Engineering You're Hired!

Electric Aircraft

Hub 6 - Team A

Technical Scope - Project Delivery Plan - Security and Assurances

In order to become a sustainable society, the greenhouse gas emissions that aircraft produce is a concerning issue that must be fixed. Our electric aircraft proposal is a green solution to this problem. By replacing a conventional engine of a traditional plane with a state of the art rechargeable battery, the emissions created from each flight will be completely cut down.

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Technical Performance data:

- Upgraded ATR 72-600 aircraft
- Purely electric system
- 2 electric motor driven propellers
- Range of up to 500km
- 78 passenger capacity
- Lithium-air battery cells
- Solar power, Regenerative Braking and extreme fast charging systems

The ATR 72-600 was chosen due to its already fuel efficient design, and its ability to perform in all environments and climates.[1]

Purchasing these aircraft and modifying them eliminate the additional costs and time requirements for developing and certifying a new design

Battery Development:

Newly developing battery technology will enable the implementation of 500Wh/kg lithium-air batteries into the aircraft as a power source. At only 20% [2] of the weight of lithium-ion counter parts, they will deliver the required power to the driving electric motors without being at risk of surpassing the maximum aircraft take-off weight of 23,000kg [3]. At a current expected lifetime of 1000 cycles [4], it is expected for the batteries to last for 3 years before a replacement is required.

