**1. Mission and Design Proposal**

The mission included 3 components. First, the aircraft must take off and maintain a low altitude flight path. Second, the aircraft climbs as high as possible over the course of a 10 second time interval and maintains level flight at the top. Finally, the aircraft must glide without power for as long as possible before reaching its original altitude prior to climb.

The primary design driver is weight and the secondary driver is a high lift to drag ratio (L/D). Reduced weight will help all aspects of the mission. Thus, it was determined to be most important. A high L/D will provide the aircraft with a good glide performance. This is because overall, the glide phase of the mission is to be optimized more than the climb phase.

The proposed design would have an aspect ratio of 5, a main wingspan of 5 feet, and a length of 3 feet. It would use a 1.25 horsepower motor and a 13 inch propellor with 8 degree pitch. It has a high wing for roll stability and a traditional tail for reduced weight.

**2. Figure of Merit Analysis**

The Figure of Merit (FoM) analysis is a tool that is used to address the choosing of components in an efficient and relatively objective manner. The FoM Analysis is not meant to produce aircraft details like wing aspect ratio, but the FoM will produce a numerical comparison between the major component types that are being considered for the aircraft. This is accomplished by choosing Figures of Merit based on our mission profile and primary and secondary design drivers.

**Figure 1. Figure of Merits Table**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Weight** | **High L/D** | **Size** | **Ease of Construction** | **Stability & Control** | **Payload** | **Row Totals** | **Weight** |
| **Weight** | 0.00 | 4.00 | 4.00 | 4.00 | 4.00 | 5.00 | **21.00** | 23.08 |
| **High L/D** | 2.00 | 0.00 | 4.00 | 4.00 | 3.00 | 5.00 | **18.00** | 19.78 |
| **Size** | 2.00 | 2.00 | 0.00 | 2.00 | 2.00 | 2.00 | **10.00** | 10.99 |
| **Ease of Construction** | 2.00 | 2.00 | 4.00 | 0.00 | 1.00 | 3.00 | **12.00** | 13.19 |
| **Stability & Control** | 3.00 | 3.00 | 4.00 | 5.00 | 0.00 | 4.00 | **19.00** | 20.88 |
| **Payload** | 1.00 | 1.00 | 4.00 | 3.00 | 2.00 | 0.00 | **11.00** | 12.09 |
| **Column Total** |  |  |  |  |  |  | **91.00** | 100 |

The figure of merits are then weighted against one another on a scale of 1 to 5 in order of importance to the design drivers. These numbers become the final weights for the component comparison. For each type of component, they are ranked from 1 to 5 in regard to the chosen figure of merits. This requires research on each component along with their advantages and disadvantages when applied to an aircraft. Each of these ranks are then weighted using the weights from the last step. Summing those weighted ranks give numerical justification for which component is most suited to the mission profile of the aircraft. Below is an example matrix of component comparison using this FoM analysis tool.

**Figure 2. Wing Component Comparison Table**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Monoplane** | **Biplane** | **Tandem Wing/Canard** | **Flying Wing/Blended Body** | **Winglets** | **Weight** |
| 4.00 | 3.00 | 3.00 | 5.00 | 5.00 | 0.23 |
| 3.00 | 4.00 | 3.00 | 3.50 | 2.00 | 0.20 |
| 3.00 | 1.00 | 3.00 | 4.00 | 5.00 | 0.11 |
| 5.00 | 2.00 | 2.00 | 1.00 | 5.00 | 0.13 |
| 4.50 | 3.00 | 2.00 | 1.00 | 1.00 | 0.21 |
| 3.00 | 3.00 | 3.00 | 1.50 | 3.00 | 0.12 |
| **3.80765** | **2.8461** | **2.6594** | **2.80785** | **3.33** | 1 |

The FoM analysis yielded some pretty standard results as far as a glider is concerned. The monoplane wing configuration was the highest ranked configuration due to its weight benefits and ease of construction. It also scored an average value in all the rest of the FoM categories. The conventional tail also ranked the highest for the same reasons. Since weight is our primary design driver, these components were valued much more highly over the others.

The tricycle landing gear component is not the lightest component, but it was chosen over lighter landing gear configurations for a few reasons. The most important reason is the ground take-off requirement imposed by the mission. Secondly, the tricycle landing gear is the most stable and provides a likelier chance of a successful take-off and landing. The power plant is a given component, and a tractor configuration is more desirable over a pusher configuration due to it’s static stability advantage.

**3. Component Designs**

Spreadsheets were used to determine numerical values for component sizing.

**4. Predictions**

Our team predicts that this design will be a performer in all aspects of the flight plan. It will have a decent climb rate and a good ability to takeoff. We expect the glide performance on this aircraft to be closer to exceptional than the other performance parameters. It is expected the glide performance will set this design apart from the competition.

