

Module : Research method and professional
Development [ACPA7004]

Research Proposal on
*Sustainable approach in aircraft seating system
for less CO2 emission.*

Course : MSc Industry 4.0 Advanced
Manufacturing

Supervisor : Graham Howe

Prepared by

Student : Rahul Bhosale
(University of Wales Trinity Saint David)

Email: 2116970@student.uwtsd.ac.uk

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Abstract

In today's world, aircraft industry has been developing intensive research in zero carbon emission on commercial aircraft. Research also shows that alternative in fuel will definitely lead to reduce this emission. Many organizations concluded that hydrogen fuel is the most viable low carbon emission fuel in aircraft and hybrid system. The aircraft interior is responsible for a proportion of impact on environment. It's been noticed that the aircraft interior is responsible for 6% and 12% in aerospace industry. The research shows the material classification of aircraft interiors & alternative that can be used which will contribute to minimize the CO₂ emission.

Transportation is one of the reasons of increasing CO₂ in the air. This carbon should be controlled to reduce air pollution. The research shows the factors that can be controlled for less CO₂ emission by aircraft transportation. (Ikhlas, 2017, Vol.28(2))

Introduction

The contribution of aircraft industry to change in climate is increasing considerably, as compared to other industries which can control the CO₂ level as they have less restriction. It has been observed that the pressure on airline industry to address environmental impact from many years ago but now study shows that due to launch of various organizations requiring airlines to get carbon credits to minimize this in international flights. Also, the emission matrix was introduced so that airlines can get an idea about how much carbon dioxide emission they are responsible for. Investigation shows that design approaches with new material implementation can be developed to have greener products.

This research understands that gap and introduces different ways to control the emission. Premium seating system is one of those (first class and business class). This may lead to a bigger part of fuel burn as they required more floor area on the aircraft thus more CO₂ intensive per RPK than the other type of seat like economy. In most of the flights premium seating is in larger amount.

The Environment - Market Analysis

According to the survey reports, the current thinking toward aircraft emissions. According to "The Pew Research Center 2021" 72% of young people think climate change is a big concern. (Pew Research). Other resources like the "NATS Aviation Index 2020" is the number one priority that emission should be reduced. Other than concentrating on the flight time and destination airport expansion. (NATS). The "CAA UK Consumer Survey 2020" states that to reduce the impact on the environment 36% would pay the flight fair more. Airbus is also doing research in upcoming years to minimize the CO₂ emission. (CAA)

Literature review - Climate & Aviation

There is a number of factors in aviation Co2 emission. If we look around the perimeter Aviation is contributing to global warming through its Co2 emission. In the first case, the commercial is responsible for 2.7% of CO2 emissions in previous years. Strategies for minimizing the non-CO2 effects provide big role for minimizing aerospace climate change. Their values must be defined. Transit in the air sector will play an important role & the massive use of low carbon resources could then lead to more environmental problems. This may lead to land use instead of air. The design of cabin components with advanced materials leads to control the co2 emission in aircraft industry. This research shows qualitative review on climate change and the significant issue affecting aviation in changing climate and adaptation. The development in the policy and the procedure required. (Baumeister, 2020)

Solutions on challenges - CO2 Analysis

The aircraft cabin design is most of the time matured and fixed as per the airline restriction so weight reduction in this region is a very challenging task. A new technique for reducing the weight is by changing the manufacturing process of developing the part. the process of additive, manufacturing is one of them and many organizations are developing their parts with this methodology. The cabin is the most difficult part to perform a circular economy. To minimize the impact of new technologies, new product development on aircraft cabin interiors should be implemented by identifying sustainability issues & implementing circularity design. assess the development timeframe and inline them in sequence as per their stages. Be a part of value chain which Involves the whole new cabin development. Enable the re-use of the parts and components waste after production .Identify the material and share the data to reuse. Define full-life strategies to minimize product impact.& total lifetime maintenance. Enable recycled material from cabins to be used in other industries with easy rebranding. Use recycled materials from other industries in cabin products.

