



UNIVERSIDAD EUROPEA DE MADRID

ESCUELA DE ARQUITECTURA, INGENIERÍA Y DISEÑO

DEGREE IN AEROSPACE ENGINEERING

FINAL PROJECT REPORT

**Design and Study of the Interior and Additional Exterior
Elements of an Aircraft to Satisfy the Needs of a Specific
Business Model**

JIMENA CUETO-FELGUEROSO ÁLVAREZ

09/06/2023



TITLE: Design and Study of the Interior and Additional Exterior Elements of an Aircraft to Satisfy the Needs of a Specific Business Model

AUTHOR: Jimena Cueto-Felgueroso Álvarez

SUPERVISOR: Miguel Ángel Cosano de Arcos

DEGREE: Aerospace Engineering

DATE: 09/06/2023

ACKNOWLEDGMENTS

Miguel Ángel Cosano de Arcos
Juan Guerrero Sancho
Celso Cueto-Felgueroso Solís
Beatriz Álvarez Rodríguez
Elisa Rodríguez Tejeiro
Ana Cueto-Felgueroso Álvarez
Heli Álvarez Rodríguez
Rafael Cueto-Felgueroso Solís

ABSTRACT

Royal Skies is an airline that offers two different services: luxury tailor-made charter flights and organized-itinerary trips around several countries. The interior of the chosen aircraft has been redesigned for this purpose, creating a relaxing area with spacious seats and at the back an entertainment area where customers can socialize and enjoy the performances aboard. The aircraft comes equipped with the latest technology; the Starlink Aviation antenna will provide the best connection onboard and the curved screen in the cabin's ceiling will help create a unique experience. Both elements will be analyzed to evaluate their effect on the aircraft's performance and safety respectively. The aircraft is analyzed using a CFD tool to calculate the effect of the Starlink antenna and other additional surface elements on the aircraft's drag coefficient. Additionally, due to the large dimensions and fragility of the ceiling curved screen, a modal analysis is performed to evaluate the screen's vibration mode frequencies and deformation to understand its effect on passenger safety. Finally, the distribution of the aircraft's cabin is adjusted to minimize the effect on the aircraft's center of gravity, without sacrificing passenger comfort.

Keywords: interior, redesign, luxury, first class, center of gravity, curved screen

RESUMEN

Royal Skies es una aerolínea que ofrece dos servicios diferentes: vuelos chárter lujosos y hechos a medida y viajes de itinerario organizado alrededor de varios países. El interior del avión elegido ha sido rediseñado para este propósito, creando una zona de relax con asientos espaciosos y una zona de entretenimiento en la parte trasera del avión donde los pasajeros pueden socializar y disfrutar de espectáculos a bordo. El avión viene equipado con la última tecnología; la antena Starlink Aviation proporcionará a los pasajeros con la mejor conexión a bordo y la pantalla curva en el techo de la cabina ayudará a crear una experiencia única. Ambos elementos son analizados para evaluar su efecto en el rendimiento y la seguridad del avión respectivamente. El avión es analizado usando una herramienta CFD para calcular el efecto de la antena Starlink y otros elementos superficiales en el coeficiente de resistencia del avión. Además, debido a las grandes dimensiones y la fragilidad de la pantalla curva del techo, se realizará un análisis modal para evaluar las frecuencias de los modos de vibración de la pantalla y su deformación para entender su efecto en la seguridad de los pasajeros. Finalmente, la distribución de la cabina del avión es ajustado para minimizar su efecto en el centro de gravedad, sin sacrificar la comodidad de los pasajeros.

Palabras clave: interior, rediseño, lujo, primera clase, centro de gravedad, pantalla curva

Contents

Chapter 1. INTRODUCTION.....	10
1.1. Problem Approach.....	10
1.2. Project Objectives.....	10
Chapter 2. EVOLUTION OF AIRCRAFT CABINS AND FLIGHT EXPERIENCES	12
2.1. 1920s and 1930s	12
2.2. 1940s and 1950s.....	13
2.3. 1960s and 1970s.....	14
2.4. From 1980s to 2020s.....	15
Chapter 3. BUSINESS CONCEPT	17
3.1. Introduction and objectives	17
3.2. Features from the past that will be used for Royal Skies.....	18
Chapter 4. MARKET STUDY OF THE ORGANIZED TRIP.....	19
4.1. Study of similar services	19
4.1.1. Tren Transcantábrico	19
4.1.2. Golden Eagle Luxury Train.....	20
4.2. Interior Design Specifications	20
4.3. Itineraries offered by Royal Skies	22
Chapter 5. FLEET PLANNING	25
5.1. Narrow Body Aircraft.....	26
5.1.1. Range	27
5.1.2. Cargo Capacity	28
5.1.3. Weight.....	29
5.2. Wide Body Aircraft.....	30
5.2.1. Range	32
5.2.2. Cargo capacity	32
5.2.3. Weight.....	33
5.3. Final Aircraft	35
Chapter 6. REDESIGN PROCESS	39
6.1. Cabin's distribution	39
6.2. Seat design	42
6.2.1. Customers' seat design.....	42



6.2.2. Crew seat design	46
6.3. Bathroom design	47
6.4. Galley's design	49
6.5. Extra interior design elements	51
6.6. Final weight and center of gravity location	55
Chapter 7. ADDITIONAL FEATURES	60
7.1. Curved Screen.....	60
7.2. Starlink antenna.....	64
7.3. Sound system.....	65
7.4. Aerodynamic study of the exterior of the aircraft	66
Chapter 8. CONCLUSION	69
BIBLIOGRAPHY	70

List of Figures

Figure 1: In-flight movie inside a German Airliner plane, 1925 [Love Exploring, 2021]	13
Figure 2: Flight attendant giving passengers postcards to chronic their flight, 1959 [Love Exploring, 2021].....	14
Figure 3: Multi course dinner served by the chef, 1969 [Love Exploring, 2021]	14
Figure 4: Onboard lounges reserved for First Class passengers in the Boeing 747-B	15
[Love Exploring, 2021]	15
Figure 5: Take-off weight vs Runway length [Airbus, 2020]	37
Figure 6: First cabin's configuration.....	39
Figure 7: Second cabin's configuration	40
Figure 8: Isometric view of final cabin's configuration.....	41
Figure 9: Final cabin configuration plan.....	41
Figure 10: Schematic seat concept	42
Figure 11: Isometric view of the first seat design.....	43
Figure 12: Isometric view of the second design.....	44
Figure 13: Cabin Cross section view with second design seats.....	44
Figure 14: Isometric view of the seat's final design (aircraft's left hand side).....	45
Figure 15: Front view of the seat's final design (aircraft's left hand side).....	45
Figure 16: Top view of the seat's final design and its measurements in cm.....	46
Figure 17: Crew members' seat design	47
Figure 18: Top and front view of the customers' bathroom.....	48
Figure 19: Isometric view of the customers' bathroom.....	48
Figure 20: Free space to maneuver the wheelchair to enter the bathroom and crew members' bathroom	49
Figure 21: Galleys final design	50
Figure 22: First and second designs of the bar.....	51
Figure 23: Isometric view of the outside and inside of the bar	52
Figure 24: Isometric view of the sofa.....	52
Figure 25: Coffee table design	53
Figure 26: Isometric view of the high table	53
Figure 27: Isometric view of the wardrobe.....	54
Figure 28: Entertainment area distribution 3D view	54
Figure 29: Top view of the second half of the aircraft	55



Figure 30: Top view of the final and total distribution of the whole cabin	55
Figure 31: Position of center of gravity A321neo at MTOW	56
Figure 32: Schematic location of MAC (represented in green)	59
Figure 33: Deformation diagram for each mode for the full screen	61
Figure 34: Deformation diagram for each mode for a single panel of the screen	62
Figure 35: Cross section of middle and end screen's holder	63
Figure 36: Gap between screen panel and holder	63
Figure 37: Isometric view of the screen	63
Figure 38: How passengers will see the ceiling of the aircraft during flight	64
Figure 39: N° round trips Starlink vs Geostationary	65
Figure 40: 3D model of the Royal Skies A321neo	67
Figure 41: Efficiency, lift and drag coefficient vs alpha Royal Skies version	67
Figure 42: Efficiency, lift and drag coefficient vs alpha commercial A321neo	68