Our empty weight is expected to be around 1.5 lbs which makes our estimated takeoff weight around 3.7 lbs. Our wing loading is estimated to be around 1.6 lbs/ft^2 which is on the low end of a glider aircraft. Our preliminary climb rate is estimated to be around 1100 ft/s which is a typical value for an aircraft with similar configuration as reported by previous senior design teams. We predict a glide rate of 2.5 ft/s and since our climb rate is 1100 ft/s, in 10 seconds of climb, we predict that we will glide for approximately 73 seconds. This is the ideal value for descent rate, but the actual performance will most likely be lower at about 60 seconds.

The spreadsheets predict a 272 feet take off distance and a landing distance of 1610 feet. Past experience tells us that these numbers are most likely inaccurate and will be much less than that. The predicted lift-to-drag ratio is approximately 26, which is in the realm of light cruise aircraft. We hope to bring this number up through some brainstorming in drag reduction methods in the future. In terms of stability and control, this aircraft will be utilizing conventional control surfaces, including, a rudder, 2 ailerons, and an elevator. This is sufficient for performing the given flight plan.

**5. Summary**

In conclusion, this aircraft is designed to be an all around performer with an emphasis on maximizing glide performance. This is accomplished by reducing the weight of the aircraft and achieving a high lift-to-drag ratio. This design features a minimalist fuselage due to the light payload requirements and has a circular for the benefits in drag reduction. The wing has an aspect ratio of 7 with a 5.5’ wingspan in order to balance the glide and climb portions of the flight. The FoM analysis pointed us towards a more conventional design for this aircraft. This will make the design easier to build and easier to fly, while still maintaining high performance and specification conformance.

**6. Appendix**

Figure 3. Control Surface Component Matrix

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **2x Ailerons, 2x Elevator, 2x Flaps** | **2x Ailerons, 1x Elevators, 2x Flaps** | **2x Ailerons, 2x Elevators** | **2x Elevons** | **Row Totals** | **Weight** |
| **Weight** | 1.00 | 2.00 | 3.00 | 5.00 | 11.00 | 0.23 |
| **High L/D** | 5.00 | 4.00 | 3.00 | 1.00 | 13.00 | 0.20 |
| **Size** | 1.00 | 2.00 | 3.00 | 5.00 | 11.00 | 0.11 |
| **Ease of Construction** | 1.00 | 1.00 | 3.00 | 5.00 | 10.00 | 0.13 |
| **Stability & Control** | 2.00 | 2.00 | 4.00 | 1.00 | 9.00 | 0.21 |
| **Payload** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 |
| **Column Average** | **1.879** | **2.0219** | **2.846** | **2.7695** | 54.00 | 1 |

Figure 4. Landing Gear Component Matrix

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **None** | **Trike** | **Skids** | **Retractable** | **Tail Dragger** | **Monowheel** | **Weight** |
| **Weight** | 5.00 | 3.00 | 4.00 | 1.00 | 3.50 | 4.00 | 0.23 |
| **High L/D** | 5.00 | 3.00 | 4.00 | 1.00 | 4.00 | 4.00 | 0.20 |
| **Size** | 5.00 | 3.00 | 3.00 | 1.00 | 3.50 | 4.00 | 0.11 |
| **Ease of Construction** | 3.00 | 5.00 | 3.00 | 1.00 | 4.00 | 2.00 | 0.13 |
| **Stability & Control** | 0.00 | 5.00 | 1.00 | 3.00 | 2.00 | 1.00 | 0.21 |
| **Payload** | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.12 |
| **Column Average** | **3.0882** | **3.3185** | **2.6485** | **1.2965** | **2.92865** | **2.6265** | **1.00** |

Figure 5. Tail Configuration Component Matrix

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Conventional** | **V-Tail** | **H-Tail** |  | **Weight** |
| **Weight** | 4.00 | 4.00 | 2.00 |  | 0.23 |
| **High L/D** | 5.00 | 5.00 | 2.00 |  | 0.20 |
| **Size** | 3.00 | 3.00 | 2.00 |  | 0.11 |
| **Ease of Construction** | 5.00 | 2.00 | 5.00 |  | 0.13 |
| **Stability & Control** | 4.00 | 2.00 | 5.00 |  | 0.21 |
| **Payload** | 3.00 | 3.00 | 3.00 |  | 0.12 |
| **Column Average** | **4.0989** | **3.2858** | **3.1427** |  | 1 |

Figure 6. Motor Configuration Component Matrix

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Mono Tractor** | **Mono Pusher** |  | **Weight** |
| **Weight** | 4.00 | 4.00 |  | 0.23 |
| **High L/D** | 4.00 | 2.00 |  | 0.20 |
| **Size** | 3.00 | 3.00 |  | 0.11 |
| **Ease of Construction** | 5.00 | 3.00 |  | 0.13 |
| **Stability & Control** | 4.00 | 2.00 |  | 0.21 |
| **Payload** | 3.00 | 3.00 |  | 0.12 |
| **Column Average** | **3.9011** | **2.8243** |  | 1 |

[spreadsheets]