Weight Optimization

The weight play an very important role in e environment impact. Each gram is added to greenhouse emission. As cabin is the only part which in contract with passenger for long period. the complete cabin weight can be controlled which will helps ti reduce less emission on terms of long / short travel in airline industry. By reducing the weight of each component by considering advance material and new techniques Below table shows the composition if cabin. Diagrammatic representation of typical twin aisle passenger cabin as shown below. The weight of the product designed is directly impact on the fuel composition. (RAC Seating).

Item number	Key to Figure 3
Seats	1
Linings	2
Stowage bins	3
Passenger service unit (PSU)	4
Services (lavatories and galleys)	5
Insulation blankets	6
Carpets	7
Floor panels	8

Table 1 : Cabin Items List

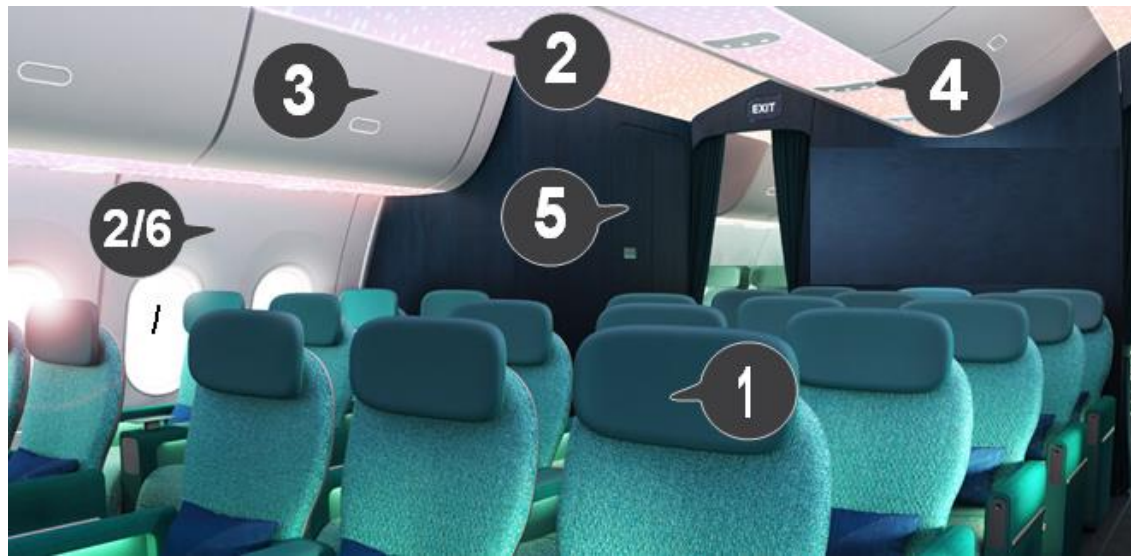


Figure 1 : Cabin Layout

The operational impact currently contribute 2.6 % of the total. If this growth continues their will be maximum rise even if carbon alternative fuel is used. Cabin weight is the considered as important factor for fuel consumption. for shorter distance the less weight will be less fuel consumption as compare to the long rang lift to drag ration improvement leads to more fuel consumption aviation industry has set a target of reducing the cabin weight by 18%. thsi will not compromise the safety. Below table shows the analysis of weight in cabin interior form one of the leading seating company.



.Item	2020 weight, kg	2030 weight target, kg	2020-2030 weight reduction
Seats	1,601	1,290	20%
Linings	363	340	5%
Stowage bins	188	220	-20%
Passenger service unit (PSU)	172	130	20%
Services (lavatories and galleys)	563	450	20%
Insulation blankets	418	310	25%
Carpets	240	210	10%
Floor panels	376	330	10%
Total	3,919	3,320	16%

Table 2 : Weight Analysis

Circularity in Cabin

Circularity is a widely recognized model which helps in the reduction of material and re-use or recycling of the seating parts. In ref to the literature review, an inexperienced circularity model is created which states that some materials are recycled to another factory but are not related to the aircraft cabin industry. Some parts are reused and fitted into another

aircraft, while a few of them are refurbished and made it workable with an approved lifespan.

