



e-ISSN: 2319-8753 | p-ISSN: 2320-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**

# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 10, Issue 4, April 2021

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

**Impact Factor: 7.512**

9940 572 462

6381 907 438

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# Design & Analysis of an Electric Motor Glider

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**ABSTRACT:** There are many electric powered aircrafts (motor glider) and airborne objects using electricity to propel them. Several methods are using batteries, solar cells, ultracapacitors, fuel cells and power beaming. We are going to design a motor glider powered by electricity specifically using batteries. The main advantage of this glider is preventing out-landing and taking-off without external power (winch and tow plane). Recently, electric engines are used instead of internal combustion engines in these gliders. In this work, the history of motor glider, differences between engine options and advantages of the electric engines are evaluated for gliding sport. As a result, most of the glider manufacturers have headed to electric motors.

**KEYWORDS:** Motor glider, airborne, wingspan, aspect ratio

## I. INTRODUCTION

Gliding is extremely popular worldwide. For this reason, there has been a rapid increase in developing of gliders. A motor glider is a fixed wing aircraft that can be flown with or without engine power. It's also a fixed wing aerodyne equipped with means of propulsion, capable of sustained soaring flight without thrust from means of propulsion.

A glider is a fixed-wing aircraft that is supported in flight by the dynamic reaction of the air against its lifting surfaces, and whose free flight does not depend on an engine.[1] Most gliders do not have an engine, although motor-gliders have small engines for extending their flight when necessary by sustaining the altitude (normally a sailplane relies on rising air to maintain altitude) with some being powerful enough to take off self-launch.

There is a wide variety of types differing in the construction of their wings, aerodynamic efficiency, location of the pilot, controls and intended purpose. Most exploit meteorological phenomena to maintain or gain height. Gliders are principally used for the air sports of gliding, hang gliding and paragliding. However some spacecraft have been designed to descend as gliders and in the past military gliders have been used in warfare. Some simple and familiar types of glider are toys such as paper planes and balsa wood gliders.

### 1. Development of flexible-wing hang gliders

Foot-launched aircraft had been flown by Lilienthal and at the meetings at Wasserkuppe in the 1920s. However the innovation that led to modern hang gliders was in 1951 when Francis Rogallo and Gertrude Rogallo applied for a patent for a fully flexible wing with a stiffening structure. The American space agency NASA began testing in various flexible and semi-rigid configurations of this Rogallo wing in 1957 in order to use it as a recovery system for the Gemini space capsules. Charles Richards and Paul Bickle developed the concept producing a wing that was simple to build which was capable of slow flight and as gentle landing. Between 1960 and 1962 Barry Hill Palmer used this concept to make foot-launched hang gliders, followed in 1963 by Mike Burns who built a kite-hang glider called Skiplane. In 1963, John W. Dickenson began commercial production.[11]

### 2. Development of paragliders

January 10, 1963 American Domina Jalbert filed a patent US Patent 3131894 on the Parafoil which had sectioned cells in an aerofoil shape; an open leading edge and a closed trailing edge, inflated by passage through the air – the ram-air design.[12] The 'Sail Wing' was developed further for recovery of NASA space capsules by David Barish. Testing was done by using ridge lift.[13] After tests on Hunter Mountain, New York in September 1965, he went on to promote



"slope soaring" as a summer activity for ski resorts (apparently without great success).[14] NASA originated the term "paraglider" in the early 1960s, and 'paragliding' was first used in the early 1970s to describe foot-launching of gliding parachutes. Although their use is mainly recreational, unmanned paragliders have also been built for military applications e.g. Atair Insect.

## II. RELATED WORK

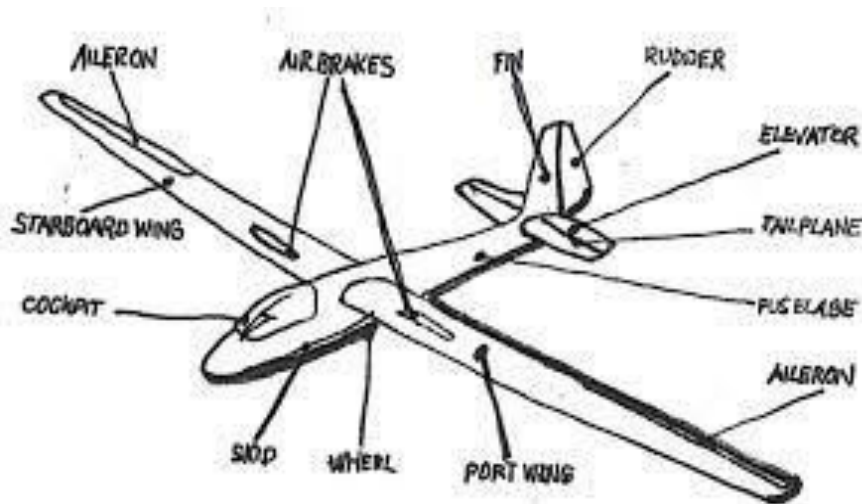


Figure.1: Basic of Glider

In aeronautics, the aspect ratio of a wing is the ratio of its span to its mean chord. It is equal to the square of the wingspan divided by the wing area. Thus, a long, narrow wing has a high aspect ratio, whereas a short, wide wing has a low aspect ratio.[1]

