Instructions to the Examiner:

The instructions listed below show how to correctly operate each individual function of the *Model Search and Rescue Helicopter*. Labels are included on the Control Panel to ensure the correct controls are used when operating the model.

The Rear Ramp:

The Rear Ramp control consists of a SPST switch labelled “Rear Ramp” on the Control Panel. In the “Up” position, the Rear Ramp will be retracted. In the “Down” position the Rear Ramp will be lowered.

The Electric Variable Speed Winch/Hoist:

The Winch control consists of a SPST switch and a Variable Resistor. When the switch is in the “Up” position, the Winch is inactive. When the switch is in the “Down” position, the Winch is active. When the variable resistor is in the central position the winch does not move. When the variable resistor is turned anti-clockwise from the centre, the winch ascends. When the variable resistor is turned clockwise from the centre, the winch descends. Moving the variable resistor incrementally varies the speed of the winch in the desired direction.

The Sliding Door:

The Sliding Door is operated by means of an attached handle. The Sliding Door sits on a slider and is free to move horizontally. By moving the handle back and forth, the door opens and closes. Stoppers have been included to limit the movement of the door and prevent damage to the model.

Propeller:

The Propeller is controlled by means of a SPST switch and a Variable Resistor. When the switch is in the “Up” position, the Propeller is inactive. When the switch is in the “Down” position, the propeller is active. The variable resistor controls the speed of the propeller. When the variable resistor is fully anticlockwise, the propeller is stationary. The speed of the propeller increases incrementally as the variable resistor is rotated clockwise.

Safety:

The Propeller will not turn if the rear ramp is in the down position. This is to avoid potential safety hazards in a real-life scenario if the helicopter was to attempt to take off with the rear ramp still down.

Analysis of the Design Brief:

The Design Brief for the Higher Level Leaving Certificate Engineering Project 2017 is as follows:

> *Design a model **Search and Rescue Helicopter** to the general specifications outlined below.*
> *The Helicopter should be your own unique design and should:*
> *(a) Have one **sliding door**;*
> *(b) Incorporate an **electric variable-speed winch/hoist**;*
> *(c) Include an **automated rear ramp**.*

In order to successfully meet the requirements of the Design Brief, I must take into consideration the criteria set down in the Design Brief.

General Guidelines:

The Design Brief outlines some general guidelines to complete the project and satisfy the Design Brief.

The Design Brief requires me to:

- Design a model Search and Rescue Helicopter
- Ensure the Model has one sliding door
- Include an electric variable speed-winch/hoist
- Have an automated rear ramp

Design Brief Specifications:

In addition to the General Guidelines outlined above, the Design Brief also includes specific requirements which must also be met.

These Specifications state that I must:

- Ensure that all main operating features are **clearly visible** without dismantling the project
- Not exceed the **maximum dimension** of **350mm**
- Not exceed the **maximum voltage** of **9 Volts** in my power supply
- Make sure the design and manufacture of this project is **my own unique, individual work**
- Carry out the **manufacture** of the project **in my school** under the **supervision** of my **Engineering Teacher**
- Have both my Portfolio and Project **clearly identified** with my **Examination Number**.
- Complete my project work and portfolio and have it ready for submission before **Friday 10th March, 2017**.

Investigation of Solutions:

One of the most important aspects of project design is thorough Research and Investigation into the many different aspects of the task at hand. In order to ensure the best finished product, I decided to research existing solutions from many different sources, including:

- Websites on the Internet
- Agencies in my local area involved with Search and Rescue
- Engineering textbook

Websites on the Internet:

I used the search engines ***Google Images*** and ***Google Search*** to find images and information regarding existing solutions to the Design Brief. The introductory section of the Design Brief was helpful in beginning my search, as the ***Sikorsky S-92 Helicopter*** and the ***Irish Coast Guard*** were mentioned as existing solutions. I began my search with those key search terms.

When researching the Sikorsky S-92, I found that the helicopter is used for a wide range of applications, including private transport, military operations, as well as Search and Rescue (SAR). I therefore narrowed my search to ***Sikorsky S-92 Helicopters in Search and Rescue***, finding multiple images that would aid my in designing the model, by providing information on the different aspects of my Design Brief, such as the *Automated Rear Ramp*, *Sliding Door*, and *Electronic Variable Speed Winch/Hoist*.

Search and Rescue Agencies in My Local Area:

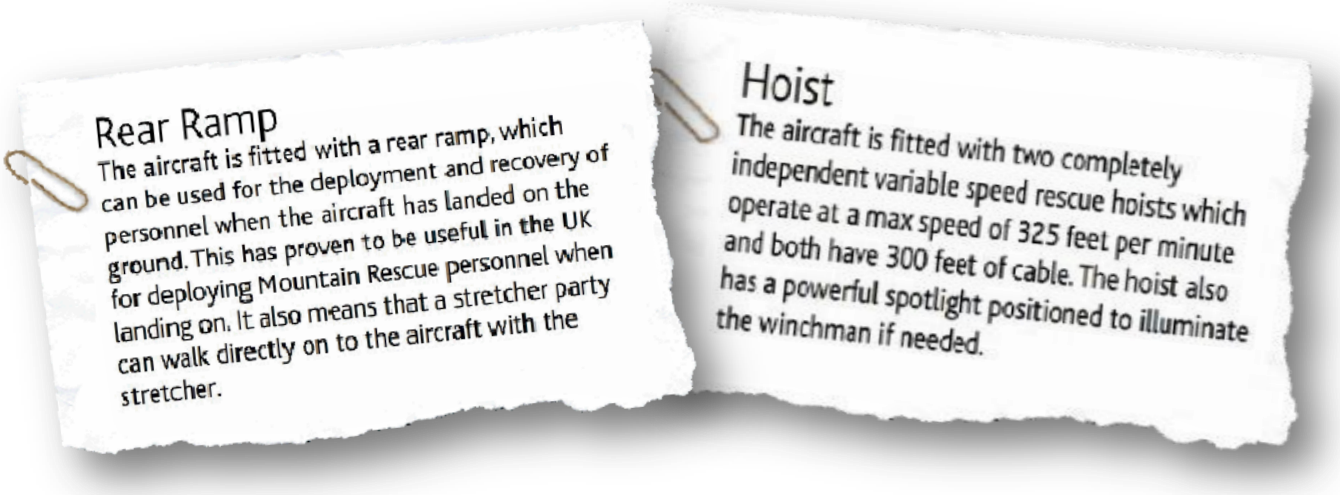
While researching possible solutions to the Design Brief, I decided to visit the website of my nearest Coast Guard Station in Skerries, North County Dublin:

http://www.skerriescoastguard.com

I found a section on this website entitled "Useful weblinks" which included a link to the Irish Coast Guard section of the Department of Transport, Tourism and Sport website:

http://www.dttas.ie/sites/default/files/publications/maritime/english/irish-coast-guard-publications/sneak-peek-s92.pdf

This website turned out to be extremely helpful in researching the existing solutions to the specific requirements of the Design Brief, namely the **Sliding Door**, **Automated Rear Ramp** and **Electronic Variable Speed Winch/Hoist**. The website included a PDF detailing the specifics of the Rear Ramp and Hoist system on the Sikorsky S-92



Rear Ramp

The aircraft is fitted with a rear ramp, which can be used for the deployment and recovery of personnel when the aircraft has landed on the ground. This has proven to be useful in the UK for deploying Mountain Rescue personnel when landing on. It also means that a stretcher party can walk directly on to the aircraft with the stretcher.

Hoist

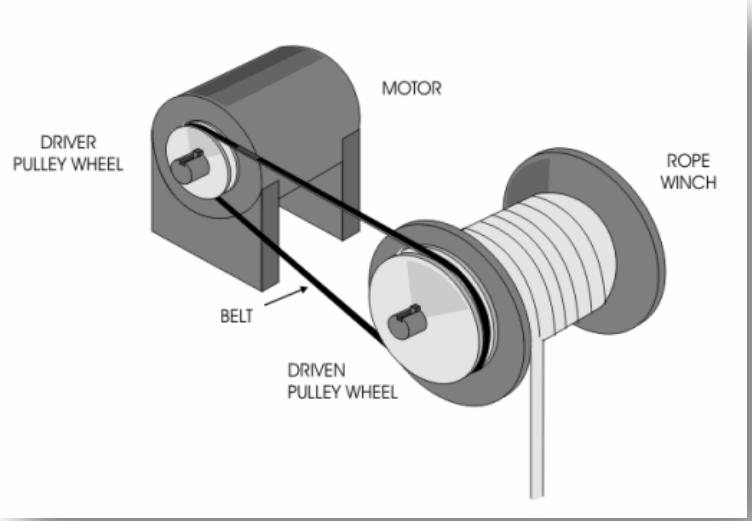
The aircraft is fitted with two completely independent variable speed rescue hoists which operate at a max speed of 325 feet per minute and both have 300 feet of cable. The hoist also has a powerful spotlight positioned to illuminate the winchman if needed.

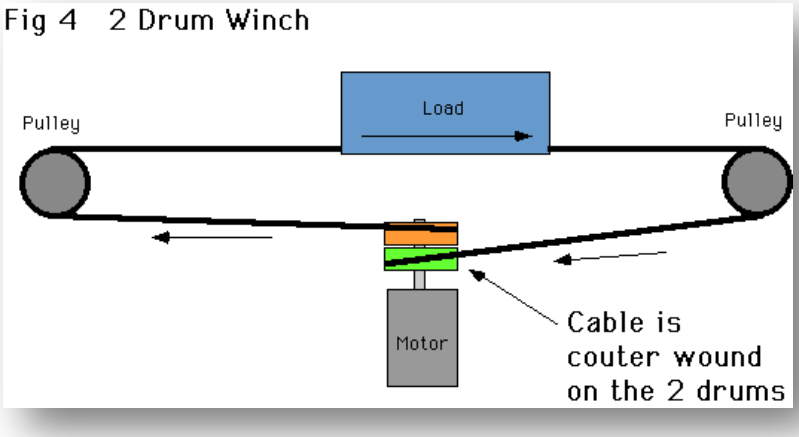
It is now clear that the Rear Ramp must allow quick and easy access to the interior of the Helicopter Model. The Hoist must be capable of lifting a load from the ground to the helicopter, be able to vary the speed of the winch and be capable of reversing the direction of motion so as to enable a load to be moved from the helicopter to the ground. The Sliding Door must also allow uninterrupted access to the interior of the SAR Helicopter Model and be convenient to open and close. Ideally the sliding door would allow direct access to the helicopter's Hoist system.

Research into Electric Variable-Speed Hoist:

Many different mechanisms may be used to control the electric variable speed hoist. I consulted my Engineering Textbook and the Internet for possible solutions.

One solution would be to have a motor and spool connected by a pulley system. The motor speed can be adjusted and the direction of rotation changed to complete those aspects of the Design Brief. This mechanism is suitably easy to manufacture from parts available to me in the Engineering Room.

