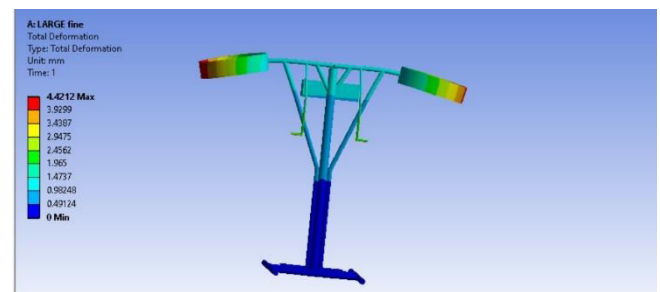


Fig.3.3.21 Analysis of total deformation

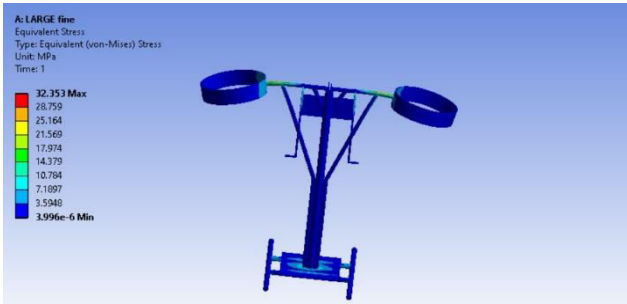


Fig.3.3.22 Analysis of Equivalent Stress

	Total Deformation (mm)	Equivalent stress (MPa)	Magnitude (N)
Min	0	3.996e-6	0
Max	4.4212	32.353	1962

Fabricated model of the spinal cord is showed in the fig 12. The model is fabricated and welded together with Tig welding process. The spinal cord provides the strength, and will be the backbone to the MAV. The propeller duct will be placed on the far end of the spinal cord. The motors and batteries will be placed on the spinal cord as showed in the design.



Fig 4.2: Fabricated model of the propeller duct

Fig.3.3.23 Result of Total deformation and Equivalent stress

3.3.3 CONCLUSION: The analysis was done for scaled down and up scaled model of the original design of the MAV. We obtained various results for total deformation and equivalent stress for both the designs. The up scaled model had less deflection when compared to the small scaled model. The Total deformation for the small scaled model is more 5.36 times greater than of the up scaled model. The equivalent stress for up scaled model is 9.17 times less than the compared with the small scaled model.

4. FABRICATION

The MAV has various major part, Spinal cord, propeller duct, motor bay, foot support, control column and horizontal column. The metal alloy is welded together with the TIG welding progress.



Fig 4.1: Fabricated model of the spinal cord



Fig 4.3: Fabricated model of the MAV

5. CONCLUSIONS

This project aims to construct a manned air vehicle with less weight and low cost, which helps a trained person to fly the machine. It doesn't need an airstrip or a runway to takeoff. The electric motors and batteries are used to generate the thrust. This can be used for the reconnaissance purpose and for any other low altitude solo flight expedition purpose.

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