Design Report 2 - Conceptual Design

Engi 7926 - Mechanical Design Project I

Group M10 - FICE
"*Flying In Control Engineering*"

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Date of Submission:
June 15th, 2018

Abstract

As part of the design process to determine the optimal aircraft design, all viable aircraft configuration design features must be screened against each other and scored to determine an optimal final design which achieves all design objectives. The second design report created by Flying in Control Engineering (FICE) will cover the possible aircraft configuration design alternatives, the concept screening matrix, the concept scoring matrix, and the features chosen for the final design to cover all design objectives for the remote control (RC) airplane project. This report is the second in a series of four reports which will be completed throughout the aircraft design, building and testing process.

Before the final design can be selected, all possible airplane configuration alternatives must be listed and discussed. The first section of this report discusses these configurations including wing layout, wing location, tail design, fuselage, engine location, landing gear, building material and airfoils. With all possible design alternatives listed, they must then be screened against each other in screening and scoring matrices to list the pros and cons of each design under a series of selection criteria. The reason for this is that the group does not have enough information for the perfect design. By selectively comparing the configurations against a series of design objectives, the strengths and weaknesses of each configuration can be easily seen to give an effective idea of the combinations of configuration choices that will result in the most competitive design.

Through ranking each design configuration against each design object, an optimal aircraft configuration design was achieved based on FICE's design objectives. The optimal design will have a combination of a high wing position, swept monoplane wing shape, conventional tail type, jet and box combination fuselage, front located engine, reinforced bottom landing gear, foam material, and the E423 airfoil.

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1. Concept Generation

1.1 Introduction

The Mechanical Engineering Class of 2019 has been challenged to design, build, and test an RC aircraft. Each team will enter their RC aircraft into a competition where the model will be judged based on its ability to carry a payload. The team that achieves the highest payload fraction, while successfully navigating a full loop of the Techniplex, will be deemed the winners.

As mentioned in Report One, the following specifications fit FICE's desired aircraft build:

Table I: Desired Aircraft Specifications

Stall Speed	< 8 ft/s
Cruise Speed	10 - 20 ft/s
Wing Loading	0.3-2.5 lb/ft^2
Power Loading	2 - 18 lb/hp
Payload Percentage	35 - 55%
Wing Semi-Span Length	30 - 36"

This report serves to document the concept generation phase during the design of FICE's RC plane. The detailed design commenced with discussions regarding various aircraft configuration options and then moved into the generation of more detailed concepts, followed by the scoring of the outlined concepts. The team's experience with the trainer model also helped in ensuring key features of the RC aircraft were designed correctly. Following this process, FICE has devised a design that can carry a high payload fraction and stay under budget.

1.2 Selection Process

To profile the various design parameter configurations, both screening and scoring matrices were used. Screening matrices were used when there were many configurations that needed to be reduced to a few viable alternatives. Scoring matrices were used in order to compare viable alternatives and choose a single configuration that would result in the most success.

Using a Screening matrix, each design configuration was ranked against a baseline for a number of design objectives. If any concept was much less effective than its alternatives, it was discarded. By using a screening matrix, the number of alternatives could be reduced, and the remaining concepts could be analyzed in more detail.

Once there was a suitable number of viable alternatives a concept scoring matrix could be used to determine the optimal configuration. Using a concept scoring matrix, each design configuration was given a weight percentage of its relative importance to the overall design. Each concept was then ranked from 1 to 5 for how well it performs under each design objective. Once this was completed, an overall rank for each airplane configuration was determined by multiplying each respective rank by the weight percentage.

1.3 Alternative Configurations

To generate a final design for the Memorial University competition, FICE has investigated eight aircraft parameters that the team believes are the key to an optimal design. The configurations discussed are as follows, the wing layout, wing location, tail design, fuselage, engine location, landing gear, materials, and airfoil.

During the investigation, a list of possible design configurations was created for each parameter. Each of the configurations was then compared using screening and scoring matrices. Based on the results of these matrices, an optimal configuration was chosen for each parameter and a final design choice was made. Each parameter and the concept selection process are detailed in Section 1.4.

1.3.1 Wing Layout

The first feature discussed at FICE was the wing layout. The team came up with four different wing layout configurations to compare: Tapered, Elliptical, Rectangular, and Swept, as shown in **Figure 1**. Each of these configurations were discussed in a scoring matrix as shown in **Table II,** with specific attention to the parameters of drag, lift, manufacturability, stability, and durability.