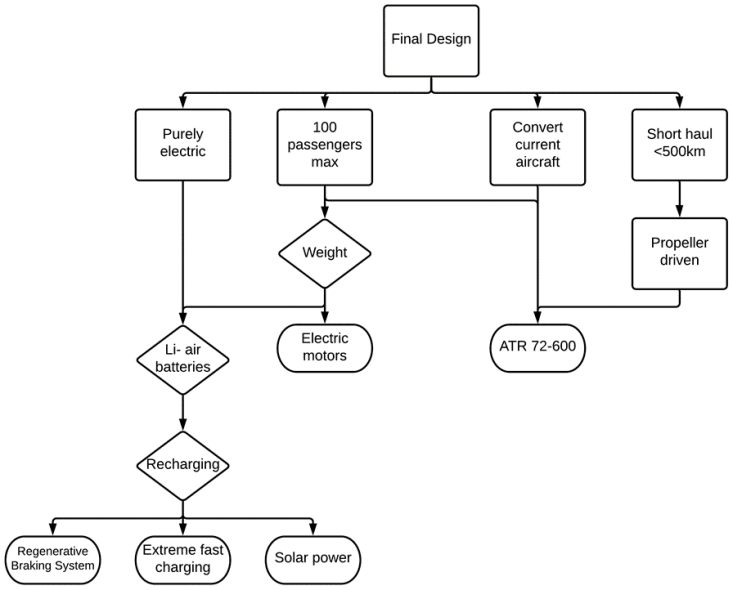

Figure 1: Project block diagram

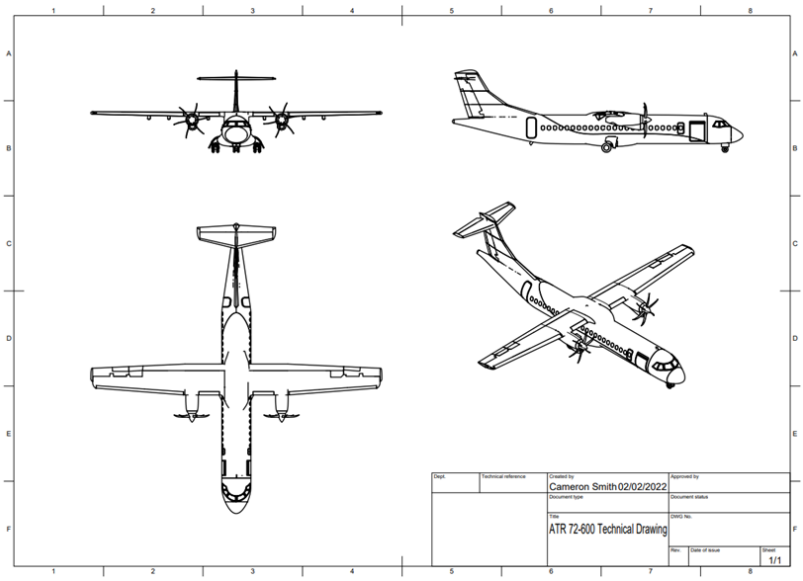

Figure 2: Technical drawings of modified ATR 72-600

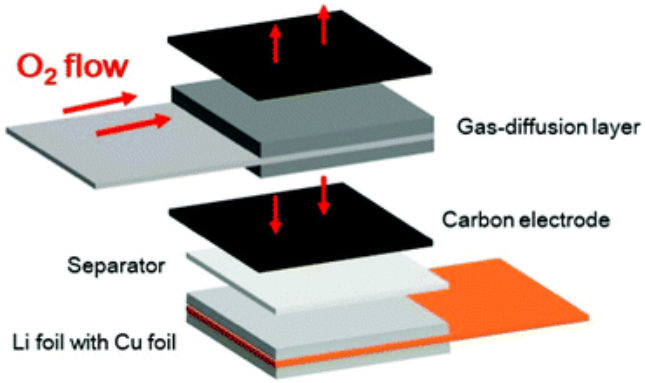

Figure 3: Schematic image of Multi-stacked LAB-cell [5]

Charging Proposal:

A combination of three charging methods are to be used. Second generation Solar cells located on the wings of the craft, a regenerative braking system incorporated into the landing gear and "eXtreme Fast Charge Cell Evaluation" (X.CEL) when grounded. A system currently under development at Argonne National Laboratory [6]

X.CEL will be the most effective method, and will be installed at all airports this craft will operate from

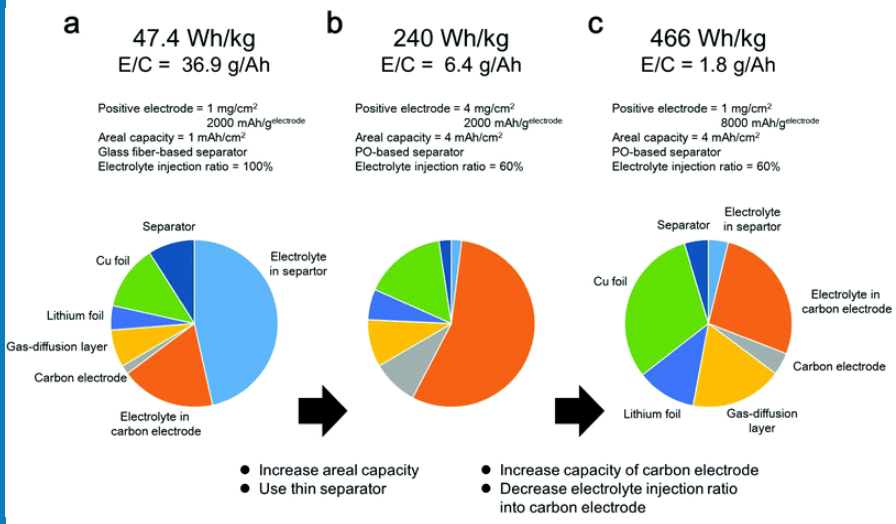

Figure 4: Energy density simulation of Lithium-air batteries [7]

Annual Operating Costs (£)		Product Costs (£) Annual	
Labor Costs	£45,500	**ATR-72600 (Aircraft to Upgrade)**	£480,000-1,440,000
Maintenance of the Battery	£500-600	**Lithium-Air Batteries (3 years life cycle)**	£330,000-400,000
Maintenance of the ATR-72600	£30,000 (£84,000 for a fuel-based plane)	**2nd Generation Solar Cells (15 years life cycle)**	£50-100 /m² ≈ £6100-12200 for the whole wing area
Other Equipment/Overheads	£100,000	**Certification of Airworthiness**	£320,000
		Engineering Costs (Hours x Rate)	£35,000
Total (Average)	£175,550	**Total (Average)**	£1,689,150

Figure 5: Cost analysis of ATR 72-600 conversion

Feasibility and integration:

Some aspects of the aircraft relies on technology which is currently under development.. These areas of technology have been identified and researched to provide a gauge of what will come in the future.

- Battery energy density has increased by 90% over the past decade - further increase following this trend estimated to deliver over 650Wh/kg energy density [8], and can be applied for longer distance journeys.
- Development of regenerative braking from a plane's landing gear is in progress in a number of projects - the development of this concept faces a number of challenges surrounding the weight of the electronic systems required.
- The potential of X.CEL is currently being investigated and developed - the technology has been proven to work on a single cell level.

All technologies have a high likelihood of becoming a reality within the project time frame, suggesting this project will be a success.