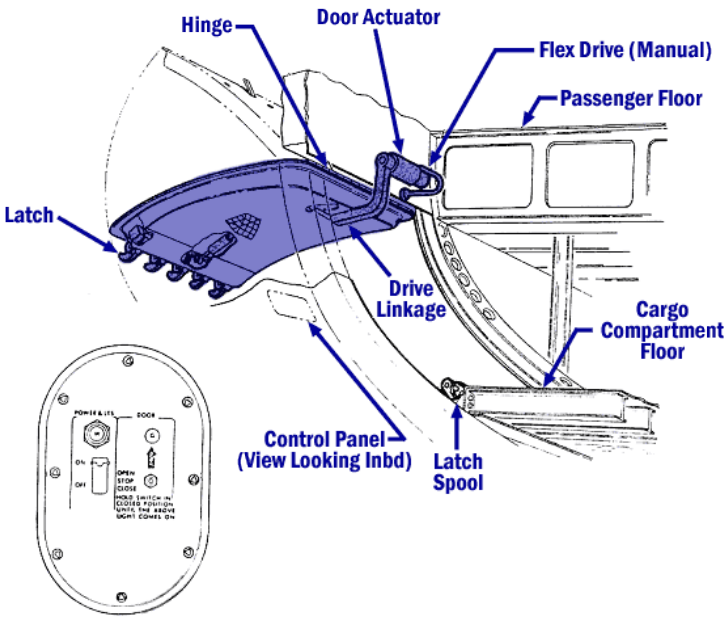


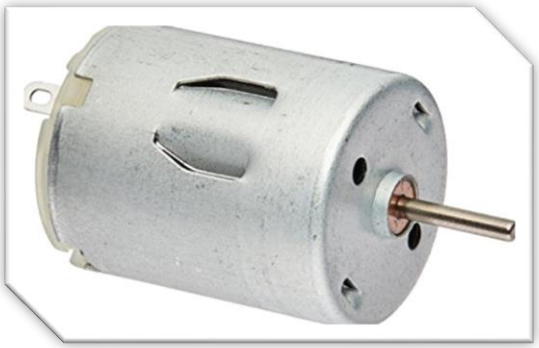


Another type of winch is a Drum Winch. The operation of this mechanism relies on two pulleys at a distance from each other connected by a belt, which is connected to a motor. As the motor turns, the belt moves around the pulleys and moves the load attached to the belt. This is a good design for a winch; however the fact that a pulley must be located on both ends of the belt's degree of motion makes it unsuitable for use in a Helicopter. The winch must have all operating parts inside or attached to the Helicopter to make it mobile. This Winch is used primarily in stationary applications where the pulleys can be fixed on both ends.

Research into Rear Ramp:

The Rear Ramp requirement of this Design Brief is a very specific application of mechanical and electronic control. Normally, for real-world usage of a rear ramp or cargo door mechanism, a pneumatic or hydraulic system is employed. The door hinges near the actuator and can be held firmly in place with a series of latches on the opposite end of the door. Practicality does not permit me to use a pneumatic or hydraulic system on such a small scale; however a similar movement can be achieved with other mechanisms.





DC Motor

A motor can be used to control the movement of a Rear Ramp, since it is simply a rotary movement. A DC motor could be used for the task, since it outputs rotary motion, however the lack of control it has with regards to positioning causes problems for something like a ramp mechanism. The DC motor has a 'spool down time' meaning once the supply of electricity is stopped the motor continues to turn for a time. This problem is solved in the design of a Servo Motor. I have outlined more information servo motors on Page 11.

The servo motor allows for precise rotary motion in both a clockwise and an anticlockwise direction. The disadvantage of a Servo Motor is that its freedom of rotation is limited to 180 degrees however this will not be a problem for my project.

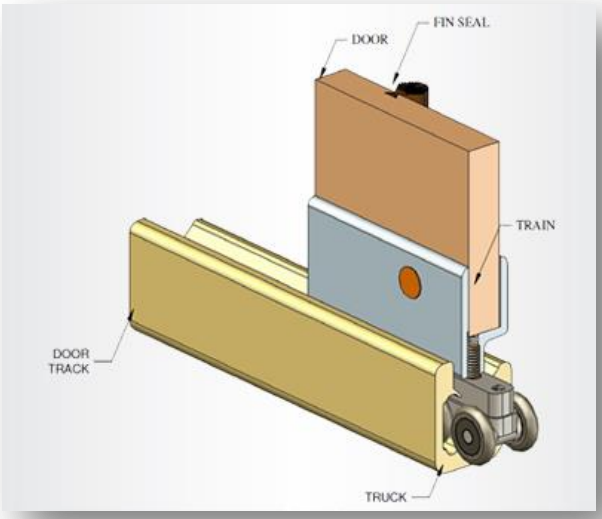
A Selection of Servo Motors

Research into Sliding Door:

Unlike the two other specific requirements of the Design Brief, the Sliding Door does not have to be electronic or automatic. I researched existing solutions already in use by the Irish Coast Guard on their own Sikorsky S-92 Helicopters.

The Irish Coast Guard use the Sliding Door accompanied by the variable-speed Hoist to move crew and patients to and from the Helicopter. This door is controlled manually by one of the helicopter operators.

Sliding Doors are commonplace in houses for things like porch doors. These use a sliding rail or a 'truck' to move the door linearly from side to side. This mechanism has low friction and is easy to control. It would also be possible to simplify the design, given the smaller scale of this project, and still get the desired result.



Sliding Door Mechanism

Simplified Mechanism

A mechanism such as the one shown to the left could be used as a simpler version of the design mentioned above. It is simpler to manufacture and has relatively low friction, with little chance of seizing up.

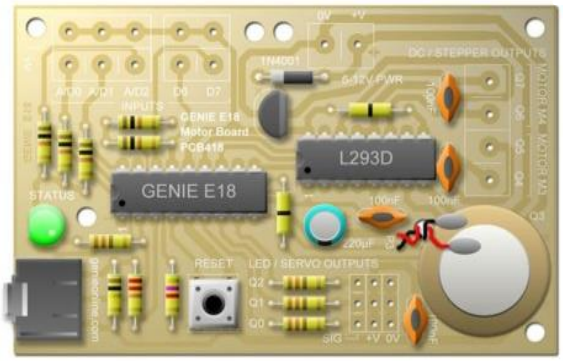
Research into Electrical Systems:

In order to satisfy the Design Brief, I must include an **"electric variable-speed winch/hoist"** and **"an automated rear ramp"**. Both of these systems can be manufactured using electromechanical means. Since the Design Brief calls for multiple electronic systems, I deemed it necessary to include a central control system which would incorporate all of these electronic parts. I decided to research into electronic solutions using various websites such as

http://www.practicalstudent.com
http://www.t4.ie

I found that a **microprocessor circuit board** would be suitable to control all necessary functions of the Model. The circuit board can control the DC motor attached to the spool of the Hoist system and an attached Propeller. It can also control the Rear Ramp servo motor, allowing for precise control and ensuring the ramp does not exceed its operating envelope. The microprocessor circuit board also fulfils one of the brief specifications in that its power supply is 6 Volts, below the given maximum of 9 Volts.

Some required parts for my Electronic systems, including a Genie 18 Motor Board, a Servo Motor, A 6V Battery Pack, and a DC Motor



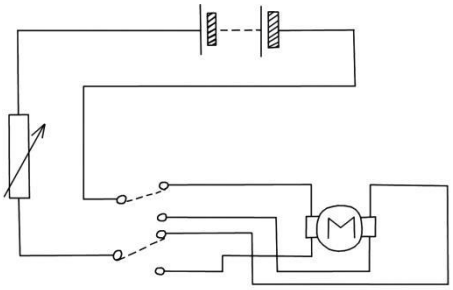
GENIE E18 Motor Control Board

Research into Automation:

Automation is the use of one or more control systems to operate equipment with minimal human intervention

Examples of Automaton include ATMs, adaptive cruise control, 3D Printing, assembly line manufacture, and military drones.

The Design Brief requires the Rear Ramp to be automated. This problem is solved by the use of the microprocessor circuit board. This control system can be programmed to allow the user to enter an input and the pre-set process will determine the correct output based on that input. This prevents the user having to manually lower the Rear Ramp, instead having to merely flick a switch.
I had alternatively considered a conventional circuit design as the control system, however I found the circuit board to be a much more convenient and flexible option.

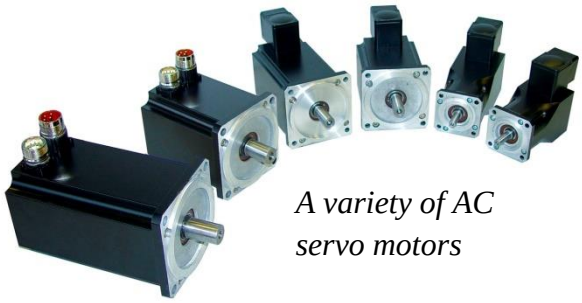


An alternative control system for the variable-speed hoist, consisting of a DPDT motor circuit and a variable resistor.

Research on Servo Motors:

A servo motor is a motor that allows for precise control of angular position, velocity and acceleration.

A diagram showing the internals of a servo motor



A variety of AC servo motors

Servo motors come in many models and sizes and consists of a motor and position sensor. They come in two types; AC and DC. I will be using a DC servo motor because they are used for smaller tasks and will run on a DC power supply. AC servo motors run off mains electricity and are typically used in industrial applications.

Servo motors are controlled by pulses sent out every 20 milliseconds. The length of the pulse determines the servo motor's position. For example, a pulse length of 1.5ms causes the motor to turn to 90^{o}, shorter than 1.5ms will set it to 0^{o} and over 1.5ms will set the servo to 180^{o}.

From my research, I concluded that a servo motor is the best option I have to control the Rear Ramp. The servo motor can be mounted on the base piece and attach directly onto the Rear Ramp door.

After researching further into servo motors, I found that their maximum rotation angle is 180^{o}. As I only need the Rear Ramp to move a maximum of 90^{o}, a Servo motor will be adequate for the task. However, for the Winch system, the spool will need to rotate many times in the same direction. I will have to use other methods of rotation for this application, such as a DC motor.

Investigation of Solutions – Summary:

- Sikorsky S-92 Helicopters are used in a wide range of applications, from private transport to search and rescue operations

- My local Irish Coast Guard station had useful information regarding the operation of their Sikorsky S-92 SAR Helicopters, specifically the Rear Ramp, Hoist and Sliding Door

- The Variable-Speed Hoist must be capable of moving a load to and from the helicopter at a desired speed

- The Rear Ramp should allow quick and uninterrupted access to the interior of the helicopter while landed and should be wide enough to accommodate both crew and equipment

- The Sliding Door must be easy to use and ideally allow direct access to the Variable-Speed Hoist

- My Electrical System will incorporate a Genie 18 Motor Board to control all of my subsystems from one central “hub”

- The automation requirement of the Rear Ramp can be met by the Genie 18 Motor Board