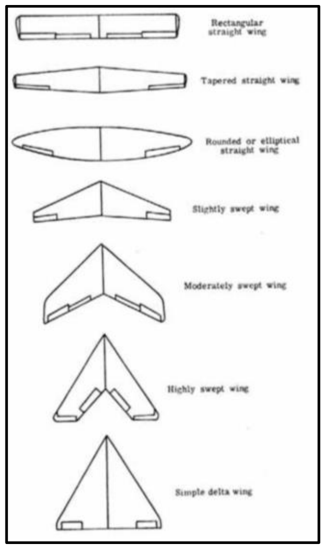

Figure 1: Wing Shape Configurations [2]

Table II: Wing Layout Scoring Matrix

Wing Layout		**Concepts**							
		A Tapered		B Elliptical		C Rectangular		C Swept	
Selection Criteria	**Weight (%)**	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Drag	20	4	0.8	5	1	2	0.4	4	0.8
Lift	20	4	0.8	5	1	2	0.4	4	0.8
Ease of Fabrication	25	3	0.6	1	0.2	5	1	2	0.4
Durability	15	4	0.8	1	0.2	4	0.8	2	0.4
Stability	20	4	0.8	4	0.8	2	0.4	5	1
	Total Score		3.8		3.2		3		3.4
	Continue?		Yes		No		No		No

The tapered wing layout increases the aspect ratio of the wings thus allowing increased lift, as well as reducing the drag because of the smaller wing tips. The tapered layout is easier to manufacture than most wing types, except the rectangular wing. The rectangular wing is the easiest to manufacture but has the worst aerodynamic properties[1]. The elliptical wing configuration benefits in a similar fashion as the tapered wings, but to an even higher degree. However, this also makes the elliptical wings very difficult to manufacture and less durable. The swept wing configuration allows for improved stability with decreased drag but comes at the cost of durability and manufacturability. It was found that the tapered wing layout offered the greatest overall performance and as a result this option will be the wing parameter configuration used in the final design.

1.3.2 Wing Location

There are many different wing locations to consider depending upon the type of plane. For the purpose of this design, FICE will consider the plane to be a monoplane, implying there is only one large wing. For monoplanes, the following main wing locations are used: Low Wing, Mid Wing, and High Wing as can be seen in **Figure 2**. These configurations will be compared in a scoring matrix as shown in **Table III** based upon the stability, manufacturability, ease of control, durability, and repairability.

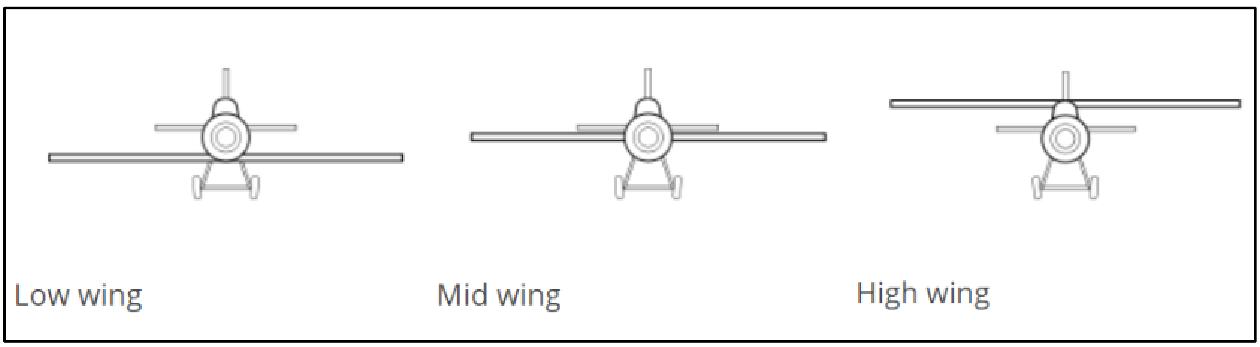

Figure 2: Wing Location Configurations[2]

Table III: Wing Location Scoring Matrix

Wing Location		Concepts					
		A Low Wing		B Mid Wing		C High Wing	
Selection Criteria	**Weight (%)**	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Stability	20	3	0.6	4	0.8	5	1
Manufacturability	15	4	0.8	1	0.2	4	0.8
Ease of Control	20	3	0.6	4	0.8	5	1
Durability	25	1	0.2	3	0.6	5	1
Repairability	20	4	0.8	1	0.2	4	0.8
	Total Score		3		2.6		4.6
	Continue?		No		No		Yes

The low wing configuration generally has poor stability and control due to a low center of lift, but is easy to fabricate and repair since it is simply attached to the bottom of the aircraft. Its durability is also low due to it being located on the bottom of the aircraft, taking most of the blow in the event of a crash. Mid wings are much tougher to manufacture and repair than low and high wings as they do not simply attach to the outside of the fuselage. However, mid wings do have better stability and control since the center of lift is raised in comparison to the low wings. They also suffer less damage during a crash due to their higher location. The high wing configuration has the best stability, control, and durability due to being located high up and having a high center of lift. It is also an easy configuration to manufacture and repair. As a result, the high wing configuration will be used in the final design.

1.3.3 Tail Design

The tail portion of the aircraft contains the elevator and rudders which are responsible for controlling the pitch, yaw, and roll of the aircraft during flight. The location of the elevator and rudders significantly change the aircraft's stability, durability and manufacturability. When researching possible tail configurations, there were many options as seen in **Figure 3** below.