List of Tables

Table 1: Dimensions of the A321neo, A321LR and A321XLR [Airbus, n.d.]	26
Table 2: Cargo Capacity of the A321neo [Airbus, n.d.].....	28
Table 3: A321neo's Performance Data [Airbus, n.d.].....	29
Table 4: Seats Weight Analysis for the Narrowbody Model	30
Table 5: Passenger Weight Analysis for Narrowbody Model	30
Table 6: Dimensions of the A330-900 & A350-1000 [Airbus, n.d.].....	31
Table 7: Cargo Capacity of the A330-900 and A350-1000 [Airbus, n.d.]	32
Table 8: A330-900 and A350-1000 Weights Data [Airbus, n.d.]	33
Table 9: Seats Weight Analysis for Widebody Models.....	34
Table 10: Passengers Weight Analysis for Widebody Models	34
Table 11: Prices for each model.....	35
Table 12: Runway distance data	36
Table 13: A321LR list of interior elements and weights	56
Table 14: Royal Skies list of interior elements and weights	57
Table 15: COG limits for the maximum weight configuration of the manual.....	58
Table 16: Modal frequencies and their deformation for the full screen.....	61
Table 17: Modal frequencies and their deformation for a single panel of the screen	62
Table 18: Comparison.....	68

Acronyms

ATC	Air Traffic Control
LR	Long Range
XLR	Extra Long Range
ACTs	Additional Centre Tanks
nm	Nautical miles
MTOW	Maximum Take-off Weight
ZFW	Zero Fuel Weight
EASA	European Union Aviation Safety Agency
B	Business class
E	Economy class
E+	Economy plus class
HI	Hawaii
COG	Center of Gravity
A/C	Aircraft
MAC	Mean Aerodynamic Chord
CG	Center of Gravity
IFE	In-Flight Entertainment
L/D	Lift over drag, efficiency
C_L	Lift coefficient
C_D	Drag coefficient

Chapter 1. INTRODUCTION

1.1. Problem Approach

There are certain global events every year where the market for private jets reaches record-breaking demands, both by companies and particulars. [LLM Reporters, 2022]

The aircraft redesign described in this project will provide certain brands and businesses with a large private jet which they can rent to move their most important customers and executives to and from these events with the maximum standard of luxury and comfort. Additionally, this aircraft redesign will also be used to create a unique travel experience where passengers will enjoy their flight in a full first-class aircraft around the world within a closed itinerary. Both services would be offered by a single charter airline, therefore broadening its market into a distinctive business model.

1.2. Project Objectives

The main objective of this project is to define the interior design of an existing aircraft to fit a new business model for a charter airline. This business model will consist of two possible services which include:

- Themed luxury charter flights for transport of VIPs to government or private-funded events such as World Cups, Fashion Weeks, etc.
- Themed luxury charter flights for organized-itinerary trips around several countries.

In order to achieve this, a deep study of the evolution in aircrafts in the last hundred years will be done to extract all the important information of each decade in terms of interior design. The idea is to go back to the luxurious flights of the past when flying was not just about traveling from one place to the other, but rather an experience in itself. This airline, which will be named “Royal Skies”, wants to make their passengers feel special and unique.

After that, a deep comparison between different aircraft models in terms of performance will be carried out to see which one is more suitable for this project. Once the aircraft is chosen, the design process of the interior will start.



The new interior design will have to satisfy the needs of the business model by also complying with the applicable certification and to consider its effects on additional interior structures, safety, performance, etc. For both services to be developed in the same aircraft, it must contain the necessary interior structure and organization to satisfy the flexibility of what the different events will require.

Additional exterior elements such as a large satellite antenna will also be designed to fit the business model's needs and the effect of these elements on the aircraft's performance will be studied. Factors such as fuel efficiency, range, and cross-section design will be taken into account.

Lastly, several studies will be performed to analyze the market needs and the viability of the project, as well as the airline's logistical needs and infrastructure.

Chapter 2. EVOLUTION OF AIRCRAFT CABINS AND FLIGHT EXPERIENCES

2.1. 1920s and 1930s

In the 20s, the era of commercial air travel began. Aircraft at first were used to transport mail but airlines saw the potential of a business in transporting passengers onboard with the airmail. Air traffic in the United States increased during these years from 6.000 passengers in 1930 to 450.000 in 1934 reaching the highest in 1938 with 1.2 million passengers. [USA Today Travel, 2016]

Flights in this period were different from nowadays. It was a privilege reserved for the wealthiest people in society. Although it was a luxurious service, flights were very noisy and uncomfortable as aircraft had to fly low approximately at 13.000 ft because there weren't pressurized cabins at that time. Aircraft could fall hundreds of feet without any notice because of the turbulence during flight. Although it was the fastest way of traveling, it was much slower than nowadays. Aircraft could reach up to 200 mph, which meant long trip times. [USA Today Travel, 2016]

The job of flight attendant was initially performed exclusively by men. After a few years they became mostly women, who were usually nurses in order to be prepared in case some passenger needed any type of assistance, such as assisted breathing which was something very common during flights and aircrafts were equipped with oxygen tanks.

During a flight, passengers and crew were subjected to major temperature variation, sometimes they were in need of a blanket because of the freezing temperatures and in other cases the heat would be insufferable. At the end of the 30s, air conditioning and heating systems were introduced in some aircraft.

Despite all this uncomfortableness, airlines tried offering a luxurious flight experience, including good food and drinks, and some aircraft even carried a screen to entertain their passengers with an inflight-film. Some airlines introduced inflight lavatories during this period, although passengers tried to avoid it as much as they could due to how uncomfortable they

were. Airlines focused on interior design to make flying more enjoyable. Seats became more pillowy, the windows were covered with curtains and they even painted and covered the walls.



Figure 1: In-flight movie inside a German Airliner plane, 1925 [Love Exploring, 2021]

2.2. 1940s and 1950s

The 1940s was an era where commercial aviation was pushed forward with the new Boeing 307 aircraft. It was the first aircraft with a pressurized cabin making it able to fly at 20.000 ft. The flight experience changed completely, with this new technology flight became less noisy and more pleasant. [Love Exploring, 2021]

In the 50s, air traffic suddenly escalated. It was the first time in history where there were more passengers flying than traveling by train. Because of the new jets that were released during this period, de Havilland DH106 and the Boeing 707, flights were more comfortable, faster and more economical, although it was something still reserved to higher classes in society.

In addition to the previous entertainment, passengers spent their time during flight chronicling on postcards, socializing with other passengers and there were live performances from famous singers and musicians to make the journeys more pleasant.



Figure 2: Flight attendant giving passengers postcards to chronic their flight, 1959 [Love Exploring, 2021]

2.3. 1960s and 1970s

The 1960s were the Golden Age of the Air Industry. Dinners were taken to the next level offering multiple courses, bread served in baskets and they even served steak and lobster. During this decade, it was also the first flight of the first supersonic commercial aircraft. It was not as successful as it was expected because it was very narrow, luggage came in another flight and it was very noisy although it only took 3.5 h to connect London with New York.



Figure 3: Multi course dinner served by the chef, 1969 [Love Exploring, 2021]

In the 70s the first non-luxury airline was born, which would be a predecessor of today's idea of low-cost carriers, Laker Airways. In this concept, passengers would have to buy the

meal separately if they wished. The introduction of the Boeing 747, which was bigger than the prior wide-body jets, opened this way of transport to the masses although it was not as accessible as today. From that time on, rich people would fly in first class maintaining all the luxurious services.