Integration of the aircraft comes with a degree of ease thanks to the model of aircraft already being in circulation, and the only additional requirement being charging stations for X.CEL. The European market will be targeted first, with the highest density of short haul flights, before expanding.

Safety:

To ensure a high standard of overall safety for the aircraft the aircraft will be subject to a scrutinous certification process before being put into service. Such certification process will include the following:

- Review stage of proposed designs
- Ground tests and test flights
- An evaluation of the aircraft required maintenance and intended operation
- Review from a selected panel of aviation experts

In addition to this in house certification process applications will be submitted to receive an official Certificate of Airworthiness, which will allow the aircraft to be put into service.

Identified risk:	Airworthiness	Lithium air batteries	Investment
Evaluation of risk:	Lack of airworthiness could produce catastrophic results	Batteries are high flammable and sensitive to extreme	The required funding for this project is large
Risk handling:	Planes should be subject to scrutinous checks and should receive high quality maintenance	Batteries should receive routine checks. batteries could be encased in fire retardant material to prevent fires	The aircraft will be rolled out as swiftly as possible. If the technology desired isn't available at time of launch, updates will be made to the aircraft during its lifetime.
Risk control:	Pilots must follow pre-flight procedures and the plane should be checked every other day	Maintenance team should check the batteries every other day	To ensure technology is developed investment into the research and design will be made.

Figure 6: Basic risk analysis of project

Project Timeline

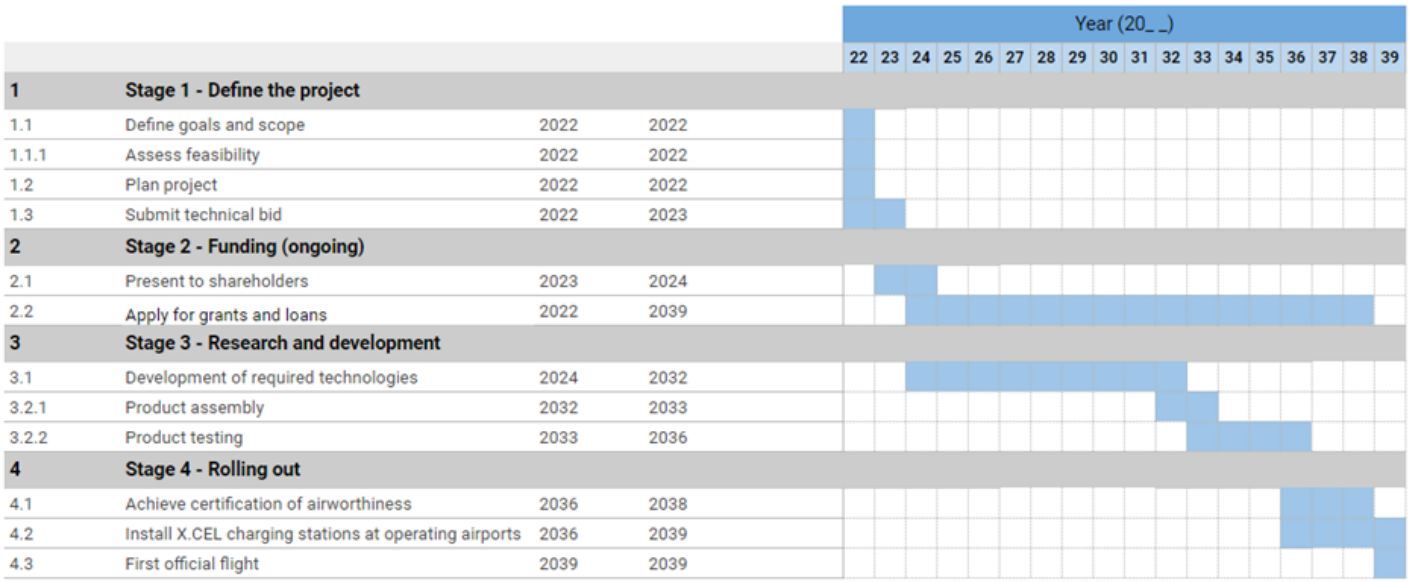

Figure 7: Project timeline Gantt chart

The Planned duration of the project will be an estimated 17 years, with the majority of that time focusing of the development of the required technology. Throughout the project funding applications will continue to be held, as profits won't be made for a number of years. Once the battery development reaches a suitable level, the technology can be sold to car manufacturers to aid in the United Kingdom's target of banning the sales of petrol and diesel vehicles by 2030.