The design of such cabins set unique barriers for lifecycle routes, the brand, material used, different finish, and process make this challenging to re-sell, and recycle for conducting lifecycle analysis.

To perform this operation the recommendations can be grouped into different sections like Encourage best practice and framework. Design features prioritization and checks for std material that shows sustainability benefits in this no new material requirement is considered. A collaborative approach between cabin design companies and the airframe. Safe and efficient production processes with std documentation.

To get detailed knowledge and understand the opportunities and challenges to implement the circular economy in aircraft seating g systems, a few interviews and literature reviews were conducted by an aircraft seating company. The data shown below are the list of people interviewed with the seating organization and were noted their thought and asked for their feedback on this topic. This was a qualitative approach to gathering this data. (Circular Economy)

No.	Organization / Dept	Interviewed / Feedback Members
1	First class seating Project	Engineering project lead / Program manager
2	Business class seating Project	Senior manager, Experience passenger
3	ITCM Team	Senior program manager
4	Engineering design - Cabin	Design Engineer / Design head
5	Industrialization	Industrialization engineer
6	Assembly line	Production Manager
10	R&D institution	Research and development team
14	Component supplier	Research and development manager

Table 3 : Expert Feedback - Analysis

Material Selection and its considerations

Material application is one of the most important factors to having a more sustainable seat in the aircraft seating industry. As it is linked with the weight, circular design principle, and design. the below analysis shows the prioritized list of aircraft seating products in the industry. As per design point of view, the certification process is costly and has a strong point to fail. New designs are almost taken reference for the existing design and from the approved material list.

Industrialization views performance and reduces the cost of manufacturing. The analysis of the following breakdown done by its weight & material. Aircraft interior parts/ component breakdown are a Seating system, Lavatories/galley equipment, IFE systems & data power, Overhead bins, Side wall panels & decorative trims, Floor panel, and assembly.

To gather this information qualitative approach is adopted, the assessment will consider the impact on the environment, the material required in each cabin, and the weight efficiency. The problematic material is HSS mainly as fasteners which are high density. LCD in which IFE displays and has a high weight, shorter life span & challenging. Carbon Fiber Plastic is mainly on Seat back / structures and is difficult to recycle. Polyethylene terephthalate (PET) /Nylon is used for Seat belts, Insulation, and air ducts. The selection process is very important and should be done in two methods screening the correct material form the large database and further ranking it as per its arability and the manufacturing cost. This will result in saving our time and money. (Maheswaran. N, Material selection, 2021)

This material application gives an idea where sustainability should be taken into account by designer while designing any component. Below are the identified problematic component in seats which will informs the focus for the cabin modification.

Cabin item	Problematic component	Development goal
Seats	CFRP back structure	Replacement or more sustainable life cycle
	Aluminum primary structure	Reduction of virgin aluminum
	Seat covers	Wool sustainability enhancement or replacement
	Seat cushions	Replacement for melamine and PU Foams
Fasteners and brackets	Inconel and steels	Lighter weight alternatives such as bonding

Table 4 : Problematic Material - Analysis

Development in Technology

The development in technology is main part in greener cabin interiors. By selecting proper material , processes and electronics will boost the research and development to reach maturity state. The following pages indicates uses of promising technologies identified. Implementation of bio-inspired design rules approach has variety of methods to analyze the functional and structural behavior. Below are the few technology described to provide capability. (Maheswaran. N, INTERNATIONAL JOURNAL OF ENGINEERING RESEARCH & TECHNOLOGY (IJERT), 2021)

The Bios Future Cabin focuses on the requirement of passengers and sustainable materials they got the technology to opt from food like sugarcane for their resin to be used in the aviation industry through their research work while designing aircraft interiors the space factor is considered and this had made possible approach by design with proper load bearing parts of the aircraft. also, the development in the IFE units is seen through converting the whole screen backrest into an entertainment device where passengers can use or connect their personal device through an app and can control the ventilation as required (sweet-sustainable-seating)

Bio inspired design (Central technology) This is the approach in designing by drawing the inspiration (process / functionality) with medium cost and high benefits.