*Figure 4: Onboard lounges reserved for First Class passengers in the Boeing 747-B
[Love Exploring, 2021]*

2.4. From 1980s to 2020s

From the 1980s onwards, there were several changes performed in the industry but not as innovative as in the decades before. The 80s was the decade when most successful low-cost carriers were born, making it something approachable to all members of society. The aircraft's interior looked very similar to current aircraft, for example lunches for economy class were served in boxes. Another main change was the prohibition of smoking inside the aircraft during flights shorter than 2 hours in the United States territory, internationally it was endorsed in the year 2000.

In the 2000s, the whole world came to a stop with the 9/11 terrorist attack and the air transport industry had to develop new procedures and technology to improve the security at airports and during flights. From now on, people without a boarding pass could not reach the boarding gates to say goodbye to their relatives. Inside the aircraft, cockpit security was



increased with a lock mechanism where pilots decide who goes in and who doesn't in case of any emergency. The air traffic after this horrible event decreased considerably and it didn't reach the numbers from previous years until 2004.

The 2010s innovations included the incorporation of in-flight wifi. In 2020, the COVID-19 crisis hit the air industry very hard. Airlines and airports had to incorporate new mechanisms to mitigate the transmission of airborne diseases in order to survive this crisis. Airlines did not serve meals or any kind of food or drinks, they didn't offer blankets or magazines to have the least possible contact. Aircraft had to incorporate newer and better mechanisms to filter the air during flight to make it safer for passengers and crew members.

Chapter 3. BUSINESS CONCEPT

3.1. Introduction and objectives

Royal Skies is the name of this new airline concept that will cover two markets. Firstly, luxury charter flights that will be tailor-made for the customer and secondly, organized-itinerary trips around several countries.

The vision of the first charter concept is to fulfill the need, in certain seasons, for private jet or first class seats in airlines. For example, during Fashion Weeks, a considerable amount of special customers and content creators move to the specific destination of said event. Brands spend a considerable amount of money paying for these expenses so why not bring them all in the same flight with a tailor-made in-flight experience. The flight could not only be used as a mode of transportation but also as an in-flight event where these customers and content creators do 'free' advertising for the brand. The brand could do a sneak-peek of the event or they could provide new products to make publicity out of them. Other examples could be major sport events such as the Super Bowl final, World Cups, Olympics, etc. or music festivals like Coachella where a lot of people from all around the world are transported to a single location. In addition, the charter option could also be used by companies that have to move a group of experts for certain meetings, expos, etc.

The organized-itinerary option will offer four different packages between different destinations. It's targeted for passengers who wish the most complete holiday trip possible, not just in terms of the variety of destinations, but also with respect to the organization of the trip itself. Since the target clients will not be able to dedicate much free time on planning their trip, every detail of the journey will be accounted for, while also giving passengers a sense of freedom and adventure.

Royal Skies will have one model aircraft initially in order to reduce maintenance costs and crew members training. This demands a flexible aircraft which can be adapted for any possible event or trip. Four different models will be analyzed and compared to determine which one is the best option for this business model. This aircraft's interior will be completely designed specially for Royal Skies to make it one of the most comfortable and unique interiors in the world.

For Royal Skies, it is important to offer good Internet and cellphone connections during flight because of the type of customers who will be making use of our services, while at the same time offering an essential safety measure since the aircraft will be located by ATC at all times. All Royal Skies' aircraft will have a Starlink antenna to provide fast connection making it possible to do streamings, video calls, etc.

3.2. Features from the past that will be used for Royal Skies

Royal Skies wants to create a special and unforgettable experience for each of their passengers, whether they are traveling with the organized trip or with a brand that rents the aircraft for a specific trip.

The cabin design is inspired by the idea of traveling by aircraft in the past, so there will be a zone with first class seats and at the back there will be an onboard lounge where passengers could meet and have a pleasant flight.

Inspired by the activity of chronicling the trip on postcards, in the case of the organized travel trip with Royal Skies, there will be a professional photographer onboard making all the pictures wherever they go. During flight, passengers can see and choose their favorite ones to create a digital album.

In the case of a brand organizing a specific trip, there could be live performances like singers, musicians, fashion shows depending on the type of brand and what experience they want to offer.

Regarding the menu, Royal Skies would offer two options. For the organized travel trip, the menus are influenced by the destination and the crew would create an amazing menu with different courses. On the other hand, the brand that rents the aircraft can choose the theme of the menu with the Royal Skies chef.

Chapter 4. MARKET STUDY OF THE ORGANIZED TRIP

4.1. Study of similar services

This idea of an organized trip by plane is inspired by the classical and luxurious trains that cover a certain area of a country or different countries from the same continent.

4.1.1. Tren Transcantábrico

The first one that is being analyzed is the Tren Transcantabrico, which travels between cities in the north of Spain. The route consists of a very special route that departs in San Sebastián, País Vasco and goes through all the provinces with the most iconic cities and villages until the last stop in Santiago de Compostela, Galicia or vice versa. The time spent will be eight days, seven nights long enough to visit charming cities like Bilbao, Gijón, Oviedo and Santander among others. The train works as a luxurious hotel that is moving connecting the stops. All the workers will treat the passengers in an exquisite and polite way giving them all they need to have a wonderful and relaxing experience.

The rooms inside the train are first class suites with a last century interior design with all the amenities of nowadays. They have an in-suite bathroom with a big hydromassage bathtub, wifi connection and 24h service. It is important for this type of experience to offer a unique service in terms of gastronomy and city tours. The train also has a pub car, a place where the passengers can socialize and have fun while traveling.

In terms of gastronomy, the Tren Transcantábrico has agreements with the best and most famous restaurants of some of the cities in places where the waiting list is of the order of months. The clients won't have to worry about these types of things; they only have to worry about relaxing and enjoying the experience. The menus served on route are inspired by the gastronomy of the destination.

In the matter of tour and visits, the Tren Transcantábrico has organized all the visits with their tickets respectively and with private and multilingual guides to know all the essential

things about the culture, architecture, etc. of the visited places. The transfers, if needed, will be luxurious and comfortable for the clients in order to have the best experience; everything is taken care of in detail.

4.1.2. Golden Eagle Luxury Train

The Golden Eagle Luxury Train is another example of an organized luxury trip, in this case, it is mostly between countries. They offer adventurous trips to wonderful and remote places while keeping it luxurious and private.

It offers very similar services explained for the Tren Transcantábrico. Here all the paperwork in terms of visas, depending on the selected route, are processed by the Golden Eagle Luxury Train in order to facilitate as much as possible the experience for the customers.

Unlike the Tren Transcantábrico where all the rooms are the same, the Golden Eagle offers two sizes of rooms where one of them is much bigger than the other although both are first class and another option is the Silver room which is more economical and less luxurious. All the passengers on board will have access to the common rooms like the dinner room, the pub car and the relaxing room where they all can socialize.

Some of their offered routes are Venice to Istanbul, Castles of Transylvania, the Darjeeling Mail which is a trip between the most amazing places in India. The journey's duration varies between seven to seventeen days.

4.2. Interior Design Specifications

From the two of the analyzed options, some ideas were taken to incorporate into Royal Skies.

First, in terms of the airplane interior layout, it was common in both trains that there were certain cars used for creating a relaxing and enjoyable environment where passengers could socialize between them. In the aircraft the back of the plane will be assigned for these types of activities. There will be a bar to offer all types of drinks to the passengers and there will be

seats to chat and enjoy the beverage. From the cockpit to this bar zone, all the seats will be located. This zone will be separated with a door in order to avoid disturbing the passengers who would prefer resting. Given that the experience inside the aircraft will be shorter-lived than that of the train experiences mentioned earlier, this bar area will be enough in terms of dedicated entertainment zones.

The seats can be fully inclined into a flat position. The materials used for the seats have to be high quality while complying with the certification specifications. All types of amenities will be provided to the guests to make them live the most comfortable experience. They will be given cosmetic products and all kinds of services to make their experience unforgettable.