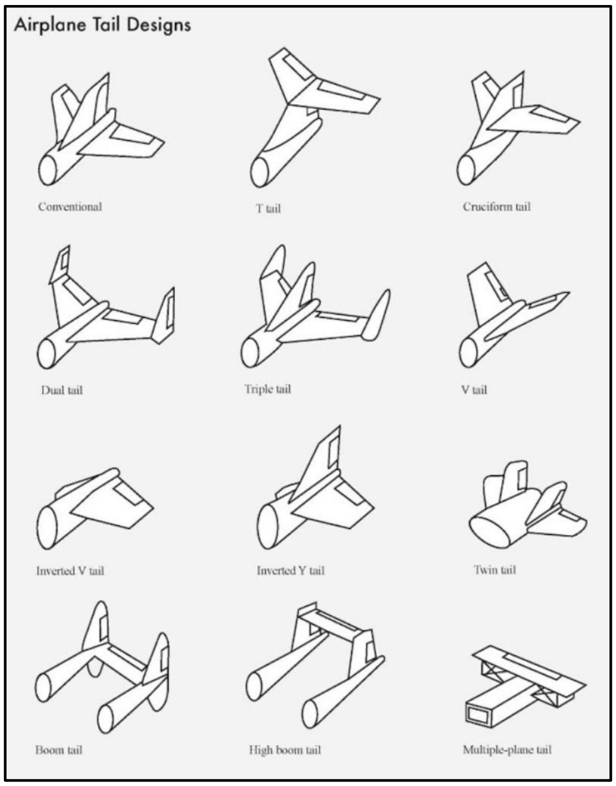

Figure 3: Tail Design Configurations[3]

A screening matrix was created to compare all options and refine the design choice with the limited information available to the group as shown in **Table IV** on the next page.

Table IV: Tail Design Screening Matrix

	Concept Screening - Tail Design						
Selection Criteria	A Conventional	B T Tail	C Dual Tail	D Triple Tail	E V Tail	F Twin Tail	G Boom
Manufacturing Cost	+	0	0	0	+	0	-
Manufacturing Time	+	0	-	0	0	0	--
Weight	++	0	+	0	++	0	-
Stability	+	+	+	+	+	+	+
Aerodynamic Performance	+	++	+	+	-	+	0
Durability	+	0	-	0	+	0	-
Low Speed Control	+	-	++	0	-	0	+
Sum '+'s"	8	3	5	2	5	2	2
Sum '0's"	0	4	1	5	1	5	1
Sum '-'s"	0	1	2	0	2	0	5
Net Score	++++++++	+++	+++	++	+++	++	---
Continue?	Yes	Yes	Yes	Yes	No	No	No

The most suitable configurations for aircraft tails were narrowed down to the Conventional Tail, T-Tail, Dual Tail, and the Triple Tail. From research, it was found that each of these configurations had very similar stability properties when observed over the course of the entire flight path. Some predominant factors for deciding to further pursue the option listed above include, ease of fabrication, weight, control and stability**[3]**. A scoring matrix was used to determine the optimal tail design as shown in **Table V**.

Table V: Tail Design Scoring Matrix

Tail Design		Concepts							
		A Conventional Tail		B T-Tail		C Dual Tail		D Triple Tail	
Selection Criteria	**Weight (%)**	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Ease of Manufacturing	10	5	0.5	3	0.3	2	0.2	2	0.2
Weight	10	5	0.5	4	0.4	4	0.4	3	0.3
Stability	25	4	1	4	1	4	1	4	1
Aerodynamic Performance	15	4	0.6	5	0.75	4	0.6	4	0.6
Durability	20	4	0.8	3	0.6	3	0.6	3	0.6
Low Speed Control	15	4	0.6	2	0.3	5	0.75	3	0.45
	Total Score		4		3.35		3.55		3.15
	Continue?		Yes		No		No		No

The conventional tail configuration is much easier to manufacture and is also more durable due to it having less complex geometry. Along with the durability and ease of manufacturing, the conventional design provides adequate stability and control with the lowest structural weight[3]. As a result, the conventional tail configuration was chosen for the final design.

1.3.4 Fuselage

The fuselage is the main body section of an aircraft which typically contains all the passengers, crew and cargo. The components of the aircraft are mounted to the fuselage including the wings, tail, landing gear and in the case of this design scenario, a payload bay to add weight for testing. A balance in the fuselage between weight and rigidity must be achieved for the optimal design. The fuselage is generally long and hollow to reduce the aircraft's weight, but maintaining sufficient rigidity in the aircraft is essential when determining the design. The aircraft's center of gravity is usually located inside the fuselage and during flight the aircraft rotates about its center of gravity creating large torques which the fuselage must be able to withstand, which emphasizes the importance of strength in its design[4].