Amorphous metals (Enabling technology) This is the having metallic property but are moldable as plastic. complex design possible with minimum cost and its highly beneficial.

3D printing Metals (Enabling technology) This is new method to produce any part of irregular shape. This process is little bit costly & highly beneficial.

High pressure die casting (Enabling technology) Possible to use secondary as circular process of aluminum which had come to end. Parts can be topologically optimized , min lead time and low RC process. This process is little bit costly & highly beneficial.

Technology Indicators

With ref form, the reviews the technology indicator assessment for the few points like cost, weight and its impact has been analyzed. also, the benefits of the technology have been captured. The indicators show the likely characteristic that can be achieved in the aircraft industry in the future. The technology indicator may vary as per the application or usage of the airplane. the sufficient amount of support or funding required to achieve the excellent usage or benefits of the technology. One of the key indicators is cost, which plays a very important role. the cost should be minimum and according to the material; and an advanced manufacturing process needs to be defined for that particular task. The introduction of more advanced materials and the manufacturing process will increase the cost and may affect the budget. The second factor is weight which also plays an important role. The third indicator is impacted. (Circular Economy)

Sustainable aircraft interior materials

There are few materials identified to reduce the cabin weight such as Solid state batteries- which are fire safe. high density, this is lighter in weight as compared to other batteries. This is less in cost and highly beneficial. The multi-color laser is a set of new light manipulation techniques that increases the capacity of fiber optics and the replacement of copper wire. This will result in lighter cabling and a 2% reduction in weight. Smart touch projectors Replace IFE screens, thin light touch display which looks like paper to the viewer's eye. This will save 5% of the weight. composites in the aviation industry is one the material which has decorative and excellent

properties. Many parts in aircraft seating are made from composite due to which the seat and its surrounding elements' weight decreases. Now many parts of aircraft are made from composite material with advanced techniques. (RAC Seating)

Guide material and design choices

The material guide and the design choices should be advised. The following mentioned cabin component embodies harmful material and design choices are advised. Carbon fiber reinforced plastic (CFRP) is mainly used for the back of the seat structure and the most suitable material alternative will be biocomposites which will give more sustainability to improve and reduction in weight. The next material like Aluminum seat structure components, then the Woolen seat covers which is also the main part in which alternatives like grape marc leather or sustainability of this material wool can be improved. The other material like seat cushions is mainly made from Melamine and polyurethane (PU) which can be replaced with its alternatives. The fasteners also play an important role in weight analysis. Steel fasteners that are lighter must be integrated. The other type of material like Aramid core composite panels which alternative should be recycled. Polyethylene terephthalate (PET) and polypropylene (PP) are mostly used for the manufacturing of air ducts and more sustainable material can be found out. The Copper wiring must have lighter weight alternatives mainly for the In-flight entertainment like all display, electronic items screen / display and using copper wirings will definitely lead to lighter harness as a part of weight optimization. (JLR - Newsroom)

Leather material also plays an important role in sustainability and circularity. Seating systems mainly consist of leather work and different types as per their classification are used on aircraft seats. The technology used by automotive company JLR used a new technology called a blockchain. This is used to ensure complete transparency within the supply chain. The company has there a partnership with a leather company that is involved in supply chain traceability. Few trials were done to check the traceability in the leather supply chain. Also, its tracking system and the process of maintaining the data digitally has enabled The company to assess the CO₂ footprint in its network and noted its supplier for its lowest carbon leather from start to finish. This company has committed to reducing the impact which is now been seen on the environment of its products. They are also providing their customer with more sustainable materials for their interior product on their vehicle with high-grade textiles on their upgraded vehicles like electric ones. To track the progress of material and technology digital twin was created in this digital world, to verify the data various verification process was developed and combined like QR code & biometrics. also, the repeatable process of checking created can be used in different companies which are dependent on leathers. This is the project that this company has created as a strategy for positive social impact and reducing the carbon across this supply chain and their products. (JLR - Block chain Technology)

