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BUS 379-02

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Design Specifications

Goals and priorities:

We began the project by translating the problem we intend to solve to a real-world context, considering which competition category generally contributes to the most important purpose of an airplane in reality. To identify which category we want to optimize performance in, we weighed the pros and cons of optimizing for each category with a table (please see below).

Category	Pros	Cons
Speed	● high max velocity ● win 1-2 categories	● shorter endurance ● lower max payload
Payload Capacity	● high max weight ● win 1-2 categories	● lower max speed ● less stable, too light in other competition categories
Endurance	● longer flight time ● Slow and steady wins the race! ● win 2-3 categories	● lower max speed ● lower max payload
Stability	● less prone to crashes: can sustain wind etc. ● win 1-2 categories	● lower max speed ● lower max payload
Aesthetic Design	● visually pleasing ● win 1 category	● not the primary factor affecting performance

After careful consideration, we agreed our primary goal in the Flying Dons Challenge is to optimize our plane for **endurance**, which is the measure of our plane's ability to stay afloat in the air relative to the maximum duration possible to arrive at a specific destination. Although a longer flight time is often associated with lower maximum speed and payload capacity, moving slow and steady will enable us to stay alive in the competition until the end.

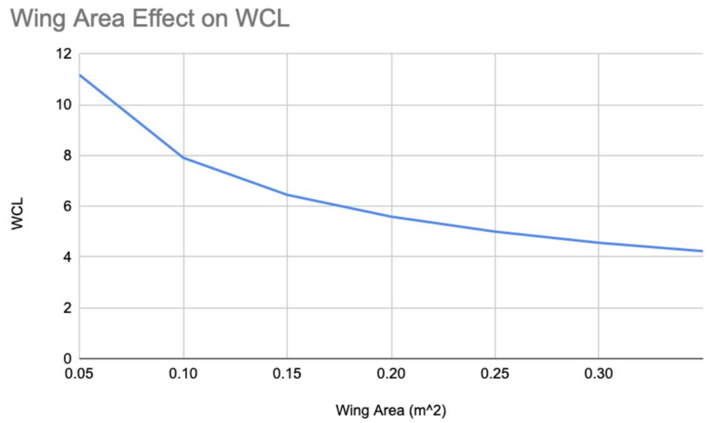
To make progress towards our primary goal, we organized necessary information to solve the problem of maximizing endurance. The information needed to solve for endurance is the equation for endurance, its variables, and the equations that contribute to each variable's values. With this information, we are able to make relationship-driven decisions to help guide the order of plane components to perform specification selection on. From observing the relationship between the variables involved in the Endurance equation, we recognize the need to prioritize the *largest* possible **battery capacity** (mAh) and *lowest* possible **current** (A). A *higher* **voltage** and *lower* **electrical power** ($Power_E$) is ideal to help us ensure our plane does not draw excess Amps or consume too much energy to fly. Since the assumption that $Power_E = Power_M$ holds, a *lower* thrust and/or velocity can help us arrive at a *lower* **mechanical power**, resulting in a plane with longer endurance. As we dedicate each week to value selection corresponding to a specific component, we consistently review the variables that influence the overall combination of T*V and refer to their relationships to reach a conclusion.

In addition to endurance, we also consider the pilot's ability to control the plane for the longest time without crashing. Thus, a Wing Cube Loading (WCL) in the range of 4-10 is preferred over a WCL that exceeds 10 as a *lower* **WCL** results in better stability and does not require pilots to be extraordinarily skilled. Due to the challenges associated with determining an optimal wing area (neither too small for a low WCL nor too large for a high AR), we expect to iterate the problem-solving process as many times needed to address odd findings and revise selected component values for improved performance.

Component Value Selection (including graphs and charts):

- Total wing area
    - 2000 cm^2 (0.20 m^2)

To determine the optimal wing area for a plane with high endurance, we first considered the effect of wing area on WCL using the graph below. Since we understood that a WCL above 10 requires pilots with greater expertise in flying, the graph allowed us to identify a subset of wing areas (greater than 0.10m^2) that likely reduce the pilot's learning curve in controlling the plane for a smooth, steady flight. However, we also recognize that an increase in the wing area up to a certain extent does not benefit our target high aspect ratio (AR). This describes the tradeoff faced between total plane mass vs. stability and lift vs. drag. In other words, we were trying to find a wing area that optimizes our stability - WCL, and at the same time, doesn't compromise our AR. Another aspect that we noticed is that although we didn't choose the smallest wing area in the given range, the area is still not the most important dimension that can affect our AR, as the wingspan and the chord play a crucial role in determining AR. Indeed by changing the dimensions of wingspan and chord, we can increase or decrease the aspect ratio, which will affect the total lift.