The aircraft won't have overhead compartments to make it more spacious. The personal purses or handbags will be located between the two seats where there will be a compartment there. All other baggage will be checked and carried in the cargo bay. Royal Skies will offer a luggage checking service so that passengers won't have to worry about doing it themselves or wait in lines.

In addition, there will be a curved screen in the ceiling of the cabin to give the cabin a feeling of openness and freedom. The screen will be fastened and kept in place with a specifically designed structure. There will be cameras outside the aircraft pointing up and down. Since some passengers enjoy seeing how the aircraft takes off and leaves the ground, the images from the cameras pointing down will be shown on their personal screen as there are other passengers that may not enjoy watching these images. On the top curved screen is where the images captured from the cameras pointing up will be shown, in order to offer a relaxing experience to see the sky while flying. Flights could be scheduled during sunrise or sunset so that the sky color changes during the flight, offering passengers a unique experience. On the back of the cabin, in the bar area, the screen could show different images according to the destination or the music that will be playing. This characteristic will be unique for Royal Skies and will be one of the main differentiators that may make passengers want to choose this service. It will be important to ensure not only that the quality of the screen is pristine, but also that the power consumed or the loads involved do not become detrimental to the aircraft.

The aircraft will be equipped with a surround sound system, to have quality sound during flight. In the part of the cabin where the seats are located, the sound will be relaxing ambient sound while in the socializing area there could be music.

Because of the type of passengers that will be traveling inside the aircraft, Royal Skies thinks that having a great Internet or phone service connection inflight will be very important for our customers. Royal Skies' fleet will have Starlink antennas on board providing great WiFi connection quality no matter where they are flying. Additionally, this constant connection will provide passengers with an additional safety service, since the aircraft will be able to be located at all times by Air Traffic Control.

4.3. Itineraries offered by Royal Skies

Unlike the Luxury Trains mentioned before, guests won't be sleeping inside the plane; Royal Skies will have a partnership with a hotel chain to guarantee the quality of the stay. The international hotel chains that have been considered are:

- Hilton
- Meliá Hotels International
- Hyatt
- Ritz-Carlton
- Mandarin Oriental Group

All of them offer a great variety of hotels around the world but in terms of services, locations and design; the hotel chain that is a better fit with Royal Skies is Ritz-Carlton. The routes will be chosen in character with the locations of said Hotel Chain.

Each of the routes will focus on a continent or a part of one. All of them will be a mixture of tourist and relaxing destinations so that Royal Skies' customers can enjoy a cultural trip while relaxing in the most beautiful and exotic places.

The Eagle Route:

New York City → Miami → New Orleans → San Francisco → Hawaii → Arizona

The Eagle Route will start in New York City, where passengers will have four days to see the most iconic corners of the city. After that, they will fly to Miami. They will be staying in Key Biscayne to have a relaxing experience in front of the most beautiful coastline of the East coast of the United States after the busy New York City. The next destination will be the historic city of New Orleans where they can delve into the culture of the South and enjoy the great food offered. After this historic city, Royal Skies will fly across the country to Half Moon Bay California, a coastline region next to San Francisco where they could spend two days visiting the city. Then, Kapalua Hawaii will be the next one in the route. Passengers will delight themselves for three days going to the beach, hiking and snorkeling. Finally, after a few days next to the ocean, Royals Skies will fly to Arizona to visit one of the most emblematic natural parks of the country, the Colorado Canyon. After two days, passengers will be departing to their homes having enjoyed a wonderful trip.

Latin Skies Route:

Santiago de Chile → Mexico City → Los Cabos → San Juan de Puerto Rico

The Latin Skies Route is the shortest one for people who want to enjoy a getaway trip while visiting amazing and diverse places. The route will start flying from Atlanta Airport to Santiago de Chile. Once they arrive, passengers will have five days to visit Santiago de Chile and an escape trip to the Atacama Desert. Then, they will fly to Mexico City to enjoy its bustle and cultural monuments during two days. Subsequently, Royal Skies will go to Los Cabos to enjoy another Mexican region at the coast for two days. The last destination is San Juan, Puerto Rico. Passengers will stay for five days in a first line hotel where they will be able to book all types of adventurous or relaxing activities.

Eastern Paradise Route:

Hong Kong → Tokyo → Thailand → Singapore → Bali → Maldives

The Eastern Paradise Route will start in Hong Kong, where passengers will stay two days to enjoy the city and visit the most important monuments. Next, they will fly to Tokyo, Japan. Here, they will enjoy three days in this beautiful and hectic city where they can visit the most iconic quarters and temples. Afterwards, they will enjoy four relaxing days in Phulay Bay,



Thailand. From Thailand, Royal Skies will fly to another incredible city: Singapore. Our passengers will stay for two days to visit their astonishing architecture. Then, they will fly to

Ubud, Bali to visit different temples and rice fields and enjoy the lifestyle of the island. The last destination of the trip will take passengers to a three day stay in Maldives to relax before going back home.

Sands and Savannas Route:

Dubai → Cairo → Tanzania → Oman

The Sands and Savannas Route starts in Dubai because of its accessibility. They will enjoy the extravaganza of the city. After this, they will fly to Cairo to visit the pyramids, souk and all the amazing cultural elements that this city offers. Then, they will travel to Tanzania to do a quick four day safari experience in the Ngorongoro and Serengeti Parks. In this trip they will be staying in luxurious tents inside the parks to live an unforgettable experience. The last stop will be Mascate, Oman, a coast region where they can relax. This city has beautiful historic monuments and beautiful beaches to end this unforgettable trip.

In order to make all of the routes unique and unforgettable, each of the flights' entertainment will be inspired by the culture of the destination. The menus will be created depending on where the aircraft is flying to, and similarly in terms of music and images shown on the ceiling screen. During long flights there will be live performances in the lounge space. For example, during the flight from Santiago de Chile to Mexico City a small group of Mariachis will be performing. Another example will be the flight from Dubai to Cairo where two dancers will perform belly dancing.

Passengers won't have to worry about their luggage as crew members will be in charge of checking the luggage and recovering it when arriving at the destination. All the bags will go directly to the hotel from the airport and vice versa. All the transfers between hotels and airports will be taken care of by Royal Skies; there will be a bus waiting for the passengers at each destination to take them to the hotel. In addition, Royal Skies will offer exclusive activities at each destination that passengers could book and enjoy. They will also hand in guides, offering different itineraries and restaurants where they can go. Royal Skies could arrange the reservations in the different restaurants that appear in the guide. Passengers will have the option to organize all these activities during their flight using the touch screen of their seats.

Chapter 5. FLEET PLANNING

Fleet planning plays an essential role within an airline and generally consists of analyzing, acquiring and managing the aircraft more suited to the airline's business plan and service and which must endure for a defined period of time. One of the most important aspects prior to fleet planning is fully understanding the market positioning of the airline as well as its aspirations.

Many factors contribute to the selection of an airline's fleet. Several of these factors are related to performance, capacity and other physical or logical characteristics, but a good fleet selection must also take into account political factors, which can be defining of an airline's success.

For any airline, but especially for a newborn airline, fleet commonality is essential. Having several aircraft which belong to the same manufacturer, family or even particular model, may limit an airline's market diversity but it will also heavily reduce costs. Maintenance, training, and engineering supporting costs will all be benefited from fleet commonality. In the case of Royal Skies, all aircraft considered for its fleet are manufactured by Airbus. This decision is based on recent public perception regarding safety with respect to other manufacturers, as well as an Airbus feature named Cross-Crew Qualification. This feature is beneficial for growing airlines since it will reduce training costs and time in case of fleet expansion, since Royal Skies' crew will only require additional training for the differences between aircraft models. Furthermore, with Royal Skies being an European-based airline, it will be politically favorable to employ aircraft made by an European manufacturer.