The interior product developed by JLR is innovative and they were working on the development of nylon to develop high-quality products for their interior made for the waste. From industrial recycled plastic JLR has developed fabric. The innovation helps the environment clean and offers

there employees and people. The regeneration of Nylon by one of the company is leader in synthic fibers. Many fashion industry has already stated using this nylon in there products like habd bags, watch strap and sports wear. The company Aqualon has recycled 41000 tones of waste by implementing a recycling process high reduces the global warming impact by 91 % and reduced the product produced by the Oil. Analysis shows that 10000 tons of ECOYL will produce 71000 barrels of crude oil. The waste is analyzed and then further feed to that chemical plant. Where the nylon is broken into its original raw material using polymerization processes. This nylon material has a wide range of uses and many applications. This material will act as important in co2 emission and saving the environment. The process adopted by this company is known as destination zero which is a great achievement for its circular economy The material used is type of leather wool made form recycle of plastic bottles. (JLR - Newsroom)

Analysis Examples :

The seating type is very important to have less co2 emission. For example, a narrow body plane is considered with 175 seats in which few seats are premium class or business class. so in this situation, the wide-body aircraft be a better choice due to the premium seat available in aircraft which will capture more space as compared to the narrow-body aircraft if taken for the analysis. even if flown with a different carrier. Its been seen that the aircraft with all economy seats and few premium seating as per their class with the same number of passengers and load factor will have loc Co2 per flight because of the few lower economy passenger seats. So the aircraft with premium seating, business class seats, and first-class seats shows less Co2 as compared to the aircraft with a maximum economy class seat which has more number of passenger in it. so the increase in CO2 will be seen if the number of passengers is increased. the wide-body aircraft is preferable to avoid any further impact on the environment in terms of Co2 emission. So based on the number of people traveling and the type of seating system used in the aircraft Co2 emission level is noted. The overall emission is based on the load factor of each seating class and the number of people in the commercial flights. The comparison with commercial flights is more than the cargo flights. Also, 80 % of the narrow-body aircraft and wide-body aircraft were wide-body has more premium class seats. In previous years Co2 emission is noted approx imate37% on the narrow bodies and 19% on the premium seating. The amenities used in the premium class seating like the dedicated lavatories , galleys, bar units, and other areas show larger co2 footprints as compared to the economy seats.. (theicct.org)

Direction for further work

Complete design and development of the item/products lifecycle circularity in the aircraft cabin industry to achieve low Co2 emissions are beneficial. The different pathways to reduce this emission and keep our environment safe and healthy are the good practices and new technologies implemented in industry products, The aircraft sector should be aligned with the automotive sector to capture sustainability in their design and development process to control the cost and gain benefits

Conclusion

The analysis identifies that the aircraft cabin can reduce aviation's environmental impact by becoming more lighter and increasing the use of its component (Circularity) in the product lifecycle and reducing their use of harmful materials. Recommendations for developing these designs and material choices have been made.

The global aviation community is committed to reducing its carbon footprint and consequently, sustainability performance is increasingly effective in providing a sales and marketing advantage. Weight reduction remains vital but cabin OEMs that can offer other forms of sustainability improvement with no cost or weight penalty, particularly those that confer a marketing value to the customer, stand to gain.

The research indicates that modification of such seating system adaption of new material with innovation strategies and collaboration within the cabins community than the whole product lifecycle, is well positioned to respond. The analysis shows that the premium passengers on commercial aircraft show 2.6 times more Co2 as compared with the passenger in the aircraft the economy. It's higher in terms of the type of aircraft body like narrow and wide body. Also, the higher premium class The various technologies can be adapted such as weight optimization by reducing the weight of the mechanical component and seating parts. Applying different materials based on their classification and usage as described in the report. The implementation of advanced material in seating systems like composite material will acts as strength as well as reduce the weight of the part, This reduction in weight and the use of appropriate material will lead to less fuel and reduce the emission. This is play an important role to control Carbon footprints.

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