Initially, we selected a wing area of 1500 cm^2 (0.15 m^2) to maximize both the endurance and stability of our plane. Though a 0.15 m^2 wing area allows the plane to move at a slightly faster maximum velocity in level flight, meaning we have the potential to score higher in the speed category at 10.189 m/s, its WCL at 10.93 without payload capacity and 13.31 with payload capacity suggests our plane is harder to fly and more prone to crashes. Its reduced capability of sustaining wind implies it does not counter turbulence well enough. Since this initial wing area weighs less than the final wing area by 500 g, it is unsurprising that it raises endurance by a few minutes as a lower weight corresponds to lower energy needed to sustain the plane in the air. Using the same set of chosen electronic components, we agreed to transition to a 2000 cm^2 (0.20 m^2) wing area as our endurance already seems fairly high at 88 minutes. While the slight increase in plane mass decreased maximum flight time to 84 minutes and maximum level velocity at 9.375 m/s , we gained from an improved WCL of 9.76 with payload to ensure an easier, more stable flight. Thus, we have significantly improved in stability, which we performed poorly than expected, rather than just prosper in endurance.

- Wingspan
    - 3.2 m (320 cm)

In order to select the wingspan value, we first considered how wingspan affected endurance. Wingspan affects endurance through aspect ratio. We discovered that we should aim for a large aspect ratio in the lift-to-drag ratio equation, where a higher aspect ratio results in a higher efficiency and a longer endurance. High AR wings, also known as long and narrow wings, produce less induced drag than short and wide wings with low AR, because they create small vortexes at the wingtip. This reduces the amount of drag or resistance that the plane experiences while travelling through the air. Thus, the high AR helps us optimize the tradeoff between lift and drag. It not only increases the amount of lift, but also reduces the total drag by lowering the induced drag.

We calculated incremental wingspan values given the wing area of 0.20 m^2.

chord ->	**Wing width (m)**	0.1	0.067	0.0625	0.0615
wingspan ->	**Wing length (m)**	2	3	3.2	3.25
	Wing Area (m^2	0.2	0.2	0.2	0.2
AR=s^2/A ->	**AR**	20	45	51.2	52.81

After analyzing the wingspan's affect on aspect ratio, we narrowed down our wingspan to values that produced aspect ratios near 52. We chose an extremely high aspect ratio based on real-world examples of high endurance planes. An example we found particularly interesting was the highest performing glider named Eta. Being the highest performing glider, it can travel further than any aircraft made by the human race. The specifications for Eta list a wing length of 9.75 m and a wingspan of 30.90 m, resulting in an aspect ratio of 51.33. We used this information to select a wingspan of 3.2 m (320 cm).