In order to decide which aircraft fits best for Royal Skies, five aircraft are going to be analyzed: three narrow bodies and two wide bodies. During the early life of the airline, only one aircraft model will be used in order to cheapen the cost of crew members training and maintenance. The aspects that will be analyzed from all five aircraft will be focused on the rough cut (technical limitations), as well as the standard specification (basic geometry, volumetric measurements, weights, design speed, etc.).

5.1. Narrow Body Aircraft

The three options considered for this category are the A321neo, A321LR and the A321XLR. The main difference is the range; the LR version has more fuel capacity thanks to the three additional center tanks while the XLR has the center wing box tank and two additional tanks; one located forward in the center and the other in the rear . They are all members of the single-aisle A320 Family. Despite being a narrow body aircraft, it has the widest cross-section within this classification, making it the most comfortable because of the extra space.

The A321neo and the LR version can create misunderstandings with the change in range but not in MTOW, etc. In order to make it all clear, for this project, the A321neo will be considered as the version with a MTOW of 97 tonnes with the two ACTs and the LR version will have the same MTOW and a total of three ACTs.

In the matter of the dimensions, the three aircraft are exactly the same. The most important dimensions from this table are the overall and cabin length, the fuselage and maximum cabin width, and the wingspan. They are essential considerations for the redesign, storage and airport compatibility.

Dimensions	Meters (m)
Overall Length	44.51
Cabin Length	34.44
Fuselage Width	3.95
Max Cabin Width	3.70
Wing Span (geometric)	35.80
Height	11.76
Track	7.59
Wheelbase	16.90

Table 1: Dimensions of the A321neo, A321LR and A321XLR [Airbus, n.d.]

With reference to the performance of the aircraft, it has improved considerably with respect to its predecessor, the A321ceo. The three versions have incorporated new engines that provide more thrust while spending less fuel, making them more efficient and therefore more

profitable for the airline and friendlier with the environment. Royal Skies can choose between two engine models, the CFM International's LEAP-1A and Pratt and Whitney's PurePower PW1100G-JM. Additionally, the A321neo has new wingtip devices in order to have a higher effective wingspan with the integration of the Sharklets. Because of all of these new additions, these new versions burn 30% less fuel than its predecessor.

[Airbus, n.d.]

The benefits of choosing a narrow body aircraft is that the recurring costs will be lower. Not only will maintenance be cheaper, but airport fees will also be significantly less. Moreover, smaller aircraft such as these are allowed to land in a larger variety of airports compared to a wide-body aircraft, and because some of the trips will go to far-away and remote destinations, the airports may not have the latest technology to operate a wide-body aircraft. Using narrow-body aircraft opens a larger list of available airports due to runway lengths and facilities.

5.1.1. Range

Range will be the first parameter being analyzed. It is a very important one as it can limit certain routes because of the distance between them. The range is limited by the amount of fuel that the aircraft is able to carry and other factors that will be constant between these three versions.

The A321neo has three tanks, two in the wings and one in the center but there is the option to have two ACTs to achieve the maximum range of 4000 nm. The maximum fuel capacity of this version is 32940 liters, which corresponds to the five tanks configuration. The engines provide a maximum operating speed of M0.82. *[Airbus, n.d.]*

The A321LR offers an extended range compared to the A321neo, this variant will have the three original tanks of the A321neo, the two ACTs and an extra ACT. The range of the A321LR can be extended up to 4500 nm. It is a more suitable aircraft for transatlantic routes as it is equipped with all the system protection needed. *[Airbus, n.d.]*

The A321XLR is the newest version of the A320 Family, since it is still in the certification process. It has extra range compared to the two versions mentioned before: it can achieve a 4700 nm range. New additions in terms of soundproofing were able to decrease in 50% the noise inside the cabin, making it a very comfortable aircraft for passengers. Comparing this

version with the performance of a widebody aircraft, A321XLR offers 45% less cost per seat while keeping the range and the amenities of widebody aircrafts. [Airbus, n.d.]

Given that the longest route within the aforementioned Royal Skies itinerary is 3550 nm, all three aircraft would be eligible in this respect. Nevertheless, it's unknown whether the range required by the clients of the charter service will be much higher than this 3550 nm route. Therefore, Royal Skies shouldn't discard any model due to an apparent excess in range.

5.1.2. Cargo Capacity

In relation to the cargo capacity, there won't be a problem with the amount of space as these aircraft models originally are designed to carry up to 244 passengers and their luggage, and the Royal Skies version is thought to carry between 30 to 60 passengers. This opens additional cargo capacity for event equipment, brand products and other miscellaneous cargo. [Airbus, n.d.]

Cargo Capacity	
Cargo LD3 capacity underfloor	10 LD3-45W
Max pallet number underfloor	10

Table 2: Cargo Capacity of the A321neo [Airbus, n.d.]

The cargo capacity reaches its maximum with the A321neo version, from there on it will decrease with the two other versions with extra range. The A321LR will be slightly smaller as the ACTs will occupy some of the previously available cargo space, but it still won't negatively affect Royal Skies since the aircraft carries a very low number of passengers. In the case of the A321XLR cargo space is further decreased but it still doesn't pose a problem.

Therefore, in terms of cargo capacity, all three models comply with the demands of Royal Skies. Additionally, this data shows that there is a possibility for range to be slightly increased if there is unused cargo space, given that weight will be reduced.

5.1.3. Weight

In this section, the weight of the three narrow body options will be compared and analyzed. This first table collects the four most important weights for an aircraft. The Royal Skies version won't achieve in any moment of its life the MTOW.

Aircraft's weight	Tonnes
Max ramp weight	97.40
Max take-off weight	97.00
Max landing weight	79.20
Max zero fuel weight	75.60

Table 3: A321neo's Performance Data [Airbus, n.d.]

The ZFW will be very similar between the three models given that the main difference between them is an increase in fuel capacity. On the other hand, the ZFW of the Royal Skies version will be lower. The main reason is that Royal Skies will carry 36 passengers while the commercial airline version has a passenger capacity between 180 to 220 if it has a two-class layout or up to 244 if it is all economy.

[[Airbus, n.d.]]

This reduction in passengers will result in a reduction of luggage and amount of seats. Although passengers of Royal Skies don't have a limitation in the amount of luggage they can bring, they won't equal the amount of luggage that the commercial airline version carries. In addition, a lot of seats won't be needed, reducing considerably the weight of the aircraft since seats include screens, electronics, life vests and other elements.

A further study about this reduction in weight will be done. Considering that the average weight of an economy seat is between 8 and 15 kg and the business-class seat is around 80 kg, an approximation of the seat weight of Royal Skies' aircraft is possible.

[Dubois, 2020]



Configuration	Seats	Weight (kg)
Full economy	244 E	2806
Two-class	173 E, 16 B	3269.5
Royal Skies	36 B	2880

Table 4: Seats Weight Analysis for the Narrowbody Model

This shows that the difference in seat weight will not be notable but, however, the true difference in weight derives from passenger and luggage weight. Considering that the average passenger weight is established at 84 kg by EASA [EASA, 2022] and that a survey carried also by EASA found no significant differences in checked baggage weight between passengers flying in different classes, [EASA, 2009] the following comparison can be made:

Configuration	Passengers	Weight (kg)
Full economy	244	20496
Two-class	189	15876
Royal Skies	36	3024

Table 5: Passenger Weight Analysis for Narrowbody Model

The reduction in passenger weight between the Royal Skies configuration and the full economy configuration is 85.24%. This shows a considerable reduction in ZFW and this will benefit the aircraft's range, minimum runway length, landing fees and fuel consumption. Therefore, even though ticket prices will have to be very high, this reduction in costs will help make it easier for Royal Skies to make a profit. [Hawaiian Airlines, 2018]

The higher range models have an increase in MTOW with respect to the A321neo, which is explained by the increase in fuel capacity. It will be important to consider the uses that clients of the charter service will make of the aircraft, since it's possible that event equipment and other event-related cargo will be occupying the "excess" cargo space.