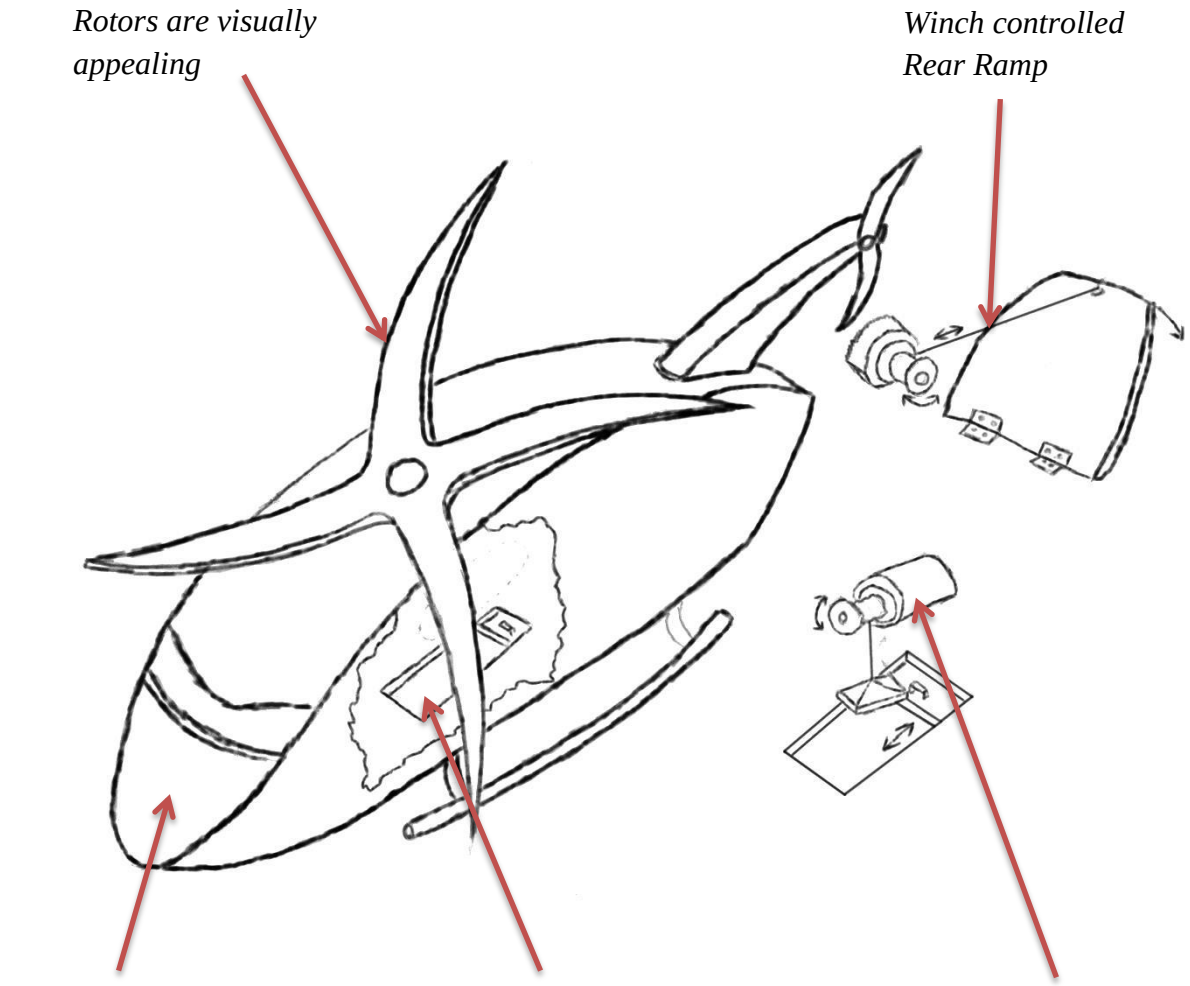
- A Servo motor is the best solution for controlling the Rear Ramp

Criteria for Selection of Solution:

Using all of the above information, I have come up with three possible solutions to the Design Brief. These are outlined below.

Design One:

This design includes a floor mounted sliding door, a rear ramp controlled by a winch/cable system, and a winch mounted above the sliding door. The helicopter body is based off a sleeker design than the Sikorsky S-92. It has a sharper front with more complex curves. This shape is very appealing, but would be difficult to manufacture.

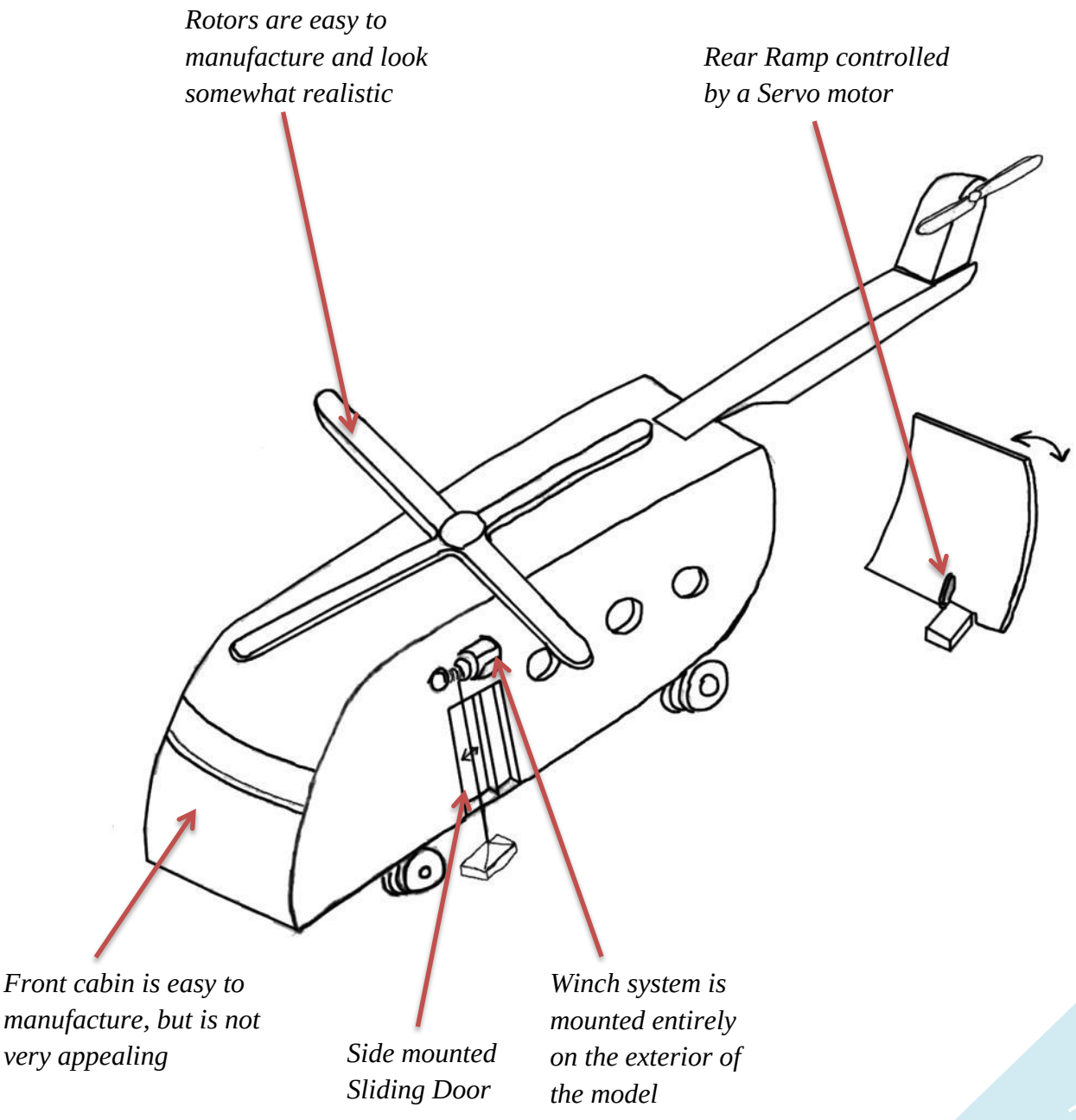


Criteria for Selection of Solution:

Design 2:

This design incorporates the side mounted sliding door, the Servo controlled rear ramp and a winch/motor system mounted entirely on the outside of the helicopter, on the side of the main fuselage.

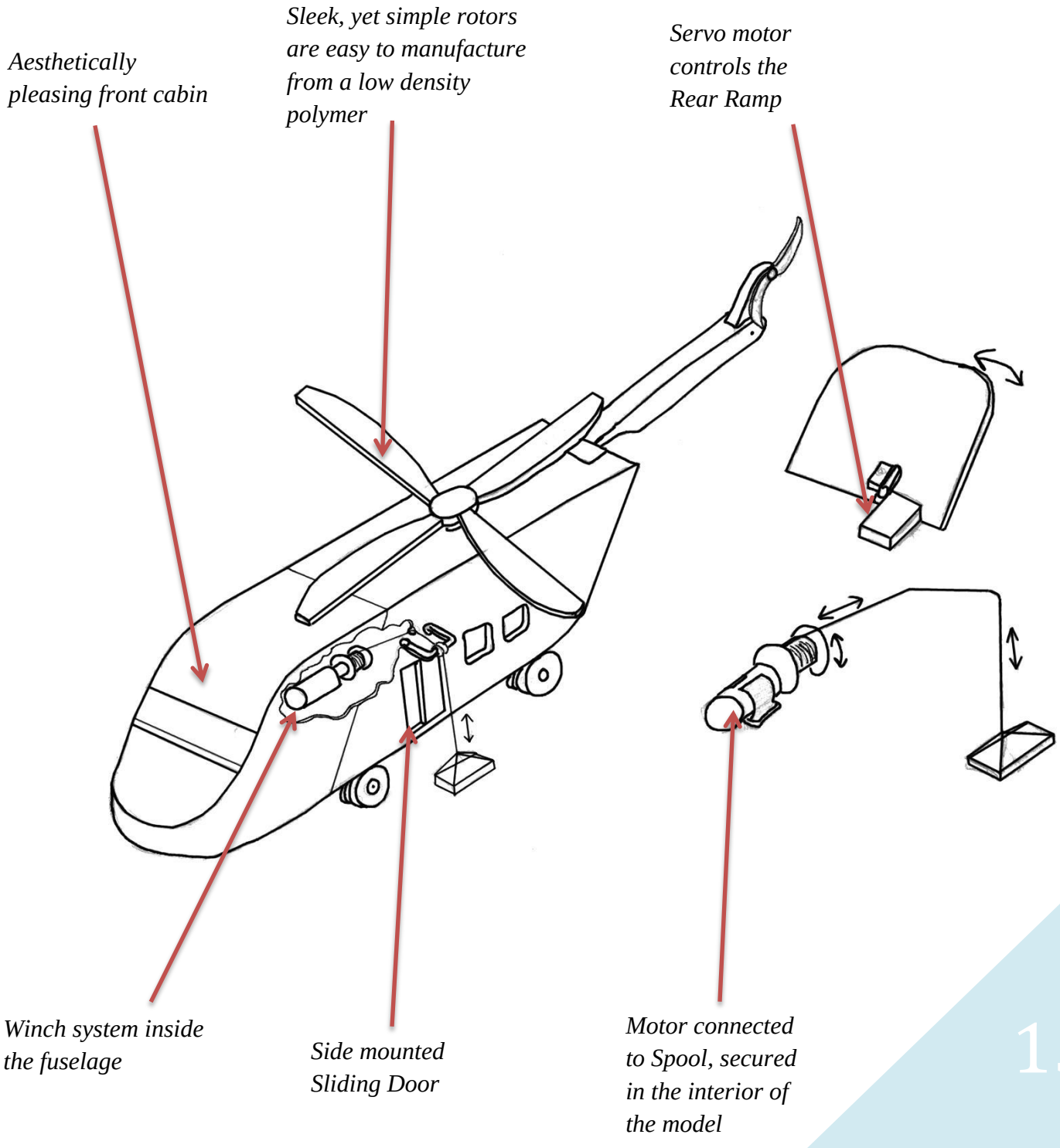
The helicopter body is more box-like, with almost no curves. This improves ease of manufacture but reduces both aerodynamic efficiency and aesthetic appeal.



Criteria for Selection of Solution:

Design Three:

This is the chosen Final Design. It incorporates all of the best functions of the two previous designs; i.e. the side mounted sliding door, the exterior hoist with interior motor, and the servo controlled rear ramp. The body shape is a compromise between those described in Designs One and Two. It allows for aerodynamic features and aesthetic appeal while also being relatively easy to manufacture.