- C_L
    - 0.8

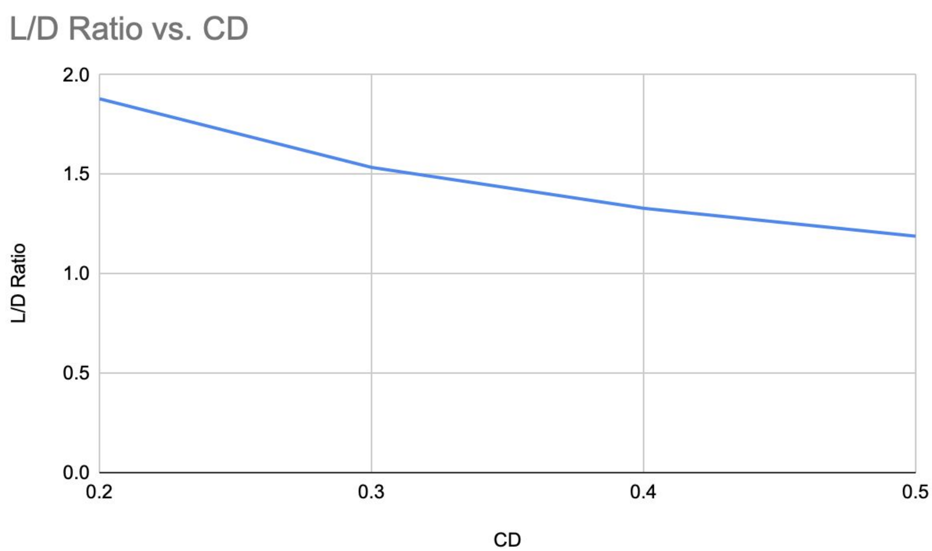
By selecting a large coefficient of lift, we are optimizing for easy flying. The larger the coefficient of lift, the less vertical and horizontal drag the plane will experience. A coefficient of lift of 0.8 makes our plane remarkably efficient, which is beneficial to our main goal of optimizing for endurance. From observing the $(L/D)_{max}$ equation, we can infer that a largest coefficient of lift relative to a smallest coefficient of drag will raise our lift-to-drag ratio to its maximum. Lift is the force of air that pushes the airplane up towards the sky and keeps it afloat in the air, independent of weight, the force of mass that pulls the plane towards the ground. Since our plane carries a little more weight due to its larger battery capacity to maximize flight time and medium wing area to account for stability, a greater force of lift is needed to counteract the force of weight and help the plane maintain level flight. In other words, more lift addresses the higher gravity and increased drag that slows and holds the plane back. Most importantly, this maximum C_L, which is in the denominator when solving for minimum velocity knowing that L=W, reduces the minimum velocity needed to sustain the plane in level flight. This is good because it allows our plane to stay in the air longer, which brings other positive effects such as fuel and energy efficiency, and the ability to carry more mass.

We also recall that the coefficient of lift is affected by the wing's shape. Thus, we decided to use an under-cambered airfoil in our visual design to accompany our plane in efficiently carrying the higher weight. With the added small, lower camber, there is a larger difference in the distance of air particles on the upper and lower surfaces of the wing. As a result, airflow travels at a higher velocity above the wing due to lower pressure and lower velocity below the wing due to higher pressure, generating greater coefficient of lift.

- C_D
  - 0.2

Since the coefficient of lift is inversely and linearly related to the coefficient of drag, we selected the lowest value available effectively minimizing the coefficient of drag and increasing the efficiency of our plane. This is explained in the lift to drag ratio: $\frac{L}{D} = \frac{C_L}{C_D}$

The connection between the lift-to-drag ratio and the coefficient of drag is clear: a lower coefficient of drag results in a higher lift-to-drag ratio. We confirmed the relationship and selected value by plotting an array of coefficients of drag and their relative lift-to-drag ratio.



The graph explains why minimizing the coefficient of drag is important: it will facilitate the maximum possible lift-to-drag ratio, effectively increasing the efficiency and therefore the endurance of our plane. Our selection for the coefficient of drag is beneficial in more than one way: a high lift-to-drag ratio allows the plane to stay in the air longer, it's more energy efficient, and can also carry heavier payloads. A low coefficient of drag and a high lift-to-drag ratio optimizes for our goal, as it increases the endurance in addition to increasing payload capacity and it's more energy efficient.

- kV
  - 1500

We went through many iterations of calculations to come to this value which represents the speed of the motor. Upon first glance, we decided to minimize kV and confidently selected 500 kV, intending to minimize thrust and velocity to optimize for endurance. This is because we also understand that the higher the kV rating and higher RPM, the more difficult it is to control the plane which does not promote the ease of flying our plane. It wasn't until we selected other components and made calculations for minimum and maximum velocity that we realized we could boost the top speed of our plane in level flight past a velocity of ~6 m/s, while still maintaining long flight time. We tried raising the speed of the motor to 2000 kV, but realized it was not a wise decision with respect to our goal of optimizing endurance as it sacrificed efficiency rating down to 72%, demanding more energy to spin the propeller. This kV will work better with the shortest given propeller diameter of 4 in., which we have considered switching to as a shorter diameter significantly reduces thrust by an exponential factor of 3.5. However, we also remember that a shorter diameter is associated with less torque, decreasing the ease to maneuver and turn the plane. With this information, we reassessed the selection and changed the motor to 1500 kV. This motor component selection greatly increases our propeller's RPM and overall plane velocity which is important for overall competition categorical optimization, as the previous selection proved only successful for only endurance optimization.