5.2. Wide Body Aircraft

In order to avoid discarding the opportunity to expand the business and offer a larger passenger capacity, widebody aircraft will also be considered. Widebody aircraft offer

advantages and disadvantages with respect to the narrow body ones. They have more space for cargo and passengers, and they can be more comfortable because of this extra space. This is especially interesting for the charter service, since it will make the performance of events much easier and brands will be able to transport more customers. Nevertheless, airport and maintenance costs and landing fees will be much higher compared to a narrow body. The two widebody aircraft that are being compared are the A330-900 and the A350-1000.

The A330-900 is the newest version of the A330 Family, it is known for its versatility as it can perform both short haul and long-range routes while keeping the lowest seat-mile cost in the widebody category. This new version, thanks to its new Rolls-Royce Trent 7000 engines, burns 25% less fuel and CO₂ emissions than the A330-800.

The A350-1000 is a very efficient widebody aircraft for both short and ultra-long range flights. It has great use to connect emerging markets that are far away from each other. Thanks to its soundproofing, the A350-1000 is the quietest twin-aisle cabin in the market, which is a great advantage for Royal Skies as they want to provide the most comfortable trips for their passengers.

In terms of dimensions, it is the biggest of the four aircraft considered. It is very spacious inside thanks to its maximum cabin width. But in terms of storing, its dimensions can become an issue.

Dimensions	A330-900	A350-1000
Overall Length (m)	63.66	73.79
Cabin Length (m)	50.36	58.03
Fuselage Width (m)	5.64	5.96
Max Cabin Width (m)	5.26	5.61
Wing Span (geometric) (m)	64.00	64.75
Height (m)	16.79	17.08
Track (m)	10.68	10.73
Wheelbase (m)	25.38	32.48

Table 6: Dimensions of the A330-900 & A350-1000 [Airbus, n.d.]

Royal Skies sees a benefit in having a widebody aircraft for the charter option, since it will offer higher range routes, increasing the spectrum of destination offers. In addition, brands and companies could carry a higher number of customers or workers as well as having more spacious lounge areas. However, for the organized-itinerary trips this extra space and passenger capacity is not as beneficial as Royal Skies wants to keep this type of trips exclusive and limited to small groups of people. Some of the activities and services would be impossible to offer with a high number of passengers.

5.2.1. Range

The range offered by the A330-900 will allow Royal Skies to create and serve longer routes that the narrow body aircraft are not able to perform. It has a higher maximum operating speed, M0.86, than the A321 models making the same trip shorter in time. The range goes up to 7200 nm.

A similar thing happens with the A350-1000 model. This aircraft has highly efficient engines, Rolls-Royce Trent XWB-97 turbofans, that make it possible to achieve a tremendous range of 8700 nm. At the same time, this aircraft burns 25% less fuel than its closest competitor. It has a maximum operating speed of M0.89, making it the fastest of this list. With this aircraft, Royal Skies would be able to connect most of the destinations in the world.

5.2.2. Cargo capacity

The cargo capacity is more than enough but Royal Skies could use the extra space to carry cargo for other companies or airlines as a second source of revenue. This will help Royal Skies increase its profit or open the possibility of offering relatively cheaper costs for their customers while keeping the same profit.

Cargo Capacity	A330-900	A350-1000
Cargo LD3 capacity underfloor	33	44
Max pallet number underfloor	9 + 5 LD3	14

Table 7: Cargo Capacity of the A330-900 and A350-1000 [Airbus, n.d.]

5.2.3. Weight

The increase in weight is huge compared to those of the narrow body models. This is not only due to the aircraft's size itself, but also to its fuel capacity. This will result in higher costs overall, but specially in terms of landing fees, airport, and maintenance costs.

Weight	A330-900	A350-1000
Max ramp weight (tonnes)	251.90	319.9
Max take-off weight (tonnes)	251	319
Max landing weight (tonnes)	191	236
Max zero fuel weight (tonnes)	181	223
Max fuel capacity (liters)	139090	164000

Table 8: A330-900 and A350-1000 Weights Data [Airbus, n.d.]

The ZFW of the Royal Skies version will be lower than that of these two models, similarly to what happened with the narrow body aircraft. Royal Skies will only be carrying approximately 54 passengers, which is considerably lower to the A330's or A350's passenger capacities. It would be possible to fit more passengers, even with Royal Skies' seat geometry limitations and common areas, but this amount of 54 passengers still maintains the exclusivity for the organized trips, which is one of the guarantees for passengers. In the remaining space, two common areas with different ambiances would be designed into the wide body models.

The weights used for this study will be very similar to the ones used in the A321neo analysis. The economy seat will weigh 11.5 kg, the economy plus seat will be 15 kg and the business class seat 80 kg. For this study, the Royal Skies version is considered to increase the number of passengers by 18 in comparison to the narrow body models.

[Dubois, 2020]

	A330-900		A350-1000	
	Seats	Weight (kg)	Seats	Weight (kg)
Three class layout	29B, 28E+, 224 E	5316	31B, 24E+, 293E	6209.5
Full economy	460	5290	480	5520
Royal Skies	54	4320	54	4320

Table 9: Seats Weight Analysis for Widebody Models

[Delta Airlines, n.d.]

[Airbus, n.d.]

[Iberia, 2022]

The conclusions about this study are similar to the ones performed for the narrowbody model. The difference in seat weighs are slightly more notable but, however, the true difference in weight derives from passenger and luggage weight. Considering the same passenger weights as in the previous study:

	A330-900		A350-1000	
	Passengers	Weight (kg)	Passengers	Weight (kg)
Three class layout	281	23604	348	29232
Full economy	460	38640	480	40320
Royal Skies	54	4536	54	4536

Table 10: Passengers Weight Analysis for Widebody Models

The reduction in passenger weight between the Royal Skies configuration and the full economy configuration for the A330-900 is 88.26% and for the A350-1000 is 88.75%. This huge decrease in weight will benefit the aircraft's range, minimum runway length, landing fees and fuel consumption. Therefore, even though ticket prices will have to be very high, this reduction in costs will help make it easier for Royal Skies to make a profit.

5.3. Final Aircraft

In order to choose the best aircraft candidate for this project, it is important to focus on certain data that this aircraft must comply with. Firstly, it's important to consider aircraft price, which is shown in the following table.

Aircraft Model	Price
A321neo	129.5 million \$. [Ahlgren and Pande, 2022]
A321LR	130 million \$ [Travel Radar, 2020]
A321XLR	142 million \$ [IAG, 2019]
A330-900	264.2 million \$ [Ahlgren and Pande, 2022]
A350-1000	366.5 million \$ [Ahlgren and Pande, 2022]

Table 11: Prices for each model

Given the difference in price between the A350 and the A330 and assuming that there is an excess both in range and capacity for both aircraft, it's possible to discard the A350 from the final aircraft decision.

The benefit of choosing one of the narrow body models is that the interior of it is constant throughout the three variants. Royal Skies may need a combination of said variants to fulfill all its services. For transatlantic routes booked through the charter service the best option is the A321LR. In the future, this variant could be replaced by the A321XLR, or added to the fleet separately, if new longer range routes are demanded. Another reason to prioritize the LR over the XLR for the first years of the airline, is the problematic certification that the A321XLR is currently enduring due to the dangerous position of some of its tanks. [Curran, 2022]

Despite the A330 being a possibly better option for the charter market than the narrow bodies, given that Royal Skies could offer higher capacity flights and be very spacious inside, it would be excessively large for the organized trip service, resulting in a larger costs per passenger ratio than the A321 models. In the future, it might be a good option to introduce these wide body models if the market demands it. Meanwhile, narrow body aircraft are the least risky option.