Criteria for Selection of Solution:

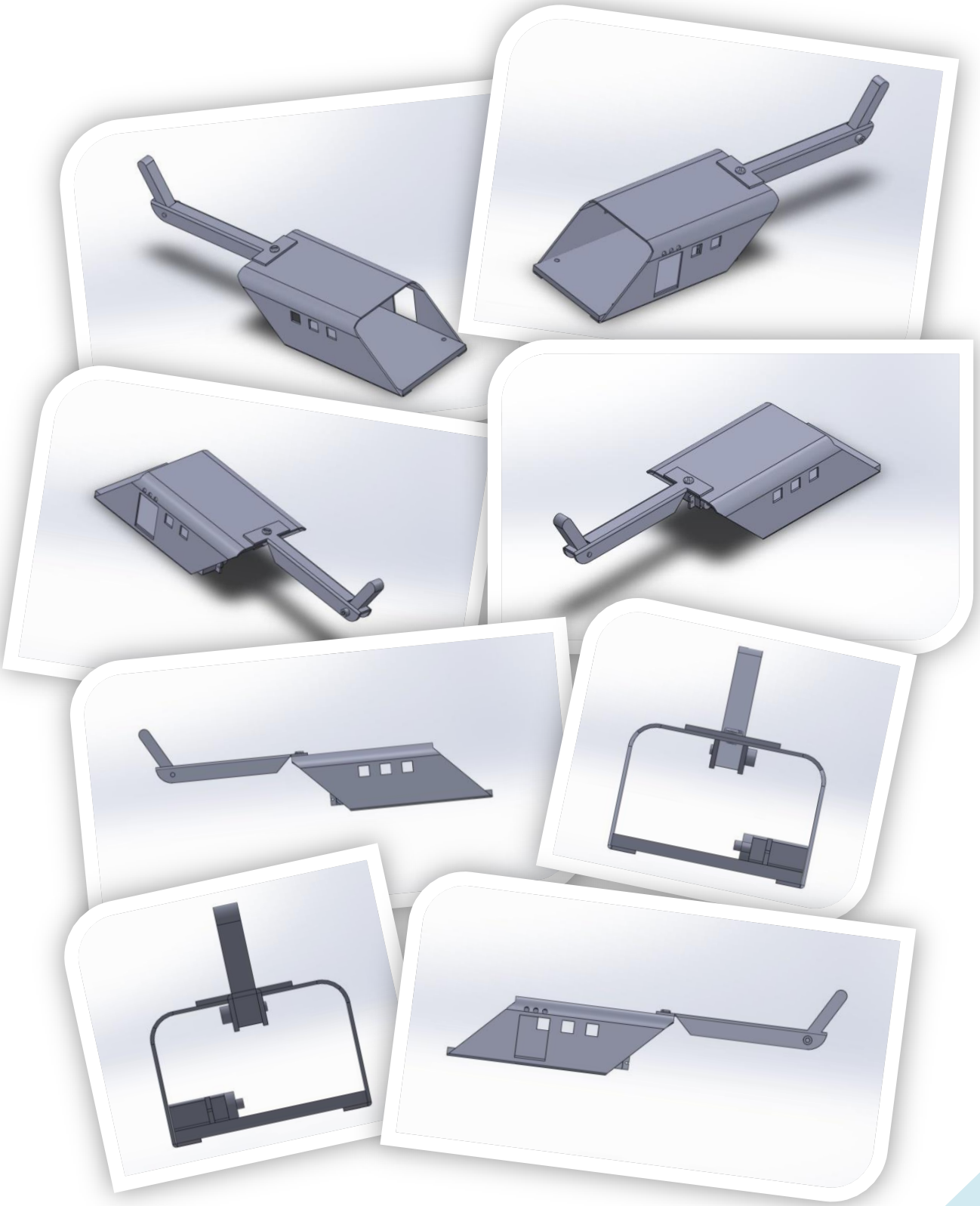
Selection of Final Design:

	Satisfies the Brief	Appealing Design	Ease of Manufacture	Cost Effective	Total Marks
Design 1	✓	✓	✗	✗	**2**
Design 2	✓	✗	✓	✓	**3**
Design 3	✓	✓	✓	✓	**4**

The table above gives an overview of the necessary requirements of the Final Design. Each of the projects has its own strengths, but **Design Three is the best of the three designs**. It incorporates the **sleek design** of Design One and the **ease of manufacture** of Design Two to make a good compromise that is **cost effective** and can be completed **within the deadline**.

Graphics of Final Design:

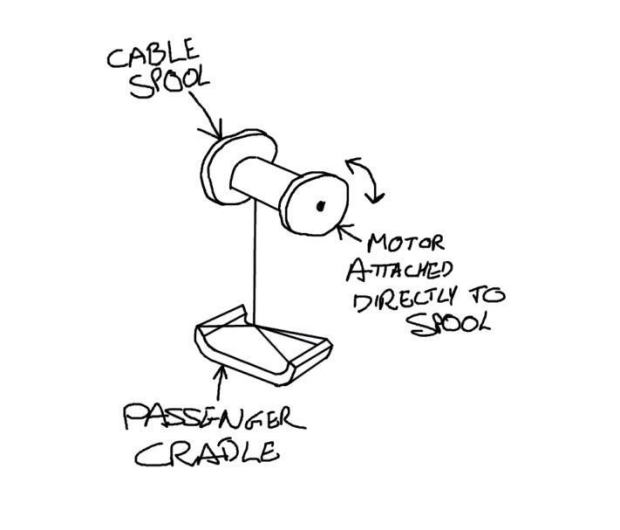
These graphics show all of the components which must be manufactured by hand and assembled into the finished project.



Electric Variable-Speed Hoist:

After researching the uses of the Hoist employed by the Irish Coast Guard on the Sikorsky S-92, I drew up some initial sketches of the Hoist system I would use. I began with several ideas, incorporating electric motors and pulley systems, among others.

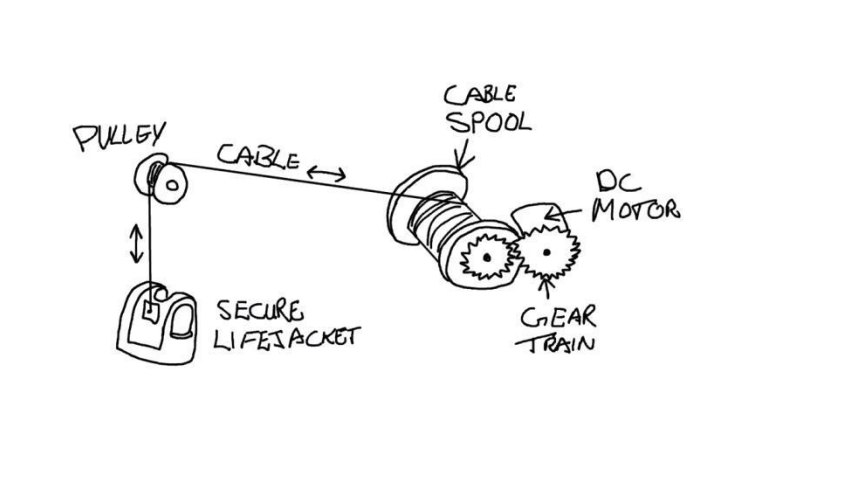
Hoist Design 1



My initial idea was to have a cable spool with a motor attached to it directly. I found this to be too cumbersome to attach to the outside of the Model. A passenger cradle was also added, as the Design Brief specifies Search and Rescue as the purpose of the Model.

My second design consisted of an external pulley which was fed from a spool kept inside the Model Helicopter. This removed the extra bulk on the exterior and kept the motor and spool secure inside the Model. I also sketched a design for a Life Jacket which could be attached to the hoist, however this would be impractical to manufacture. I therefore decided to keep the Passenger Cradle from Design 1 and the hoist/spool placement of Design 2.

Hoist Design 2

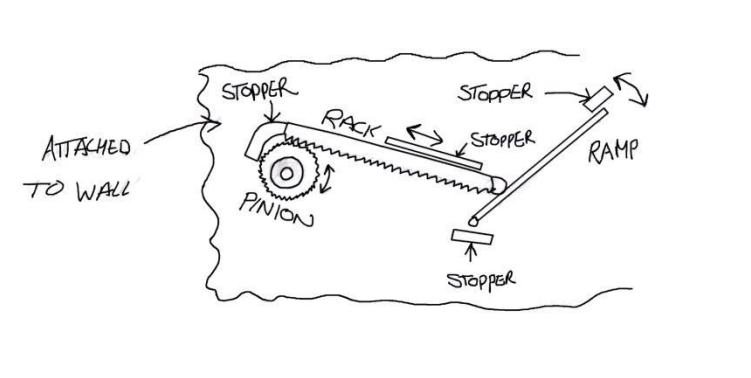


Automated Rear Ramp:

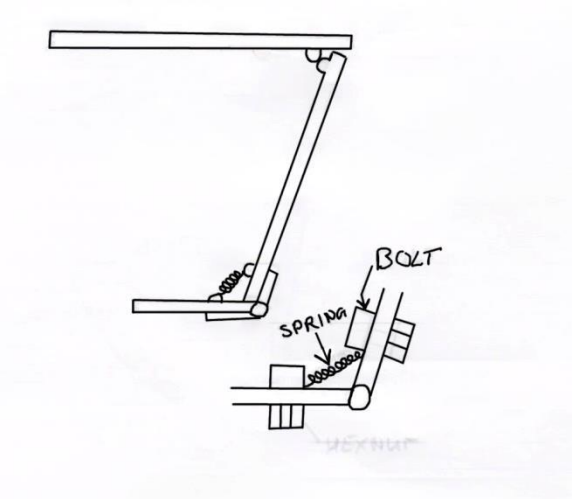
I made some initial sketches of my automated Rear Ramp system based of research into existing solutions as well as using the electromechanical techniques described in my Engineering textbook.

My initial designs consisted of a rack and pinion mechanism to open and close the rear door, by running the pinion clockwise and anticlockwise. I found this solution to be unreliable and difficult to manufacture.

Rear Ramp Design 1

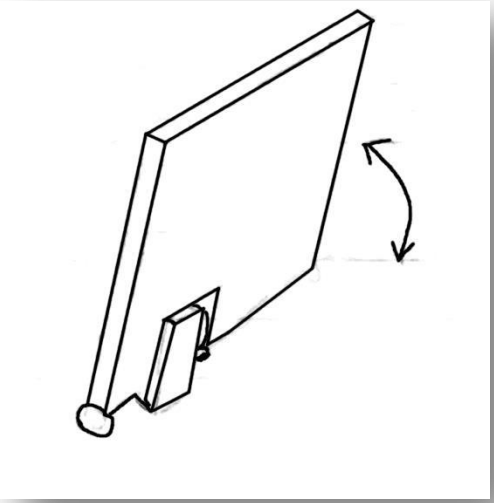


Rear Ramp Design 1, with the addition of a spring mechanism.



I then decided to include a spring in the design, which would serve to close the Rear Ramp when pressure from the rack is released. This solved the problem of unreliability with *Design 1*, however the mechanism was still difficult and time consuming to create.