After completing research of suitable fuselage designs, four possible options were selected for investigation including; streamlined taper, long cylindrical, jet style, box style and long cylindrical with a tricycle undercarriage[5]. All five concepts will be evaluated in the screening matrix in **Table VI** below, followed by a scoring matrix in **Table VII** for the three best options in the screening matrix. For both the screening and scoring process a variety of selection criteria has been selected to determine an optimal design; including manufacturing cost and time, weight, durability, aerodynamic performance and payload space.

Table VI: Fuselage Design Screening Matrix

Concept Screening - Fuselage					
Selection Criteria	A Streamlined Taper	B Long Cylindrical	C Jet Style - Round Nose, Tapered Tail	D Long Cylindrical - Tricycle Undercarriage	E Box
Manufacturing Cost	0	0	0	0	+
Manufacturing Time	-	+	0	+	+
Weight	+	-	+	0	-
Durability	0	0	+	0	-
Aerodynamic Performance	+	-	+	0	-
Payload Space	0	+	-	+	+
Sum '+'s"	2	2	3	2	3
Sum '0's"	3	2	2	4	0
Sum '-'s"	1	2	1	0	3
Net Score	+	0	++	++	0
Continue?	Yes	No	Yes	Yes	Combine with C

After completion of the screening matrix, it was determined that the three fuselage design concepts that would be selected for further evaluation include; streamlined taper, jet style combined with box, and long cylindrical with tricycle undercarriage. Although the jet style recorded the best results it presented some difficulties for manufacturing with the materials being provided. It was determined that for the scoring matrix the fundamentals of the jet style design including a rounding nose and tapered tail would be incorporated with a box style fuselage.

Table VII: Fuselage Design Scoring Matrix

Fuselage		**Concepts**					
		A Streamlined Taper		B Combination of Jet Style and Box		C Long Cylindrical - Tricycle Undercarriage	
Selection Criteria	**Weight (%)**	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Manufacturing Cost	10	3	0.3	4	0.4	3	0.3
Manufacturing Time	15	2	0.3	5	0.75	4	0.6
Weight	20	4	0.8	4	0.8	3	0.6
Durability	20	3	0.6	4	0.8	4	0.8
Aerodynamic Performance	20	4	0.8	4	0.8	3	0.6
Payload Space	15	3	0.45	4	0.6	4	0.6
	Total Score		3.25		4.15		3.5
	Continue?	No		Yes		No	

Once the scoring matrix was completed the results determined that the optimal fuselage is option B, a combination of the box and jet style design. Overall, the aerodynamics of the jet style paired with the ease of manufacturing and payload space offered by the box style combined to make the optimal design for this project.

1.3.5 Engine Location

The engine of an aircraft is generally either located in the front of the aircraft or the back. To determine which is the optimal location, a screening matrix was created as shown in **Table VIII** to compare the design objectives which are the most relevant to this parameter.

Table VIII: Engine Location Screening Matrix

Concept Screening - Engine Location		
Selection Criteria	A Front of Aircraft	B Back of Aircraft
Manufacturing	0	0
Weight	0	0
Size	0	0
Stability	++	-
Aerodynamic Performance	+	-
Reliability	+	-
Sum '+'s"	4	0
Sum '0's"	3	3
Sum '-'s"	0	3
Net Score	++++	---
Continue?	Yes	No

From research it was found that locating the engine in the front of the aircraft allows for the propellers to pull the aircraft behind it. This causes the aircraft to have increased stabilization since the point of thrust generation is in front of the aerodynamic center of pressure. A propeller at the front of the aircraft also encounters air that is relatively undisturbed, increasing the thrust output. Locating the engine at the back of the plane causes the propeller to have to push instead of pull, resulting in a less stable aircraft. A propeller located at the back of an aircraft also encounters highly disturbed air since the fuselage would have just passed through the same space. A back located propeller can also run into issues on takeoff due to the front of the aircraft angling upwards, the ends of a propeller could hit the ground beneath the plane. It was determined that locating the engine at the front of the aircraft is the optimal design choice under all relevant criteria and, therefore, this will be the engine configuration going forward.

1.3.6 Landing Gear

Usually when designing an aircraft landing gear, wheels are the first choice since they allow the aircraft to gain speed easily for takeoff situations. However, in the Memorial University competition, the landing gear will only be used for landing purposes because a team member will assist the aircraft during takeoff. This allowed FICE to brainstorm and come up with three different landing gear configurations, the wheel landing gear, the ski landing gear, and simply a reinforced bottom. To determine which is the optimal configuration, a scoring matrix was created as shown in **Table IX**.