Other essential data unaffiliated to the remaining aircraft models are runway distance and distance between the chosen destinations. In terms of defined routes, the more critical one is the Santiago de Chile to Mexico City flight. The distance is 3550 nm and the range of the A321neo is 4000 nm. Note that the route distance was measured in a straight line, and that it may vary depending on the exact flight route taken by the aircraft. Considering that the A321neo won't be flying at its maximum weight, there is not any problem with this route. It's possible, however, that charter clients require flying a longer route. Additionally, the required passenger capacity could also be greater than what is offered by Royal Skies.

The runway length of the destinations is another aspect that must be taken into account to decide the aircraft. Some of the destinations are remote places and the runways are not as long as the ones of main airports. In Annex I, all the runway lengths are specified. The critical runway lengths are:

	Take-off distance (m)	Landing distance (m)
A330-900	2350	1850
A321neo	2150	1850

Table 12: Runway distance data

To calculate these distances the aircraft is considered to fly at MTOW. The A321neo is more versatile than the A330 for this characteristic. There are three airports that are critical in this aspect; La Guardia, Louis Armstrong New Orleans and Kapalua Airport. These runways were chosen due to their lower costs, which would increase Royal Skies' margin, but in order to maintain the three destinations, some changes must be performed.

For New York City, there is the possibility to take off and land in John F. Kennedy International Airport where runway length covers all of the considered models. The solution for the New Orleans destination is to use the other runway that this airport offers which is longer than the one considered. For Kapalua airport there is only one runway and it is extremely short for all the aircraft considered. The solution is to take off and land in Kahului Airport which is the main one in Maui, HI. The longest runway is 2133 m [Airnav, 2023], which is still not enough for one of the two A321 models and A330. It will be easier for an A321 to be able to take off and land in this airport considering that the Royal Skies aircraft won't be flying at its MTOW; the necessary takeoff distance is reduced considerably. With this consideration the only competent option for Royal Skies is an A321 whether it is the neo or

the LR version. A further study must be taken in order to determine if the decrease in weight is enough to take off and land on this runway. [Airnav, 2023]

The following graph relates aircraft weight and runway length for different airport pressure altitudes. Kahului airport has an elevation of 55.4 ft, which is practically sea level. Therefore, the curve labeled “0” is the one that will be important for this airport’s study.

The Royal Skies’ redesigned model will have lower take-off weight when compared to the commercial version. As an early approximation, the average take-off weight of the Royal Skies version will be around 85 tons which would mean a decrease of 12.37%. Once the redesign is completely done, a deeper study in weights will be performed. With this new TOW, the graph returns that a runway length of approximately 1800 m would be enough for the A321 to take off and land in this problematic airport.

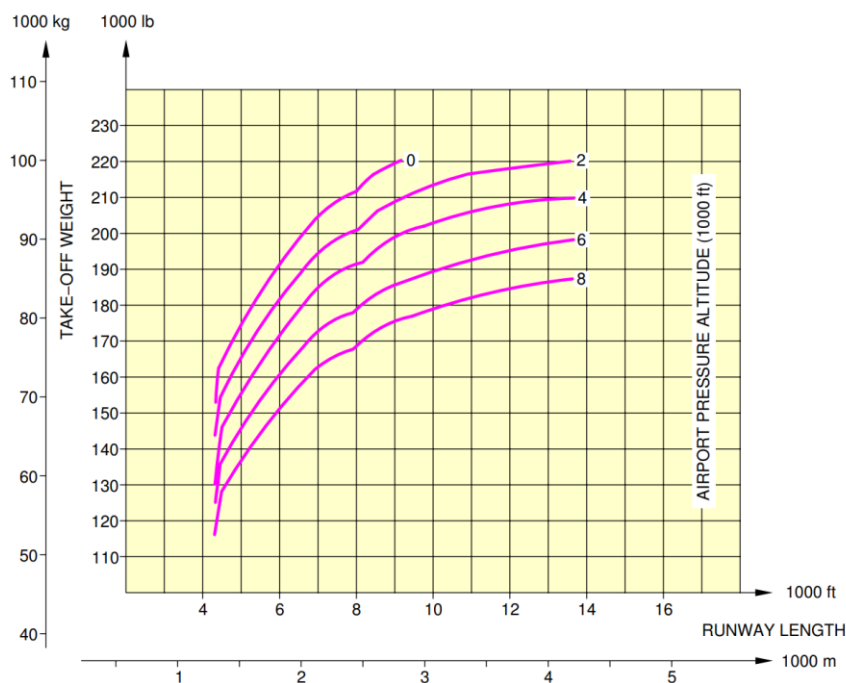


Figure 5: Take-off weight vs Runway length [Airbus, 2020]

Although other airports were not as critical in terms of runway length, this graph shows how heavily the altitude of the airport can affect the performance of the aircraft when taking-off and landing in an airport. The Phoenix Sky Harbor International Airport is at 1134.8 ft of height [Airnav, 2023]. The distance needed to take off and land will be higher than the airports that are located at sea level but still there is enough runway for the Royal Skies A321 version.



There are other airports that can have high altitude but the runways are long enough for all cases, which is why they are not being further analyzed.

With this final limitation, and considering previous comparisons related to efficiency in the different services, required range, etc, the best option for Royal Skies is to have the A321LR which can reach all the destinations. In the future, thinking about expanding the fleet, the

A321XLR and A330 will be considered to offer higher range charter connections and/or more spacious aircraft interiors. Another important benefit that will bring the LR vs the A321neo is that this aircraft is perfectly equipped to fly over the Atlantic ocean.

Chapter 6. REDESIGN PROCESS

For Royal Skies it is very important that the interior design of the aircraft is representative of the type of brand that the company wants to transmit to their customers. It's essential that it transmits the message that this is an evolution towards "the first class of today".

In the 70s, airlines did not need to fill the aircraft with seats close to each other. It was normal to have lounges for first class passengers and in some cases for economy class. When the industry suffered an economic change and a huge increase in air traffic, airlines had to fit all the seats possible in order to obtain higher profit. In addition to this, Economy and Business class seats improved considerably and there was a point at which Business seats were even better than the preceding First class seat models. When this happened, passengers realized there was no added value to the more expensive First class tickets, and they eventually disappeared in most airlines.

6.1. Cabin's distribution

The area of the cabin of the A321neo models is 120.54 m². The width of the floor is 3.5 m and its length is 34.44 m. This space must be taken advantage of to the maximum since every centimeter will be essential in making the aircraft profitable.

The following *Figure* is the first cabin distribution design, where there are a total of 40 passenger seats, two bathrooms and an area to socialize and enjoy some drinks and music. The first part of the cabin is assigned to the galley and the main bathroom. It is followed by the relaxing area where all the seats are located. In this space, passengers will relax, talk to their companions and watch movies or other types of entertainment. At the rear of the aircraft the entertainment area and second bathroom of the aircraft are located.



Figure 6: First cabin's configuration

There are several problems with this configuration. Firstly, there is no space for the artists of the live performances or extra crew that might be needed in certain charter event flights. Secondly, there must be a restroom for crew members only.

Because of these two problems there were a few changes performed. First, a customer's row was eliminated because of the need for extra space for a crew member's bathroom and extra seats for performers or crew. The second cabin's distribution had the crew member's seats and their bathroom in the first area of the cabin. The rest of the aircraft stayed the same, followed by the customers' first bathroom and the galley. Then the passengers' seats and at the rear the entertainment area and second customer's bathroom.



Figure 7: Second cabin's configuration

Nevertheless, there was another problem with this second configuration. The center of gravity of the A321 tends to be too displaced towards the front and with this configuration it is more favorable to have it more forward than the commercial version. In order to improve this, it is advisable to move weight to the rear of the aircraft to move the center of gravity towards the desired direction.