Rear Ramp Design 2

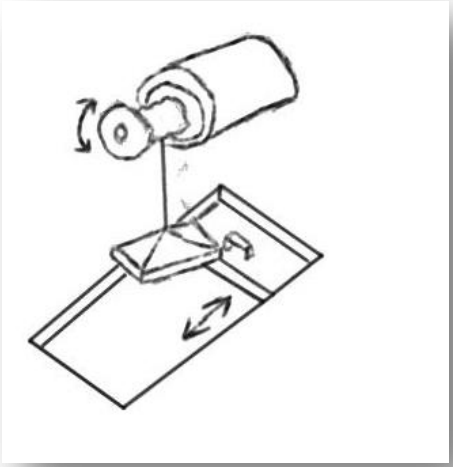


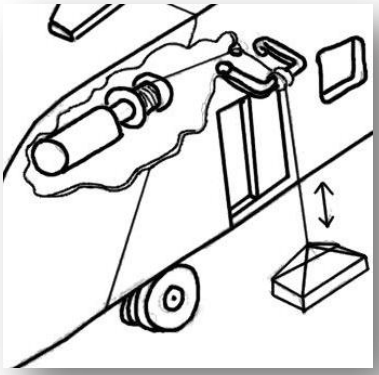
I came up with my final design after returning to my Engineering textbook and finding the section on Servo Motors. Servo Motors allow for precise rotational movement about an output shaft and can be controlled with electronic input. This is exactly what I require to meet the specifications of the Design Brief.

Sliding Door:

In keeping with the Design Brief's Search and Rescue aspect, I intend to mount my Sliding Door on the side or my Helicopter Model with the electric Hoist situated above the door. In a Search and Rescue situation, this setup would be invaluable to a rescue crew.

I had initially considered putting the Sliding Door on the interior of the model, on the floor. This would provide easy access from the exterior of the helicopter to the interior of the helicopter when using the Hoist. I felt that this option was viable, but posed a safety risk for anyone standing inside the helicopter. There is a risk of falling through the open door, resulting in injury or possibly death.



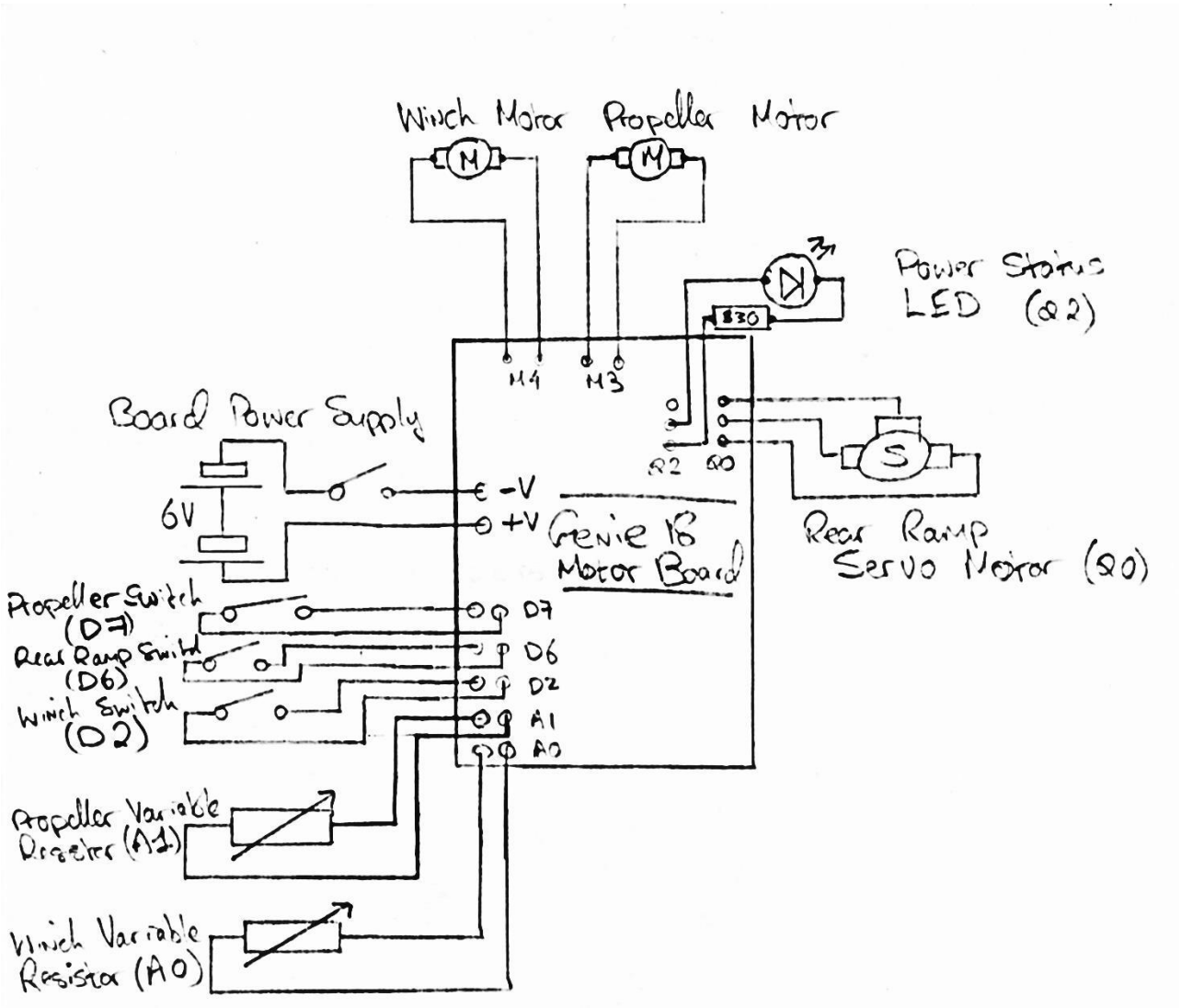


I therefore decided to put the door on the side of the helicopter. This is a safer design, since the interior floor of the helicopter is solid and passengers can move around freely. There is also excellent access to the side mounted Winch system, allowing for quick movement into and out of the helicopter.

The Sliding Door will consist of an aluminium door on a slider that can move horizontally. A handle will be attached to the door to allow the operator to move it more easily.

Electrical Systems:

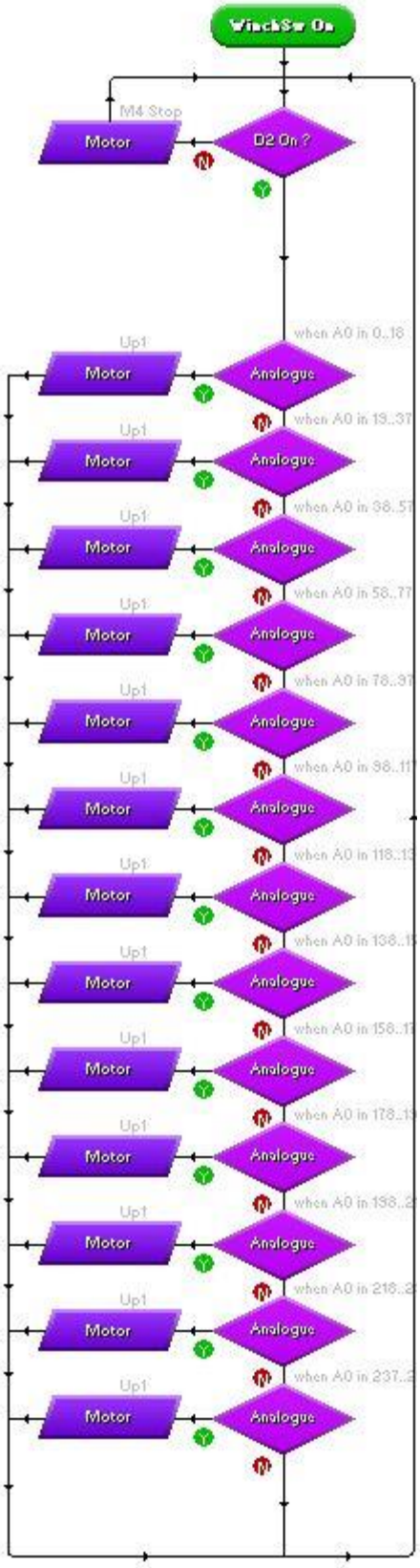
Since the Design Brief calls for multiple electrical systems to be incorporated into the project, I have decided to include a microprocessor circuit board into my design. This will act as a central "hub" to control all of the electrical systems in my project. My preferred choice is the Genie 18 Motor Board. This board is straightforward to assemble and includes connections for switches, variable resistors, DC motors and servo motors. I require control for a servo motor and two variable-speed DC motors, with inputs from switches and variable resistors.



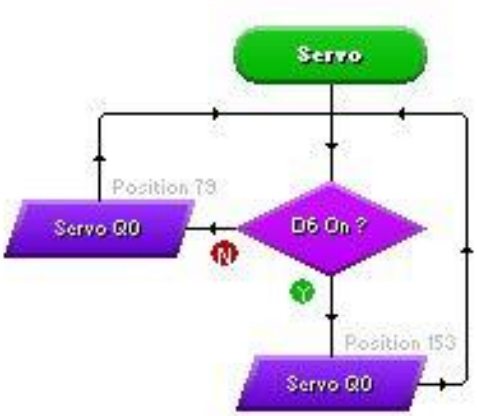
Circuit Diagram for the Genie 18 Motor Board Circuit

Program Flowchart:

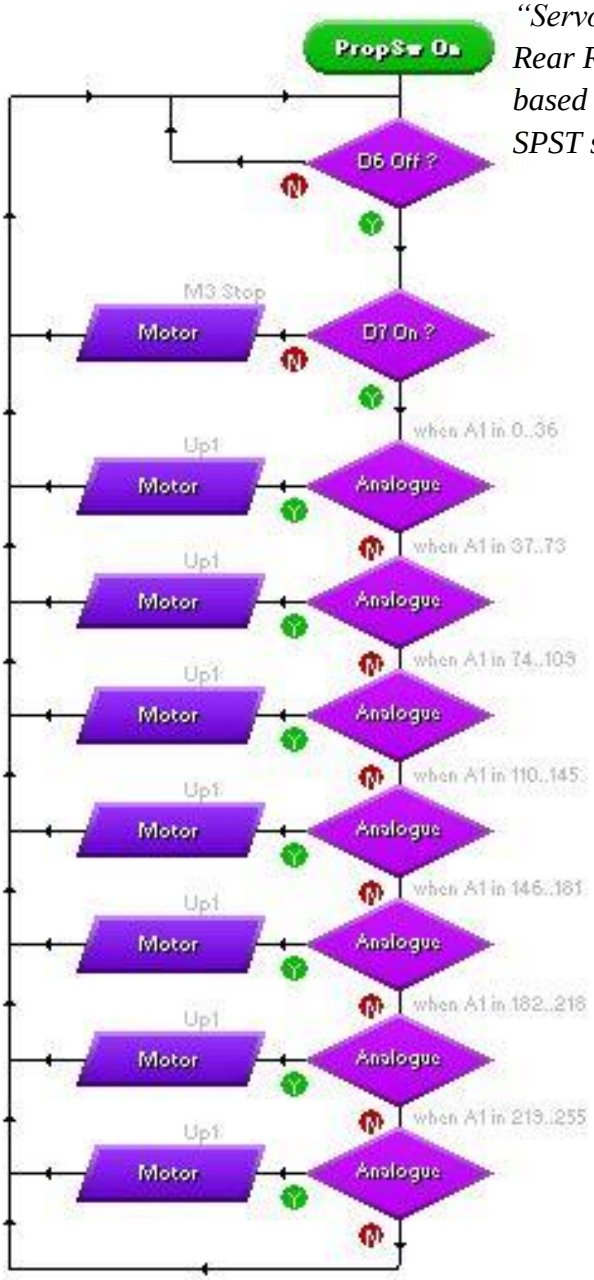
The Genie 18 microprocessor board requires me to create a program in order to control the various inputs and outputs of the electronic system. This flowchart is shown below



"WinchSw On" (left) controls the Winch DC Motor and varies its speed based on the input from the Variable Resistor



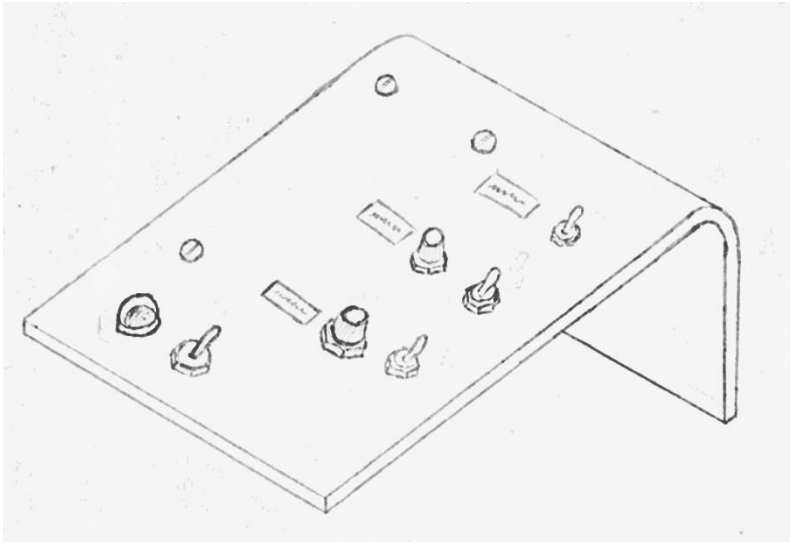
"Servo" (above) controls the Rear Ramp Servo Motor based on the input from the SPST switch.