Aspect ratio and other features of the planform are often used to predict the aerodynamic efficiency of a wing because the lift-to-drag ratio increases with aspect ratio, improving the fuel economy in powered airplanes and the gliding angle of sailplanes.

**Structural:** A long wing has higher bending stress for a given load than a short one and therefore requires higher structural-design (architectural and/or material) specifications. Also, longer wings may have some torsion for a given load, and in some applications this torsion is undesirable (e.g. if the warped wing interferes with aileron effect).

**Manoeuvrability:** a low aspect-ratio wing will have a higher roll angular acceleration than one of high aspect ratio, because a high-aspect-ratio wing has a higher moment of inertia to overcome. In a steady roll, the longer wing gives a higher roll moment because of the longer moment arm of the aileron. Low aspect ratio wings are usually used on fighter aircraft, not only for the higher roll rates, but especially for longer chord and thinner airfoils involved in supersonic flight.

**Parasitic drag:** While high aspect wings create less induced drag, they have greater parasitic drag, (drag due to shape, frontal area, and surface friction). This is because, for an equal wing area, the average chord (length in the direction of wind travel over the wing) is smaller. Due to the effects of Reynolds number, the value of the section drag coefficient is an inverse logarithmic function of the characteristic length of the surface, which means that, even if two wings of the same area are flying at equal speeds and equal angles of attack, the section drag coefficient is slightly higher on the wing with the smaller chord. However, this variation is very small when compared to the variation in induced drag with changing wingspan.



III. METHODOLOGY

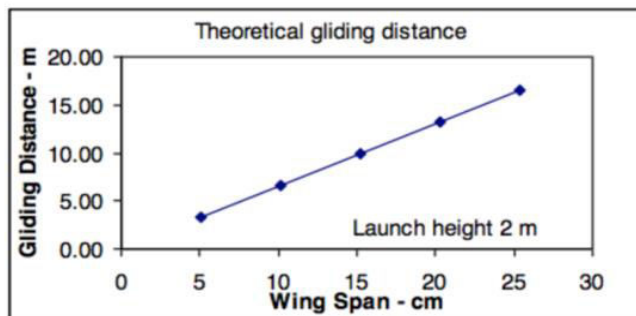
- ▶ The wings on a glider have to produce enough lift to balance the weight of the glider. The faster the glider goes the more lift the wings make. If the glider flies fast enough the wings will produce enough lift to keep it in the air. But, the wings and the body of the glider also produce drag, and they produce more drag the faster the glider flies. Since there's no engine on a glider to produce thrust, the glider has to generate speed in some other way. Angling the glider downward, trading altitude for speed, allows the glider to fly fast enough to generate the lift needed to support its weight.
- ▶ The way you measure the performance of a glider is by its glide ratio. This ratio tells you how much horizontal distance a glider can travel compared to the altitude it has to drop. Modern gliders can have glide ratios better than 60:1. This means they can glide for 60 miles if they start at an altitude of one mile. For comparison, a commercial jetliner might have glide ratios somewhere around 17:1.
- ▶ In order to achieve the objective, this project will work on the following:
  1. How to design a motor glider
  2. How to sample different types of batteries
  3. How to determine the best position for the battery

IV. EXPERIMENTAL RESULTS

Basic aerodynamic theory shows glider will glide farther as the wingspan increases. A basic equation for maximum gliding distance is:  
 $Distance = Height * 0.5 * (\pi * e * b * b / f)^{0.5}$

Distance	Distance glider flies in a steady glide angle (meters)
Height	Height of glider above ground where flight begins (meters)
Pi	Constant equal to 3.14159 (no units)
e	Wing span efficiency, usually close to 0.8 (no units)
b	Wing span (meters)
f	Drag area, for paper airplanes about 0.0006 for a paper airplane where the folds are taped flat, 0.0012 for open folds (meters <sup>2</sup> )

This equation is applied in an accompanying Excel file, and shown below





#### V. CONCLUSION

Finally, our electrical solution meets or exceeds all project requirements 285 mile range at max cruise with 30 minute backup. Aircraft operates within centre of gravity limits. Aircraft operates within airframe weight limits. Batteries are not affected by altitude changes

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**INNO**  **SPACE**  
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**7.512**

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STANDARD  
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