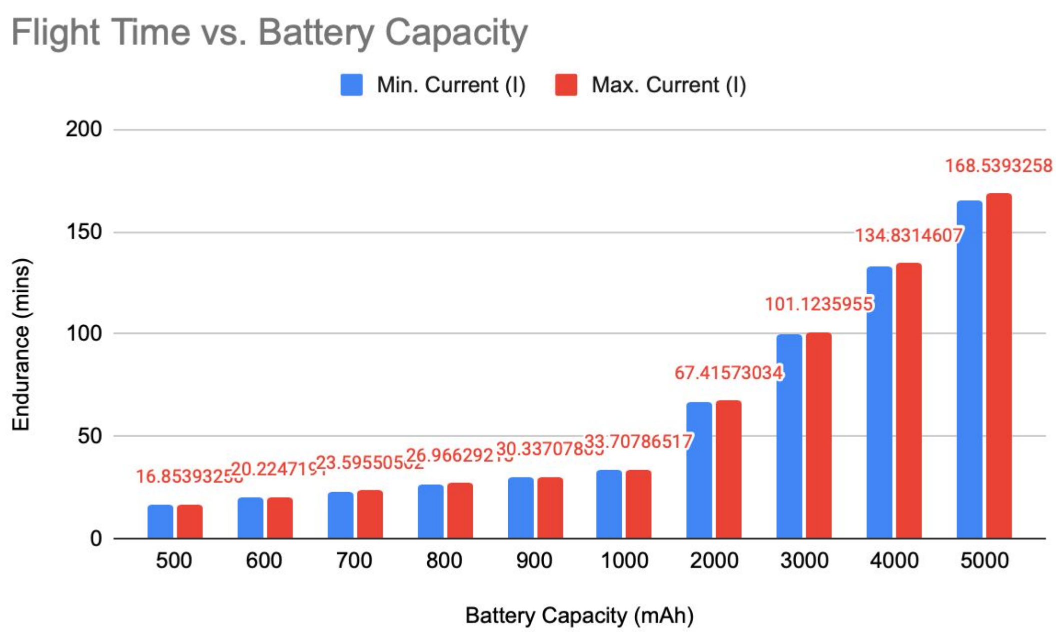
- Vo
    - 3-cell, 11.1 Vo

Like many other components, we began value selection by considering the relationship between voltage and endurance. At first, we chose a 7.4V battery to help minimize the mass of our plane to keep it flying as long as possible. Upon further calculation, we found ourselves in a tough situation: the minimum velocity needed to maintain level flight was *higher* than the maximum velocity of our plane. Our plane had more weight than it had speed, which meant our plane would never reach level flight. The first change made to address this issue was to decrease the capacity of our battery to reduce the plane mass. This helped slightly, but the problem persisted. It turns out that voltage has a much larger effect on RPM (and therefore speed of the plane) than it has on mass. At this stage, we remind ourselves that voltage is how much potential is in a battery. Potential is not a measure of energy, but rather only tells us how fast the propeller wants to spin, not how strongly or long it will spin. We raised our voltage from the 2 cell, 7.4V battery to the 3 cell, 11.1V battery and found our maximum velocity in a much more reasonable range. We also learn from this iterative process that there may have been insufficient energy coming from the battery given its large capacity, hindering our plane from maintaining level flight.