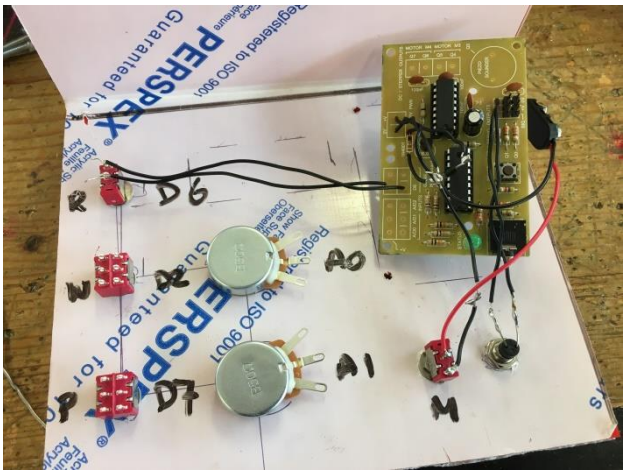
"PropSw On" (left) controls the Propeller DC Motor and varies its speed based on the input from the Variable Resistor

Control Panel:

In order to control my Helicopter model, I must include electronic systems. I have decided to move my electronic inputs and processing to a control panel. This will leave more room inside the model itself for the **Hoist** and **Rear Ramp** subsystems, as well as an optional propeller motor. By moving all of my inputs to a dedicated panel, I can ensure that the operator is away from potential dangers such as spinning rotors and other hazards. I will also be able to clearly label each component to better facilitate the operation of the model.

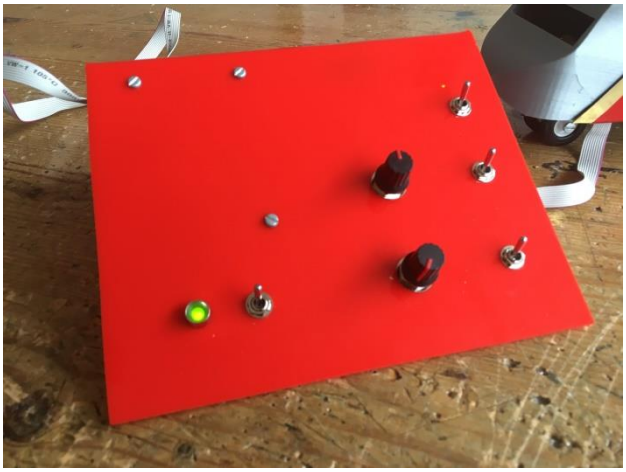


Sketch of the Control Panel



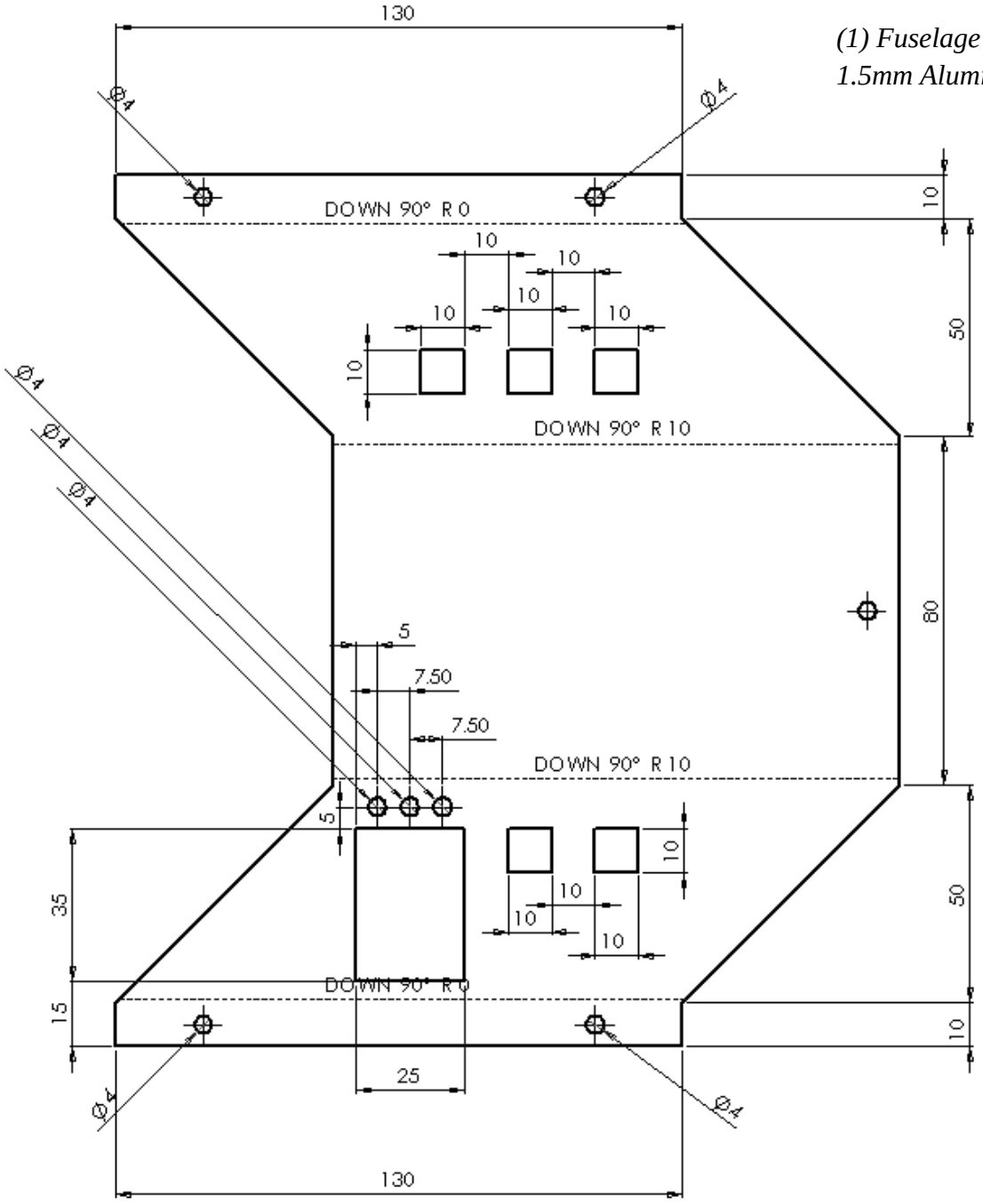
Control Panel wiring being assembled

Control Panel before finishing



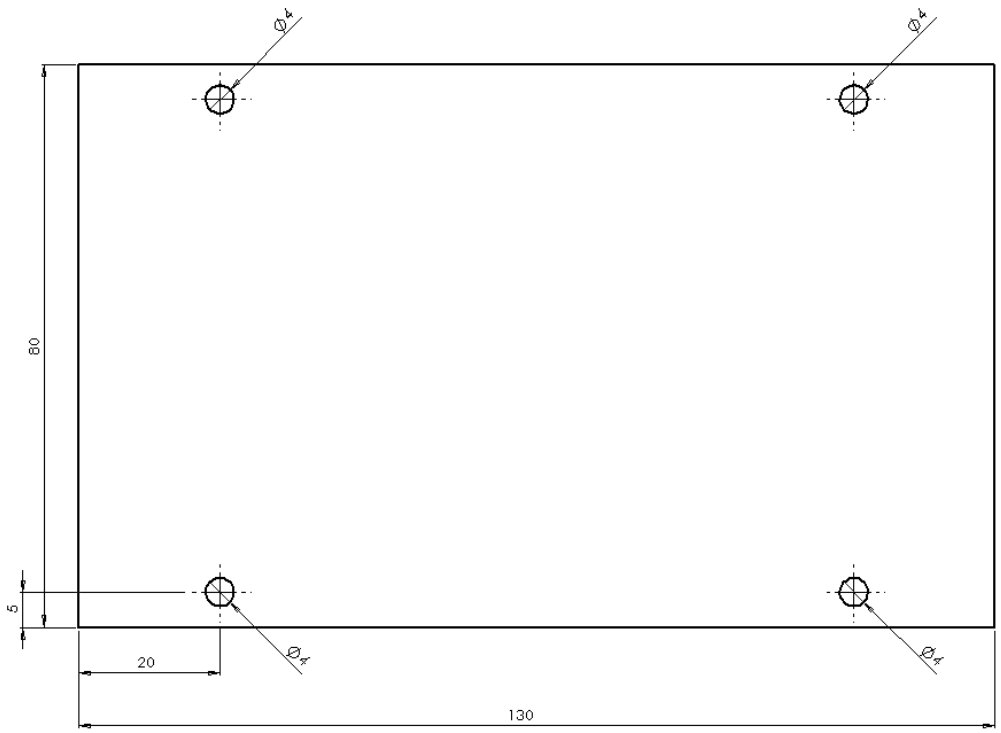
Finished Control Panel

Production Drawings:



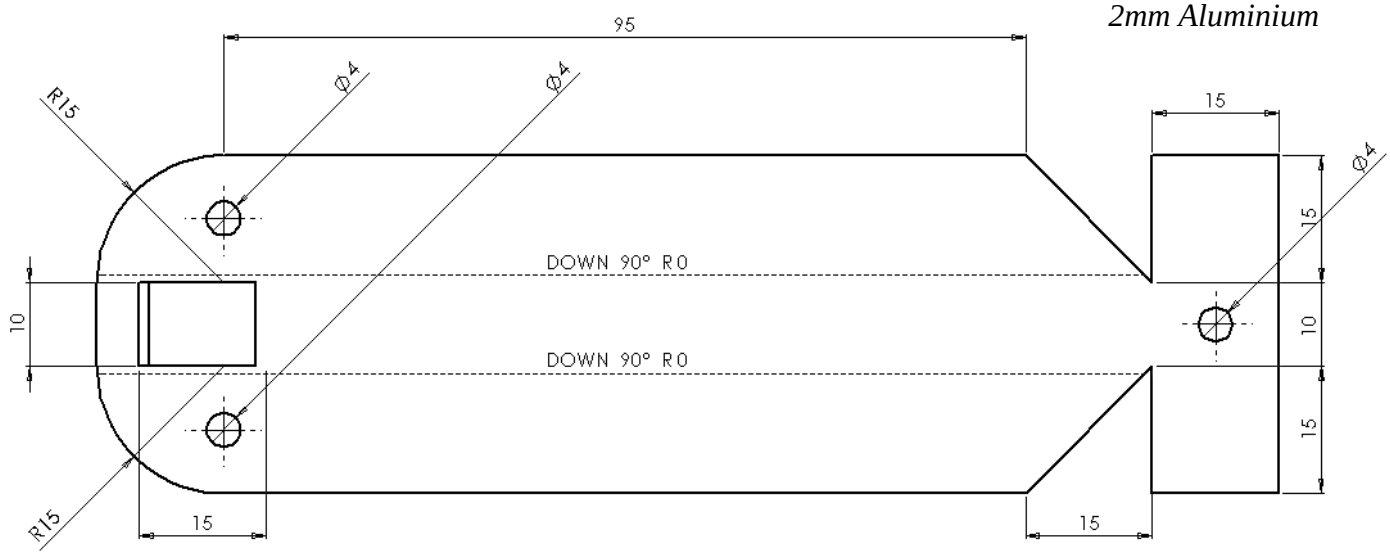
(1) Fuselage
1.5mm Aluminium

Production Drawings:

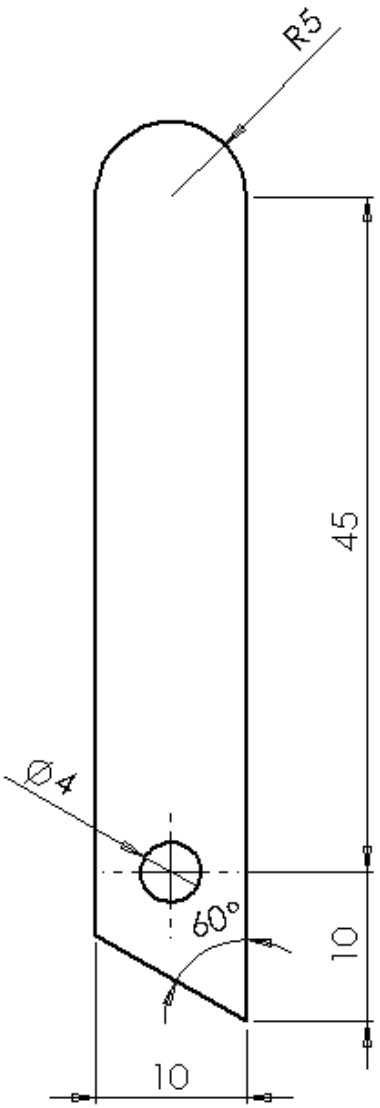


(2) Fuselage Base
5mm Acrylic

(3) Tail Connector
2mm Aluminium



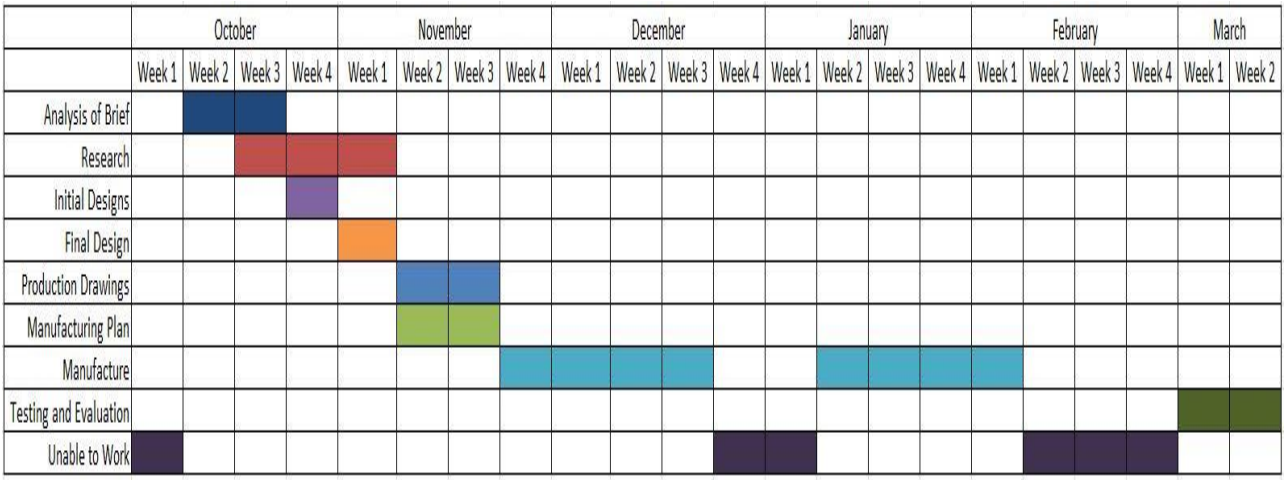
Production Drawings:



(4) Tail
10mm Aluminium Square Bar

Plan for Manufacture:

Before beginning my project, I made a timeline to organise the time I had to complete each task.



The Design Brief was released in the second week of October 2016 and the project must be completed before the 10th March 2017. I am unable to work during school holidays, however I can keep my portfolio up to date during this time. I have structured the timetable to allow ample time to **analyse** the Design Brief, to **research** different solutions, to **design** a working model of my project and finalise those designs in **Production Drawings**, to **manufacture** my designed project and to **test and evaluate** the project, making changes where necessary to ensure it meets the requirements of the Design Brief.

Before beginning my manufacturing stage, I wrote up a list of the different aspects of the manufacturing process and the order in which those aspects must be completed in order to achieve the desired result.

Step One – Datum Reference / Datum Edge

This is a crucial first step in any manufacturing process. An accurate datum edge ensures that all subsequent measurements made on the part are precise and correct.

Step Two – Marking Out

Once a datum edge has been attained, the part must be marked out accurately, following the Production Drawings exactly. Precise marking out ensures that later shaping processes result in an accurate finished part.

Plan for Manufacture:

Step Three – Drilling

Drilling is done before the cutting stage so that square edges still remain in order to hold the work securely in the vice. Accurate drill holes are important and holes should be marked with a dot punch before drilling. When drilling larger holes, a pilot hole should be drilled first. Also, ensure the correct feed rate and speed of the drill is being used for the material being drilled.

Step Four – Cutting

Cutting is usually carried out with a Hacksaw or Coping Saw. The work should be held firmly in the vice and the cut should be made vertically downwards. Ensure enough material is left on the line of cut to be filed to line. This ensures a good surface finish on the work, as rough cutting with a hacksaw or coping saw leaves rough, uneven edges.

Step Five – Filing

Filing is the removal of small amounts of material from the work piece. Many different files can be used depending on the shape of the surface or how much material is to be taken off. Ideally, a smooth file should be used after rough filing. Draw filing can then be done to remove tool marks and leave a smoother surface for sanding and polishing.

Step Six – Sanding and Polishing

Once the material has been filed to line, emery cloth of different grades can be used to smooth the surface even further. This leaves the surface ready for polishing. A polish can be applied after the part is completely finished being shaped. The polish brings out the material's surface appearance and gives the part an appealing look.

If these steps are followed in order, the parts to be produced will be finished to a high quality and accuracy. The precise manufacture of each part ensures that assembly is a much simpler task, as part dimensions will not need to be altered to fit together. This speeds up production time considerably.

Plan for Manufacture:

In order to better organise my manufacturing process, I created a Parts List and outlined each part required for my project. I also costed all of those parts to get a reasonable estimate as to the final cost of the project. As with many projects undertaken in Engineering, costing is an important factor in ensuring a design is viable.

Part Number	Material	Size (mm)	Amount
1	Aluminium	200x180x1.5	1
2	Acrylic	**130**x**80**x**4**	1
3	Aluminium	140x45x2	1
4	Aluminium	60x**10**x**10**	1
5	Aluminium	80x75x1.5	1
6	Aluminium Bar	⌀30x25	1
7	Polystyrene	300x40x3	2
8	Hex Bolt	M4x15	4
9	Hex Nut	M4	1
10	Threaded Bar	M4x25	3

Material	As Supplied	Required	Cost Per Unit (€)
Aluminium	1250x625x1.5	1	94.19
Acrylic	1000x1000x4	1	28.50
Aluminium	1250x625x2	1	52.88
Aluminium	10x10x1000	1	15.99
Aluminium Bar	⌀30xA	1	
Polystyrene		1	
Genie 18	-	1	10.65
DC Motor	-	2	2.07
Servo Motor	-	1	5.35
Pulley Set	-	1	
Hex Bolt	M4x15	4	0.04
Hex Nut	M4	1	0.02
			Total: €

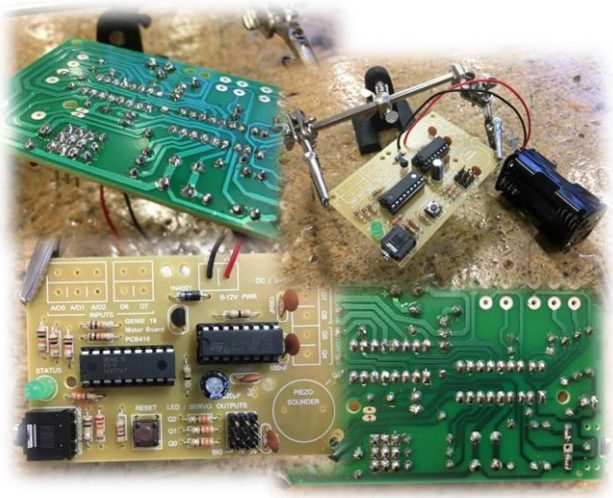
This cost list takes into account standard sheets of Acrylic and Aluminium available to purchase. It is important to remember that if the project was to be mass produced, the cost of materials would be significantly lower.

Manufacture:

The manufacturing stage lasted from Week 4 of November 2016 until Week 1 of February 2017. This gave me ample time to complete the project. The detailed plans I had made for manufacture as well as 3D renderings of the final design aided me greatly in my manufacturing stage. I have outlined some key elements of my manufacturing stage below.