Our Commitment to Sustainability:

The sustainability of this particular design has been deeply considered during the ideas development. There are a number of UN sustainability goals that we have identified as important targets to be met for our design,these are goal numbers: 7,11,12 and 13. *A visual explanation of each can be seen below.*

Investment and innovation in battery and motor technology will drive down the associated costs making the development of electrical aircraft a more financially viable option. Additionally the usage of solar cells within the wings of the plane to partially charge the batteries make use of zero GHG energy production.

Communities will be connected by electrical aircrafts through the introduction of this aircraft. This is an increasingly sustainable method of transport

Without electric aircraft air travel is not a sustainable consumption of energy. The potential increase in sustainability provided by the electrification of aircrafts can develop air travel to a point were it becomes sustainable

A fully electric aircraft makes a positive impact as the emissions of air travel will be drastically reduced.[9]

In addition to the sustainability goals, we shall be meeting considerations for the planes as they are retired. There are two particular ways we believe we can make a positive impact after the retirement:

1. 2nd life battery schemes - degraded batteries can be donated to schemes which look to make usage of the batteries as an energy storage solution. This would be a useful step in promoting the adoption of renewable energy particularly if such a scheme could be executed in less developed countries.[10]
2. Artificial coral reefs - the retired craft can be stripped to its bare components and placed on _the sea bed, this in term will promote marine life and in turn increase the health of the ocean

Cyber security statement:

These policies detail how we aim to handle certain issues surrounding business operations, ensuring that everybody is safe and following the best practices. Firstly, to keep companies safe from malicious software, firewalls will be enabled which will protect our network by filtering incoming and outgoing network traffic and blocking unknown networks from gaining unauthorized access as well as antivirus software downloaded and activated. This will help prevent spams, phishing, ransomware. Furthermore, following the GDPR (General Data Protection Regulation) encryption policies would be implemented so that sensitive information within the company will be obscured unless accessed by approved users[11]. In addition, password and email policies will be put into operation, this will detail advice on creating strong passwords and systems will be implemented to make staff change their passwords on a regular basis and should avoid writing them down in visible locations. Another policy which would benefit from criminals getting hold of sensitive information would be an acceptable use policy to block any unauthorized websites to prevent potential viruses and also sensitive information will be available to certain staff depending on their role in the company[12]. All these measures will be put into operation in order to prevent another data breach similar to one experienced by Cathay Pacific Airways where 9.4 million records were breached[13].

Team Name	Electric Aircraft - Hub 06 - Team A				
Cameron Smith	**Luke Spurr**	**Mafaz Syed**	**Tim Ketkar**	**Robbie Bowen**	**Qingquan Hu**
					
Aerospace Engineer	**Aerospace Engineer**	**Mechanical Engineer**	**Electrical Engineering**	**Mechanical Engineer**	**Natural language processing Engineer**
As an aerospace engineer, I have experience in the design and use of aircraft. This includes the structures and materials used to provide safe and efficient flight, optimising fuel efficiency to lessen the effect flying has on the environment and power to weight ratio for increased speed in military settings, or range and passenger numbers in a commercial one.	As an Aerospace engineer I have an understanding on materials and manufacturing techniques of aircraft. Also I have a basic knowledge on structures, fluid/thermodynamics and an awareness of the impact traditional combustion engines have on the environment. Safety is also of great importance and will need to consider the safety of our design and for it to meet guidelines set in place.	As a mechanical engineer, I am capable of providing expertise on combustion engines and gas turbines that would best suit the design, and perform calculations to define the engine's efficiency. These calculations will give an insight into the working conditions of the equipment, therefore aiding in selecting a suitable material.	As an Electrical engineer I will be able to provide advice on the electrical systems used within the design: i.e power sources, communications, electrical motors. Additionally I will be able to provide knowledge on renewable energy sources which will be an important step in producing a sustainable solution.	As a Mechanical Engineer I will be able to help develop designs of the key aspects of the plane, such as the engine and general shape, whilst considering the manufacturing process. The process will involve iterations that optimise the overall efficiency of the plane so that maximum thrust is generated.	As a NLP Engineer I am going to Help the electronic systems in the aircraft cabin become more intelligent. For example, through voice recognition, the temperature of the air conditioner and the brightness of the lights can be adjusted according to the needs of passengers. Or based on the information provided by the radar, through image recognition, the precise objects passing in front of the aircraft are analyzed.

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