- Capacity
    - 2500 mAh

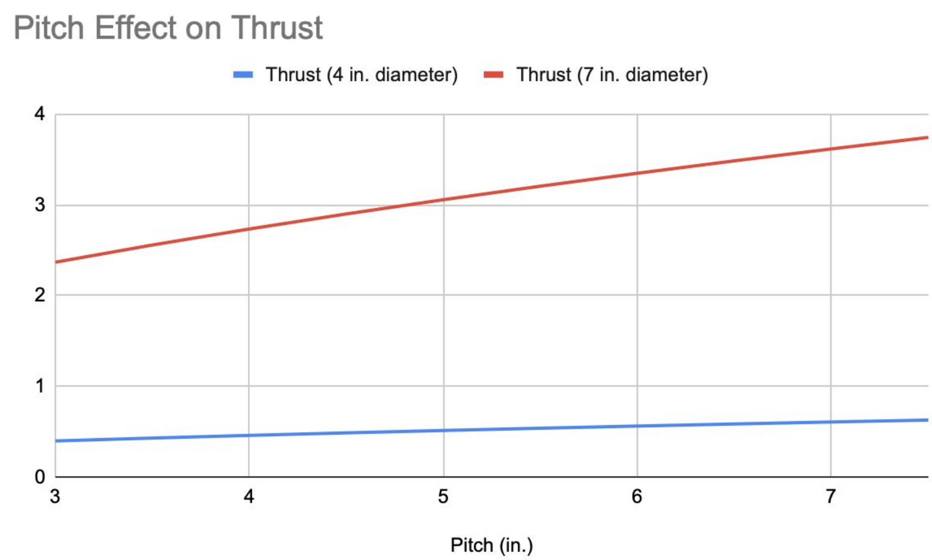
Although we initially selected a battery capacity of 5000 mAh, we found the mass of the battery to be much too heavy for a plane that’s not optimized for payload capacity nor for speed. The goal of optimizing for endurance ensured that we focused on the values that could have increased the flight time and not reduced it significantly. As endurance is equal to capacity (mAh) over current (A), and capacity is directly proportional to endurance, we thought of increasing capacity to increase endurance. Increasing endurance by increasing capacity means that our plane can stay in the air longer without losing fuel. From choosing a capacity of 5000 mAh, the endurance was around 3 hours, which would have guaranteed us to win this category but at the cost of losing in the other categories as more battery capacity also means more mass of the battery. Thus, 3 hours endurance was far above what we considered necessary to place highly in the endurance category. Therefore, we chose to reduce our battery capacity by half from 5000 mAh to 2500 mAh so that we could be fair game in speed and payload categories as well, while still optimizing for endurance.

As seen in the graph below, the larger the battery capacity, the longer the flight will last in minutes given a fixed maximum current of 1.78 Amps. The maximum flight duration possible begins to increase more significantly than with a capacity below 1000 mAh. Thus, we agreed on a battery capacity between 2000 and 3000 mAh to secure a battery life that lasts longer than an hour and does not put our total plane mass at stake. The graph below also shows that there is little difference between our minimum and maximum endurance, which makes sense given the low range in our plane's velocity.



- Diameter x Pitch
    - 7in. x 3in.

To calculate a pitch for our plane, we turn to the only equation where pitch is a variable: thrust. Since we know the only effect velocity has on overall thrust is that it causes thrust to decrease over time, we will use a velocity of 0 when calculating data points for thrust given an array of pitch values to analyze the relationship between thrust and pitch.



Based on our calculations and observations using the graph above, we can determine that a lower pitch equates to a lower thrust. It is clear the thrust exerted on a plane with a 7 in. diameter is higher than the thrust exerted on a plane with a 4 in. diameter, meaning we can achieve a higher velocity given our components with a 7 in. diameter. Though a higher pitch is acceptable despite opting for lower thrust (as it only increases by a small factor of 0.5 if increased), we selected the least angled blade to allow for more torque. Since we are optimizing for endurance, not for speed, we will select the lowest pitch available. Propeller pitch can range from 3-7.5 in., so we have selected a pitch of 3 in. to optimize flight time. The shortest diameter propeller was also not selected because it would increase the top velocity for our plane, which increases mechanical power, and can have a less than ideal effect on our endurance. While the slightly longer moment arm of a 7 in. diameter creates more inertial resistance that has to be overcome to rotate the blade, the maximum C_L selected helps generate sufficient lift to allow the plane to reach level height at an efficient speed.

While we initially wanted to maximize efficiency with a 4x3 propeller, we found that we could achieve ideal final calculated values with a 7x3 propeller. Although this configuration will give us a slightly lower efficiency rating, it will allow for a more reasonable velocity and give stability which we find to be a worthwhile tradeoff for our remote controlled plane. In fact, the tradeoff of longer diameter and lower pitch will result in a lower top speed but will ensure that the plane has more torque. This implies that the propeller will push less air but efficiently, and therefore we will get more torque which will help us gain more control over the plane.