Genie 18 Circuit Board and Electronic Assembly:

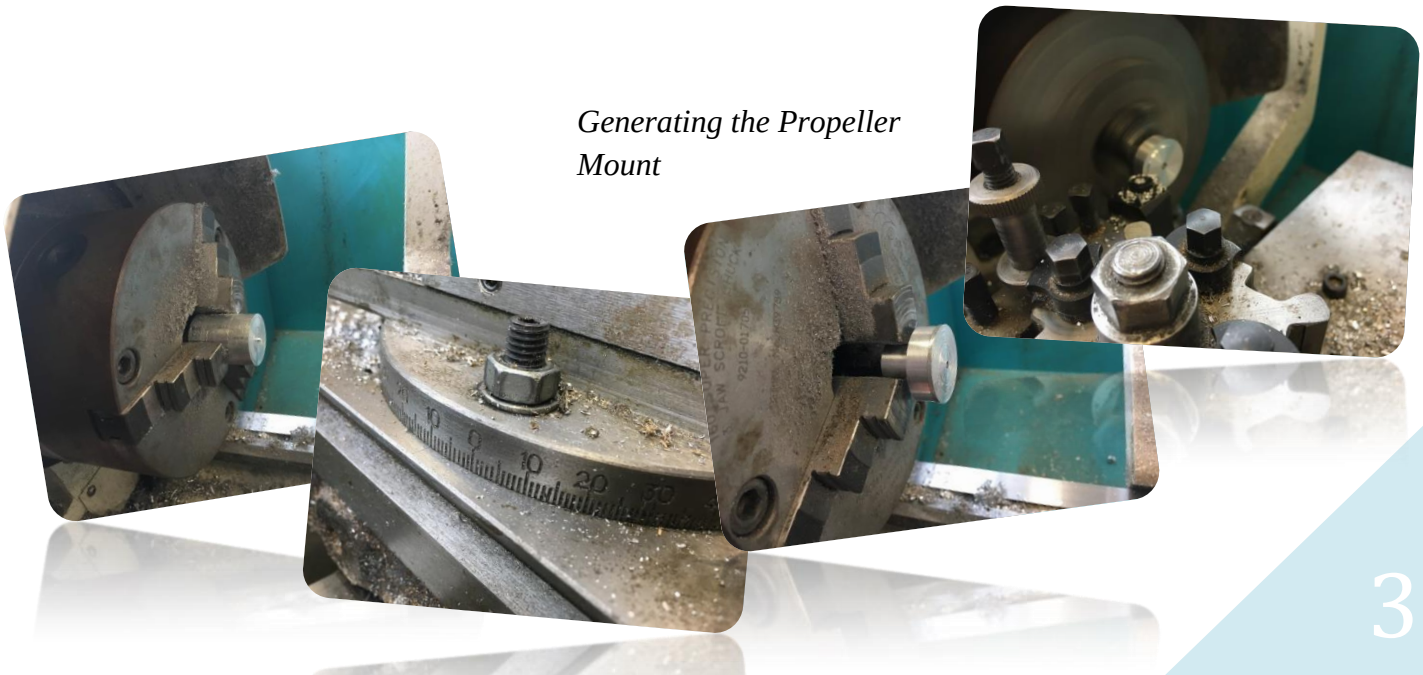
The manufacture of this circuit board required specialised manufacturing processes including knowledge of electronic components, soldering, and basic computer programming with the Genie Design Studio. This component controls the electronic mechanisms in the project including the Rear Ramp, Winch, and Propeller.



Soldering the Genie 18 Motor Board

Propeller Mount and Lathe Work:

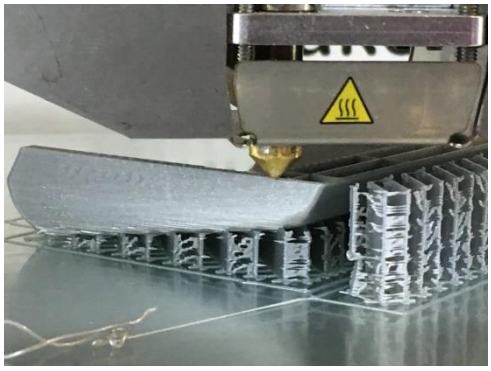
The cylindrical propeller mount required the use of the Workshop Lathe knowledge of parallel turning, taper turning, facing off, and parting off generating processes. This piece holds the propeller blades and attaches to the propeller motor by means of a spacer.



Generating the Propeller Mount

Manufacture:

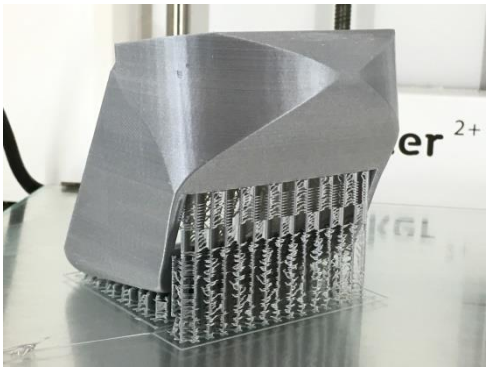
Helicopter Cabin and Rapid Prototyping:



The 3D Printer produces the component by applying layer upon layer of thermoplastic polymer.

The Helicopter Cabin was a unique component of this project. While the design brief does not specifically call for a front cabin, I decided to include one to make the model more aesthetically pleasing.

Helicopter cabins are normally rounded at the front in order to lower air resistance. This design would be difficult to manufacture accurately. Using a vacuum forming mould would require unattractive draft angles. I needed a way to create this complex shape while maintaining clean, 90 degree corners. I decided to create this cosmetic piece using Rapid Prototyping, specifically 3D Printing.



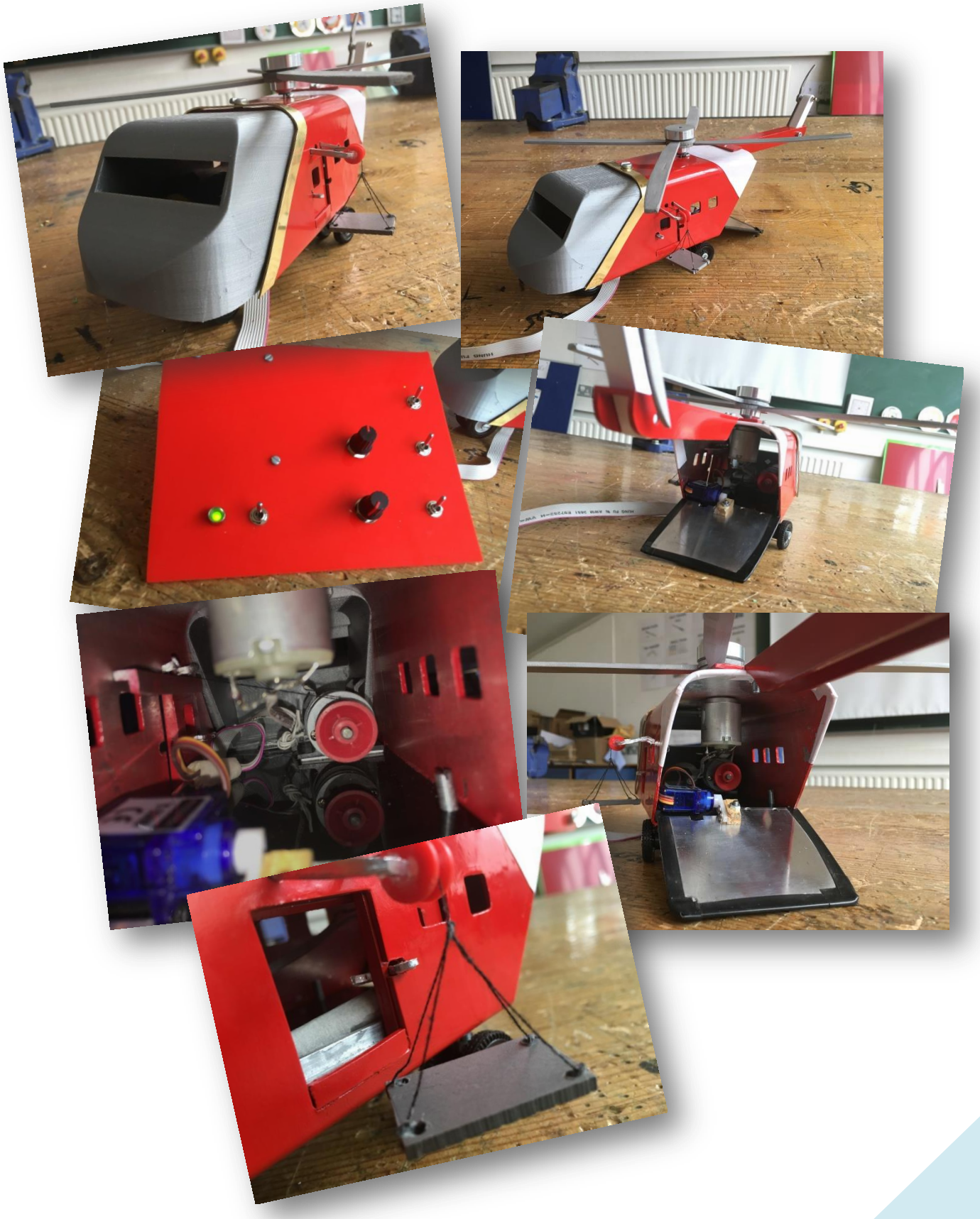
As the layers build up, the 3D Printer also creates supports to strengthen the structure and provide a platform to print upon. These supports can be easily removed with needle nose pliers and the surface finished with emery paper

Firstly, I designed the cabin in *SolidWorks*, taking measurements directly from my project to ensure a close fit. I then uploaded the finished file to the 3D Printer for production. The component took five hours to complete. The Printer produced a very accurate and highly finished part for me to use in the project and it required little finishing, except for the support structures added by the printer for stability and the holes needed to secure the component to the fuselage.

The finished component attached to the final project. The component was a close fit on the fuselage

This method was advantageous not only because I could get an accurate result, but also because of the time saved in the manufacture of this component. I was able to spend my time perfecting other aspects of my project instead of concerning myself on a less important and purely cosmetic aspect of the design.

Final Project:



Testing and Evaluation:

Testing:

Once the manufacturing stage of the project was complete, I performed an evaluation on the performance of the product. This ensured that it met all the requirements of the Design Brief.
Before beginning my evaluation, I reviewed the Design Brief specifications to ensure I reviewed every requirement of the brief. The model met all of the requirements of the Design Brief. I have incorporated a **sliding door**, an **automated rear ramp**, and an **electric variable speed winch/hoist**. The project functions adequately with regards to these mechanisms.
Additionally, my finished project meets the specific requirements of the Design Brief, outlined on page 2. My project is **unique and of my own design**, it was completed **within the school workshop under the supervision of my Engineering teacher**, and was completed **before the deadline**. My maximum dimension is **below 350mm**, and my maximum voltage is **below the limit** of 9V. My **examination number** is also **clearly marked** on both my **project** and my **portfolio**.

In order to test each component part of my electronic and mechanical systems, I put them through thorough testing. I toggled the Rear Ramp switch repeatedly to ensure it will stand up to continual use and I also applied a moderate pressure to the ramp to see how it holds up to force. The ramp held up well and did not fail. For the Winch, I added progressively heavier weights to test the capability of the winch to carry objects to and from the helicopter. I repeatedly activated the winch and varied its speed to ensure it was consistent in its operation. The winch functioned perfectly adequately. The propeller was tested by turning on the propeller and varying the speed to ensure consistent results. I also attempted to stop the blades while they rotated by introducing a length of card. The propeller stopped, with no damage to it or the card. The low density polymer ensures that if someone's hand were to be caught in the spinning rotors no damage would be done. For the Sliding Door, I repeatedly opened and closed the door to ensure it did seize up. This mechanism also functioned as desired.

Overall, the testing phase was a complete success, with all parts functioning as planned.

Testing and Evaluation:

Evaluation:

I thoroughly tested all of the mechanical aspects of my project to ensure they fulfilled their requirements. While testing my electronic components, I had to make changes to my computer program and also to some of my electronic components.
The positioning of the Rear Ramp servo motor is very precise and the servo will not automatically stop if it encounters resistance to its movement. For this reason, I had to ensure the ramp's open and closed positions were clear of the fuselage and the ground.
I also encountered difficulty with the variable resistors I used to control the direction and speed of the winch and the speed of the propeller. The range of resistance of the variable resistors was from 0Ω to 50Ω. This range is too small to be detected by the Genie 18 board. As a result, I had to change the variable resistors I used, to ensure the project functioned as required.

Overall, I am happy with how the project went. I prepared well in advance of manufacture and as a result, I encountered few problems in my design. The use of 3D modelling in *SolidWorks* and the creation of a cardboard prototype of my finished project aided me greatly in overcoming challenges in design and manufacture.

This project heightened my understanding of many different aspects of the Leaving Certificate Engineering curriculum. I have learned and honed many skills through the completion of this project, such as working with electronics, computer programming, precision manufacturing, and careful planning. These skills will help me greatly in my Written and Day Practical Examinations and also later on in Third Level Education.

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