Table IX: Landing Gear Scoring Matrix

Landing Gear		**Concepts**					
		A Wheeled Bottom		B Ski Bottom		C Reinforced Bottom	
Selection Criteria	**Weight (%)**	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Durability	25	2	0.4	3	0.6	5	1
Manufacturability	30	2	0.4	4	0.8	4	0.8
Weight	20	3	0.6	3	0.6	3	0.6
Ease of Landing	25	2	0.4	4	0.8	4	0.8
	Total Score Rank		1.8		2.8		3.2
	Continue?		No		No		Yes

The wheel landing gear is highly efficient on flat, hard surfaces, but can cause the aircraft to experience a rough landing when attempting to land on a surface such as the grass at the Techniplex. The wheels are also the least durable in the event of a crash due to having a long lever arm with a small diameter. While the wheels are not nearly as difficult to manufacture as the wing, when compared with the other options for landing gears, they are the toughest to manufacture. The ski landing gear is more effective at landing on rough, soft surfaces and should provide a smooth landing. This landing gear is slightly more durable than the wheeled configuration but can still easily be broken off the aircraft in the event of a crash. The reinforced bottom acts similarly to the ski landing gear when landing on a rough, soft surface, but it avoids the risk of any piece breaking off in the event of a crash. The reinforced bottom is also very easy to manufacture as it simply requires using a tougher material or multiple layers on the bottom of the fuselage. As a result, the reinforced bottom configuration will be used in the final design.

1.3.7 Build Materials

When designing a RC aircraft, dozens of materials can be used to achieve an effective result. For the purpose of this section, FICE will continue to use the materials researched in Report One and will assess these based upon which should be used for the majority of the aircraft. These materials include foam, corrugated plastic sheets, carbon fibre, ABS polymer, and balsa wood. To determine the optimal material, a scoring matrix was created as shown in **Table X**.

The foam, and balsa wood materials each have extremely low weight and cost but their durability is not optimal. Corrugated sheets and ABS polymer materials increase the durability, cost and weight, but the added durability may be necessary such that the aircraft does not break on impact. Carbon fibre is by far the most durable option, but its added weight and cost would give the aircraft a disadvantage[6].

Table X: Materials Scoring Matrix

Materials		**Concepts**									
		A Foam		B Balsa Wood		C Corrugated Sheets		D Carbon Fibre		E ABS Polymer	
Selection Criteria	**Weight (%)**	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Weight	25	5	1.25	4	1	4	1	2	0.5	2	0.5
Durability	20	4	0.8	3	0.6	4	0.8	5	1	4	0.8
Cost	10	4	0.4	3	0.3	4	0.4	2	0.2	3	0.3
Ease of Fabrication	25	4	1	3	0.75	4	1	2	0.5	3	0.5
Repairability	20	4	0.8	3	0.6	3	0.6	1	0.2	2	0.4
	Total Score		4.25		3.25		3.8		2.4		2.5
	Continue?		Yes		No		With Foam		No		No

From the matrix, the foam material was selected to build the majority of the aircraft in addition to corrugated sheets where durability is more essential. The foam and corrugated sheets can be fabricated and sized using a laser beam cutter and the materials are readily available, all leading to their selection. While these options were chosen to be used as the main material, FICE recognized that the durability of carbon fibre could be very useful to reinforce delicate areas of the aircraft.

1.3.8 Airfoils

Airfoil geometry is very important to consider when designing an aircraft as this will determine the amount of lift the aircraft can generate and also has a big impact on the drag experienced. Similar to the materials section, the airfoils discussed by FICE in Report One will be used in this section for comparison and selection purposes. The airfoils discussed in Report One were the S1223, E423, Clark Y, E197, and the NACA 2412. To determine the optimal airfoil, a scoring matrix was used as shown in **Table XI**.

Table XI: Airfoil Concept Selection Matrix

Airfoils		**Concepts**									
		A S1223		B E423		C Clark Y		D E197		E NACA 2412	
Selection Criteria	**Weight (%)**	Rating	Score	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Lift	20	5	1	4	0.8	3	0.6	3	0.6	3	0.6
Drag	20	5	1	4	0.8	3	0.6	3	0.6	3	0.6
Durability	20	1	0.2	4	0.8	3	0.6	5	1	5	1
Ease of Fabrication	20	1	0.2	4	0.8	3	0.6	4	0.8	4	0.8
Repairability	20	3	0.6	3	0.6	3	0.6	3	0.6	3	0.6
	Total Score Rank		3		3.8		3		3.6		3.6
	Continue?		No		Yes		No		No		No

As discussed in the previous report, the S1223 had the best aerodynamic values but when actually considered for the design, the durability of the airfoil is the lowest due to its thin trailing edge. Thus, it would have to be reinforced if it was considered for the design. The E423 had the next best aerodynamic values with a stronger trailing edge, meaning reinforcement is not required. The Clark Y, E197, and the NACA 2412 each have lower aerodynamic values but they also have a far stronger trailing edge which poses no risk of breaking on impact[7][8].