Expected performance in each category (upper, middle, lower):

- Speed: middle

    - We made changes to our battery, wings, and motor to facilitate higher speeds while still maintaining a long endurance. We improved from an initial maximum speed of ~6 m/s to ~9 m/s.
- Payload: lower
    - Our plane is likely heavier than our competitors, given our exceptionally high battery capacity and end goal of optimizing for endurance.
- Endurance: upper
    - We feel confident that this category is where our plane will perform best. Since we aimed to optimize for longer flight time since the early stages of the project, we recognized the need to minimize the current (Amps) drawn from our large battery capacity.
    - Our final maximum endurance calculations indicate a current of 1.78 Amps.
- Stability: upper
    - We sacrificed our total plane mass a little to increase the wing area from 0.15 m^2 to 0.20m^2. This helped us arrive at our WCL in the ideal range of 8-10 for easy flying. In addition to improved WCL, our electronic components are placed towards the front of the plane rather than aft to promote a stable flight.
- Aesthetic design: upper
    - Each component in our model is original and reminiscent of real-world elements.
    - USF-inspired theme (GO DONS!)

Calculations

Min and Max Velocity:
Minimum velocity (at level flight): 8.75 m/s

Target: V_{min} needed to keep our plane in level flight

Equation: $L = \frac{1}{2}\rho V^2 A C_L$, $L = W$

$W = mg$

Given: $\rho = 1.218 \frac{kg}{m^3}$

$A = 2000\ cm^2 = 0.2\ m^2$

$C_L = 0.8$

$m = \underset{\text{plane}}{0.5kg} + \underset{\text{battery}}{0.213kg} + \underset{\text{motor}}{0.04kg} + \underset{\text{propeller}}{0.007kg}$

$= 0.76 kg$

Missing: $V_{min} = ?$

$\cancel{L} = \frac{1}{2}\rho V^2 A C_L = \cancel{W} = mg$

$\frac{1}{2}\rho V^2 A C_L = mg$

$V^2 = \frac{2mg}{\rho A C_L}$ $V = \sqrt{\frac{2mg}{\rho A C_L}}$

$V_{min} = \sqrt{\frac{2(0.76kg)(9.81\frac{m}{s^2})}{(1.218\frac{kg}{m^3})(0.2m^2)(0.8)}} = \sqrt{76.51 \frac{\frac{kg \cdot m}{s^2}}{\frac{kg \cdot m}{m^3}}} = \sqrt{76.51 \frac{m^2}{s^2}}$

$V_{min} = \boxed{8.75 \frac{m}{s}}$

$8.75 \frac{m}{s}\left(\frac{1km}{1000m}\right)\left(\frac{1mi}{1.61km}\right)\left(\frac{60s}{1min}\right)\left(\frac{60min}{1hr}\right) = \boxed{19.44 \frac{mi}{hr}}$

Maximum velocity (at level flight): 9.375 m/s

Target: V_{max} of our plane in level flight

Equation: $T = c_1 \dfrac{\rho RPM d^{3.5}}{\sqrt{p}} (c^2\ RPM p - V)$

$D = \frac{1}{2}\rho V^2 A C_D$, $T = D$

Given: $\rho = 1.218 \frac{kg}{m^3}$ $d = 7in., p = 3in.$ $C_D = 0.2$

$C_1 = 3.59\times10^{-8}$ $A = 2000\ cm^2 = 0.2 m^2$

$C_2 = 4.23\times10^{-4}$

Missing: $RPM = ?$, $V_{max} = ?$

$RPM = kV \cdot V_0 \cdot e$

$= 1500 \cdot 11.1 \cdot 0.78$

$= 12{,}987$

$$T = 3.59\times10^{-8}\left(\frac{1.218\frac{kg}{m^3}\cdot 12987\cdot(7)^{3.5}}{\sqrt{3}}\right)(4.23\times10^{-4}\cdot 12987\cdot 3 - V)$$

$= 0.2975(16.48 - V)$

$= 4.9 - 0.2975V$

$D = \frac{1}{2}(1.218\frac{kg}{m^3})V^2(0.2m^2)(0.2) = 0.024V^2$

Solve for V_{max} knowing $T = D$.

$4.9 - 0.2975V = 0.024V^2$

$0.024V^2 + 0.2975V - 4.9 = 0$

$$V_{max} = \frac{-(0.2975) \pm \sqrt{(0.2975)^2 - 4(0.024)(-4.9)}}{2(0.024)}$$

$\frac{0.450}{0.048} = \boxed{9.375 \frac{m}{s}}$

$\frac{-1.045}{0.048} = 21.77 \frac{m}{s}$

$$\underbrace{9.375\frac{m}{s}\left(\frac{1km}{1000m}\right)\left(\frac{1mi}{1.61km}\right)}_{0.0058}\left(\frac{60s}{1min}\right)\left(\frac{60min}{1hr}\right) = \boxed{20.88\frac{mi}{hr}}$$

plane battery motor propeller

Min and Max Endurance:

Minimum endurance: 82 minutes

Target: Endurance$_{min}$

$$Power_{m(min)} = T_{min} V_{min}$$
$$= \left(2.30 \frac{kg \cdot m}{s^2}\right)\left(8.75 \frac{m}{s}\right)$$
$$= 20.13$$

Since $Power_m = Power_E = I V_0$,

$$20.13 = I \cdot \underbrace{11.1}_{\text{3-cell battery}}$$
$$\frac{20.13}{11.1} = I$$
$$1.81 = I_{min}$$
$$Endurance = \frac{2500\ mAh}{1.81 A} = \frac{2500\ mAh}{1810\ mA} = 1.38\ hrs \times 60\ mins. = \boxed{82\ mins.}$$

Maximum endurance: 84 minutes

Target: Endurance$_{max}$

- Capacity = 2500 mAh

Solve for current(I) knowing $Power_E = Power_m$.

$$Power_{m(max)} = T_{max} V_{max}$$ ← note: we aimed to find a smaller maximum T & V combination.

$$= \left(2.11 \frac{kg \cdot m}{s^2}\right)\left(9.375 \frac{m}{s}\right)$$
$$= 19.78$$

Since $Power_m = Power_E = I V_0$,

$$19.78 = I \cdot \underbrace{11.1}_{\text{3-cell battery}}$$
$$\frac{19.78}{11.1} = I$$
$$1.78 = I_{max}$$

$$Endurance = \frac{Capacity}{I}$$ Capacity ← largest possible; I ← lowest possible

$$= \frac{2500\ mAh}{1.78 A} = \frac{2500\ mAh}{1780\ mA} = 1.40\ hrs \times 60\ mins. = \boxed{84\ mins}$$

Stability and Flying:

0.0058

$$WCL_{(w/o\ payload)} = \frac{m}{A^{1.5}} = \frac{\overset{\text{plane}}{0.5\,kg} + \overset{\text{battery}}{0.213\,kg} + \overset{\text{motor}}{0.04\,kg} + \overset{\text{propeller}}{0.007\,kg}}{(0.2\,m^2)^{1.5}} = 8.50$$

$$WCL_{(w/payload)} = \frac{m}{A^{1.5}} = \frac{0.5\,kg + 0.213\,kg + 0.04\,kg + 0.007\,kg + \overset{\text{payload}}{0.11299\,kg}}{(0.2\,m^2)^{1.5}}$$

$$= \boxed{9.76} \text{ easy flying} \checkmark$$

The result from the WCL shows that our plane has a rating of easy flying. This means that the small mass over a large wing area makes the plane fairly easy to fly, as there is not a lot of inertia in the plane. So, it doesn't need long distances to make maneuvers.

In addition to minimizing the WCL and landing a rating of easy flying for both our minimum and our maximum payload capacities, we designed the plane in such a way that our components give our plane center of gravity (CG) 3. CG 3 means slightly forward-heavy, which increases the overall stability of our plane even further. To explain this, we should consider the tradeoff between the combination of vertical and horizontal movements.

In terms of horizontal stability (turning left and right), the center of gravity that we chose is CG 3 which is slightly forward of the plane. So, when the tail flap gets pushed from the rear and is going through the center of gravity point, in this case CG 3, it's going to create a very small angle of turn. In other words, since the angle of rotation is near the very front, it makes the angle of turn very small as the force of push is going from the tail along the body of the plane, and through the center of gravity. As a result, it increases the overall stability of the plane. Thus, when the CG is furthest to the front, it takes more force to maneuver the plane, whereas when the CG is closer to the front, the angle of rotation is near the very front, and the angle of turn is very small. This implies that the plane is more stable.

In terms of vertical stability, the center of gravity itself doesn't influence the rotation of the plane, but the forces of the wings that are creating lift do. So, there are two forces: the force of wing, which makes the plane go up; and the force of tail, which makes the plane slightly go down. These forces acting relative to the center of gravity are going to determine the ability to maneuver and fly through the sky. We chose to place the CG towards the front but still not too close to the front, since the CG is under the wings. In our case, the force of wing and force of weight are going to be acting in the same direction, as a result, there is a larger difference in the angle of attack, which in our case makes the nose of our plane slightly pointing down. This is also why we have the greatest coefficient of lift as a CG slightly towards the front makes the nose point down, so we need a greater lift to maintain level flight.