2. Concept Selection

2.1 Design Methodology

The concept screening and scoring process has been completed and configurations have been chosen, thus, allowing FICE to move forward in the design process. The next step is to complete the detailed sizing information for the aircraft design. FICE plans to complete this by using important parameters to optimize the geometry for each component.

When considering the airfoil and the wing geometry, FICE plans to optimize these based on the lift and drag experienced. These should be sized such that the lift is high enough to overcome the weight of the aircraft. Ideally, FICE would like to maximize the lift such that a high payload fraction can be achieved. The aircraft will be traveling at low speeds and is required to make fairly tight turns, thus, the wing geometry and airfoil must be sized such that the lift is optimized for the cruise speed and the aircraft is capable of being controlled through tight turns, while remaining stable. The propeller used in the design must be sized such that it is able to produce enough thrust to overcome the drag and achieve the desired cruise speed.

2.2 Testing

With the final design criteria selected, testing can commence on FICE's planned design. Various tests will be conducted to determine areas of weakness in the current design such that these areas can be modified in advance to the competition.

2.2.1 Thrust Test

Thrust is an important factor relating to the aircraft FICE is building. The amount of thrust produced at the propeller directly correlates to the cruise speed. This must be higher than the stall speed such that crashing is avoided.

To conduct the thrust test, place the propeller-motor-battery assembly on a scale while the propeller is off and zero the measurement. Then turn on the propeller, the absolute value of the measurement is the thrust produced by the propeller.

2.2.2 Flight Test

This test will consist of the team performing multiple practice runs such that the team member who is throwing the aircraft at takeoff has a consistent method. These practice runs will also serve to allow the team to gauge the performance of the aircraft during flight and make changes where necessary. The team will perform a couple of rough landings to ensure the structural integrity of the aircraft will not be compromised during a competition landing. This test will ultimately help the team avoid possible errors on the competition date.

2.2.3 Wing Loading Analysis

The wing loading of an aircraft defines the lift created per unit area of the wing. Faster moving aircrafts generated more lift per unit area, thus, allowing them to have smaller wings. Since FICE is interested in creating an aircraft with higher maneuverability instead of high speed, a lower wing loading would be performed optimally. Generally, RC aircrafts used in similar competitions have a wing loading ranging from 6-120 lb/ft^2. With a design in mind and the materials known, FICE can use the following equation to assess the design's wing loading:

$$Wing\ Loading\ = \frac{Total\ Weight}{Planform\ Area\ of\ the\ Wing}$$

2.2.4 Power Loading Analysis

The power loading of an aircraft defines how much reserve power is available for maneuvering as the power loading value is the inverse of the power to weight ratio. This means, the lower the value of power loading, the easier it is to maneuver. High maneuverability is desired by FICE, thus meaning FICE will aim for a low power loading value. In competitions similar to Memorial's, the power loading typically ranges from 2-18 lb/hp. Again, using the current design plan and materials, FICE will use the power loading equation shown below to optimize the aircraft prototype.

$$Power\ Loading\ = \frac{Total\ Weight}{Maximum\ Power\ Available}$$

2.3 Models to Test, Fabrication, Procurement Plan

Throughout testing FICE plans to use one main model with modular components such that broken components can be easily replaced. This will allow FICE to test the design at a rapid pace, thus, ensuring issues will be resolved quickly.

The following fabrication and procurement plan will be followed by FICE:

Table XII: Fabrication and Procurement Plan

BUILD	ITEM	DESCRIPTION	SOURCE	AQUIREMENT DATE	FABRICATION	PERSON RESPONSIBLE
Trainer	Trainer Kit	Trainer Build	Memorial University	Week 2	N/A	Alex Keating
	Logbook	Keep Track of Progress	Staples	Week 2	N/A	Alex Keating
	Utility Knife	Trainer Build	Walmart	Week 2	N/A	Alex Keating
	Skewers	Trainer Build	Walmart	Week 2	N/A	Alex Keating
	Packaging Tape	Trainer Build	Walmart	Week 2	N/A	Alex Keating
	Hot Glue Gun w/sticks	Trainer Build	Walmart	Week 2	N/A	Alex Keating
	Cardboard Glue	Trainer Build	Walmart	Week 2	N/A	Alex Keating
Competition	Foam	Main Fuselage Material	TBD	Week 8-10	Hot Wire CNC	Matthew Butt
	Support Rods	Added Structural Strength	Kent	Week 8-10	N/A	Matthew Butt
	Glue/Tape	Used to Secure Parts	Walmart	Week 2	N/A	Alex Keating
	Other Materials	Used to Optimize Aircraft	Various	Week 8-10	N/A	Matthew Butt

3. Conclusion

This report discusses the concept selection process which FICE used in order to choose design configurations based off important parameters that affect the overall design. This process involved the use of concept screening and scoring matrices, which allowed the team to choose configurations without bias. Through this process, FICE has obtained a highly efficient overall design plan. In the weeks to come, FICE will carry out detailed design analysis such that building can commence as soon as possible, as well as creating CAD models for each aircraft component.

4. References

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Appendix B

The FT Explorer Trainer Aircraft was analysed using XFLR5 by FICE. To perform this analysis the dimensional values were a combination of data measurements by the team and values taken from “Tutorial XFLR5 2018”[9]. In this analysis the main wing was modelled as a “NACA 4412” airfoil and the elevator and fin as the “NACA 0009” airfoil. Both of these in conjunction allowed FICE to model the relative size and position of each component in respect to one another to make the simulation as accurate as possible. It should also be noted that the developers of XFLR5 do not recommend putting body components into the simulation so these, as well as any additional components, will be modelled as point masses with moments of inertia. **Table XIII** shows the weights of each component.

Table XIII: Component Weight

Component	Mass (g)
Main Wing	248
Elevator	44
Fin	25
Motor	97
Battery	142
Electronics	41
Tail Servos	47
Front Body	42
Mid Body	46
Back Body	31
Total	763

To set up the analysis the following parameters were used, a Reynolds number (Re) ranging from 20,000 to 1,000,000 and an angle of attack (α) ranging from -2° to 12° in 0.2° increments. Two forms of analysis were run on the aircraft, the first being a “Type 1 (Fixed Speed)” and the second being a “Type 2 (Fixed Lift)” analysis, shown in blue and green, respectively. 10 [m/s] was used for velocity.

The results from this analysis can be seen in **Figures 4, 5, 6 and 7**. In addition, the data from the XFLR5 simulation was exported in Excel. With this data, a ratio of L/D was created for each of the various attack angles and averaged over the range. The results for both the fixed speed and fixed lift can be seen in **Table XIV.** The two are comparable at 13.01 and 13.89, respectively.

Table XIV: XFLR5 Results

Test Type	Average L/D Results
Type 1 Fixed Speed	13.02
Type 2 Fixed Lift	13.89

It should be noted that although the results produced by XFLR5 are a responsible estimation for the performance of the aircraft, they are not by any means exact. As mentioned earlier, this form of analysis ignores the physical effects of components other than the wing, elevator and fin such as the fuselage, propeller and other body parts. Secondly, the weights, dimensions and positions of all components are "as measured" and there is a certain amount of human error in these values.