Considering the tradeoff between the horizontal and vertical movements will determine our overall stability, which is why we chose to have a CG slightly to the front as it increases the stability of our plane.

Min and Max Mass → Payload:

Minimum Payload Capacity: 0.47 g

MAXIMUM & MINIMUM PAYLOAD CAPACITY

① MINIMUM PAYLOAD CAPACITY

EQUATION: $L = \frac{1}{2}\rho V^2 A C_L$ $\quad L = W = mg$

GIVEN: $\rho = 1218 \frac{g}{m^3}$ $\quad C_L = 0.8$

$V_{min} = 8.75\ m/s$ $\quad g = 9.81 \frac{m}{s^2}$

$A = 0.2\ m^2$

MISSING: Minimum payload capacity

$$L_{min} = \frac{1}{2}\left(1218 \frac{g}{m^3} \cdot \left(8.75 \frac{m}{s}\right)^2 \cdot 0.20\ m^2 \cdot 0.8\right)$$

$$= \frac{1}{2}\left(1218 \frac{g}{\cancel{m^3}} \cdot 76.56 \frac{\cancel{m^2}}{s^2} \cdot 0.20\ \cancel{m^2} \cdot 0.8\right)$$

$$= 7460.25 \frac{m \cdot g}{s^2}$$

Since $L = W = mg$ $\quad L = W = 7460.25 \frac{m \cdot g}{s^2}$

$$m = \frac{W}{g} \rightarrow m = 7460.25 \frac{\cancel{m} \cdot g}{\cancel{s^2}} \cdot \frac{\cancel{s^2}}{9.81\ \cancel{m}} \rightarrow m = 760.47g$$

battery = 213g
motor = 40g
propeller = 7g
$\}$ 260g

mass of the plane = 500g

MINIMUM PAYLOAD CAPACITY = (760.47 − 260 − 500)g = 0.47g

Maximum Payload Capacity: 112.99 g

(2) MAXIMUM PAYLOAD CAPACITY

EQUATION: $L = \frac{1}{2}\rho V^2 A C_L$ $\quad L = W = mg$

GIVEN: $\rho = 1218 \frac{g}{m^3}$ $\quad C_L =$

$V_{max} = 9.375\ m/s$ $\quad g = 9.81 \frac{m}{s^2}$

$A = 0.20\ m^2$

MISSING: maximum payload capacity

$$L_{max} = \frac{1}{2}\left(1218 \frac{g}{m^3} \cdot \left(9.375 \frac{m}{s}\right)^2 \cdot 0.20\ m^2 \cdot 0.8\right)$$

$$= \frac{1}{2}\left(1218 \frac{g}{\cancel{m^3}} \cdot 87.89 \frac{\cancel{m^2}}{s^2} \cdot 0.20\ m^2 \cdot 0.8\right)$$

$$= 8564.06 \frac{m \cdot g}{s^2}$$

Since $L = W = mg$ $\quad L = W = 8564.06 \frac{m \cdot g}{s^2}$

$$m = \frac{W}{g} \longrightarrow m = 8564.06 \frac{\cancel{m} \cdot g}{\cancel{s^2}} \cdot \frac{\cancel{s^2}}{9.81\ \cancel{m}}$$

$$m = 872.99\ g$$

battery = 213g
motor = 40g
propeller = 7g

$\left.\begin{array}{l}\text{battery} = 213g \\ \text{motor} = 40g \\ \text{propeller} = 7g\end{array}\right\} 260g$ $\quad$ mass of the plane = 500g

MAXIMUM PAYLOAD CAPACITY $= (872.99 - 260 - 500)g$
$= 112.99\ g$

Visual Specs

Aesthetic Design:
https://www.tinkercad.com/things/gxvINzu7teX-final-design-plane/edit?sharecode=FPQT1aCNLsGub5n79X3K8Om_Fo6bsbXYaJ2MwpLDBpQ

Design with components and where they're placed inside the plane:
https://www.tinkercad.com/things/lax79MUlq0P-final-plane-components/edit?sharecode=UWHUgCO6tmqKIWMNs9NuqANvJCGK30_WIGHaQejccAk