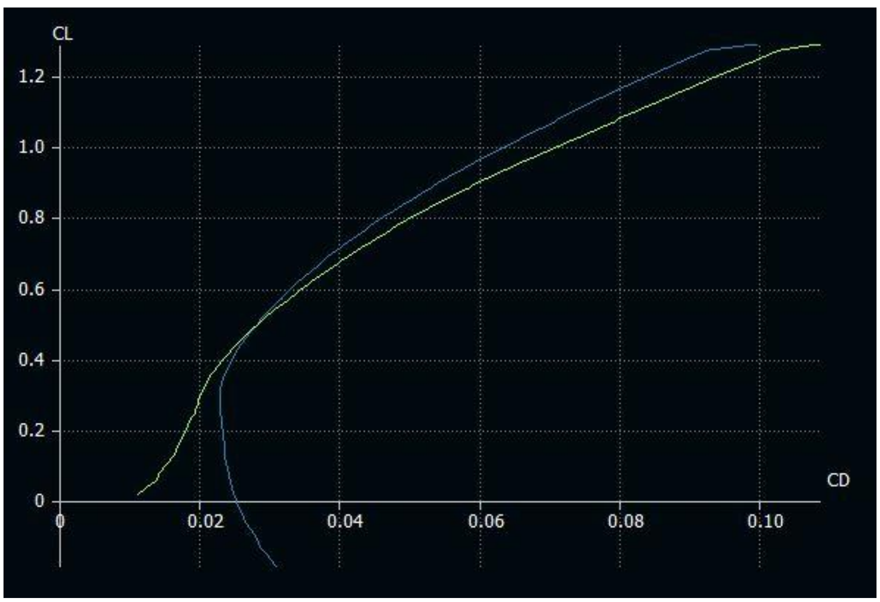

Figure 4: CL vs CD

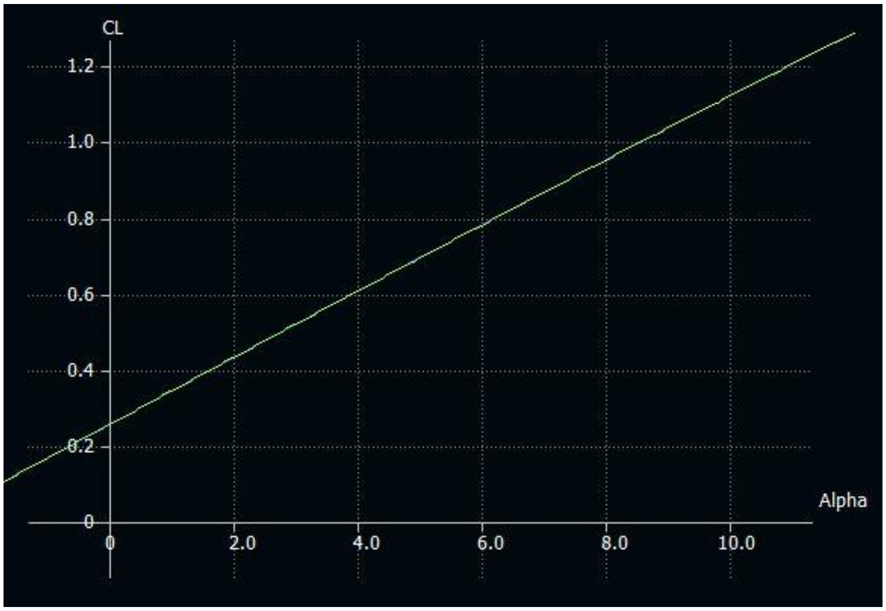

Figure 5: CL vs Alpha (α)

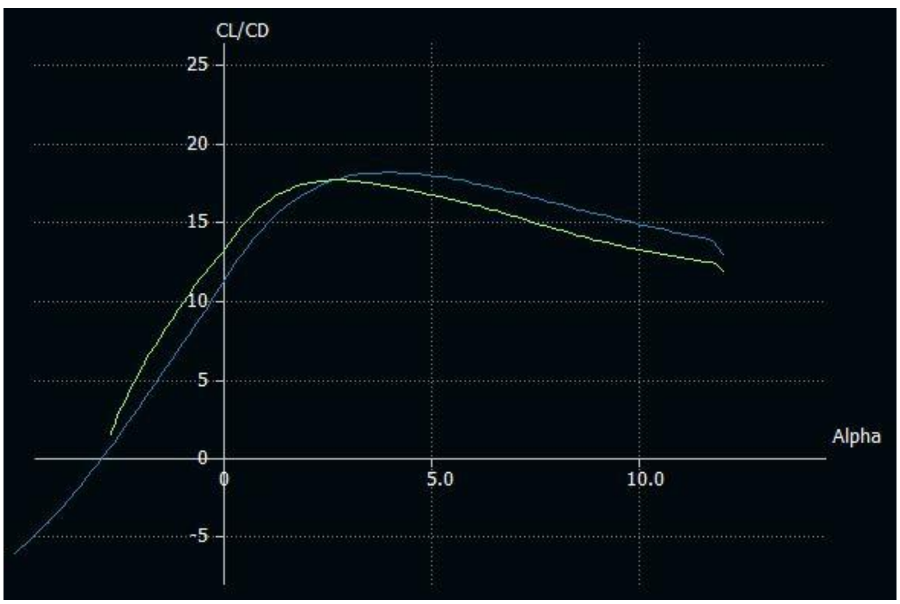

Figure 6: CL/CD vs Alpha (α)

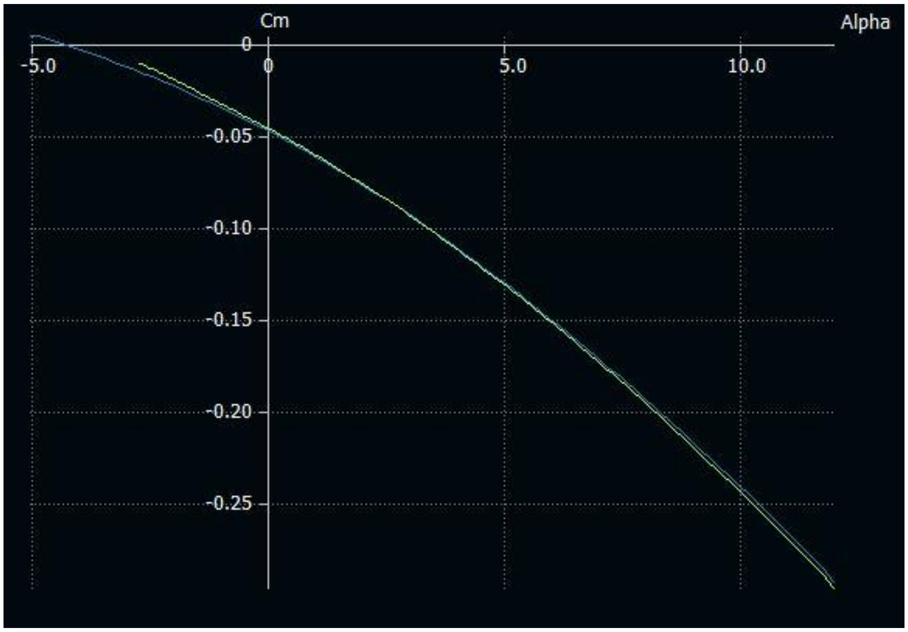

Figure 7: Cm vs Alpha (α)