The final configuration is shown in the following *Figure*. Although it was beneficial to have the galley in the front of the aircraft because of the logistics when loading and unloading the food and drinks of the aircraft, it will be in the middle of the aircraft. This new location will be optimal for Royal Skies flights for several reasons. It will move the center of gravity to the back and it will separate the relaxing area and the entertainment area. Having the galley between these two areas will make everything easier for crew members to provide food service in both places. The customers' seats location was never considered to be changed because they must be at the most silent area of the aircraft which is the front. At the end of the aircraft is the entertainment area. It is going to be equipped with a bar area where customers could order all types of drinks and cocktails, a seating area with sofas and small tables to enjoy the drinks.

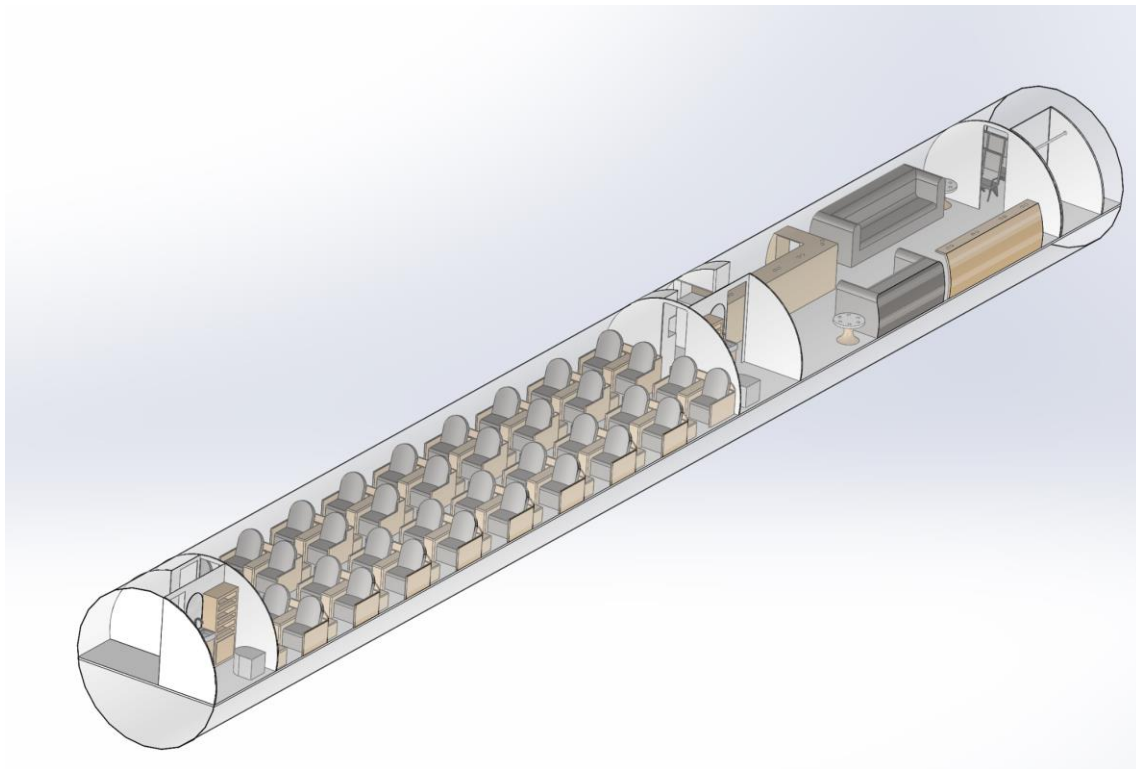


Figure 8: Isometric view of final cabin's configuration

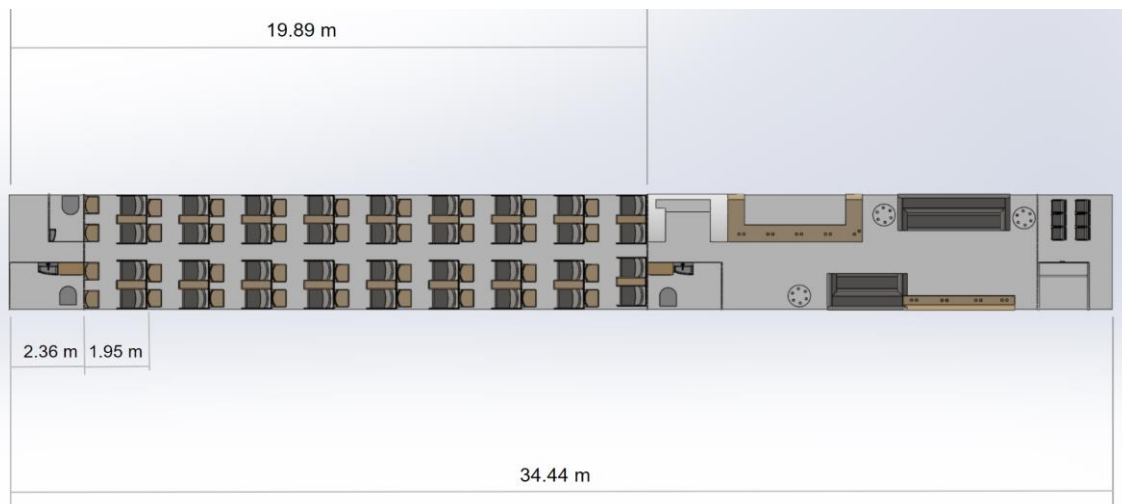


Figure 9: Final cabin configuration plan

All the things needed to be loaded on the aircraft's galley will be done from the back of the aircraft. The reason for this is to have more space to carry all the necessary things without having to maneuver between the customers' seats.

This configuration solves the aforementioned problems. There are seats for the extra crew or live performers, it has three restrooms; two assigned to customer's use and one

conventional one for crew members. The configuration has changed in order to distribute the weight in order to keep the center of gravity further aft.

6.2. Seat design

6.2.1. Customers' seat design

The customers' seats must be very comfortable, spacious, and equipped with all types of in-flight entertainment systems. Its design is inspired by different business classes of well known legacy airlines. At first, it was considered to include 10 rows of seats, making up a total of 40 passengers, but because of the live performances or extra crew needed for certain events, the decision was to have 9 rows, and therefore 36 passengers in total.

The seat design is not designed to be individual but rather in pairs, i.e. the seat case contains two whole seats. The seats become completely flat so that passengers can relax during flight. In addition, when the seat is not in flat mode, a comfortable, smaller seat in front of the main one is available so that passengers may talk face-to-face. Under this front seat there will be space for passengers' purses or handbags, and the rest of their luggage will be checked in the cargo space. Additionally, in between the two seats there will be space to hide the tables, as well as USB and type C USB connectors to charge passenger's electronic devices. Also located in this space will be LED headlamps that the passenger will be able to adjust to read or eat with light without disturbing the rest of the passengers. It will also be equipped with two bottle holders so that passengers can leave their drinks without being scared of it falling.

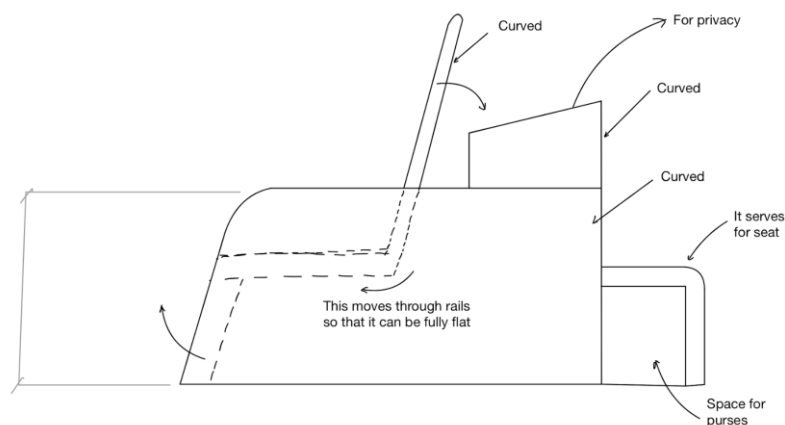


Figure 10: Schematic seat concept

Figure 10 shows the first seat design. The seat's case is made out of plastic for weight reduction but with a woodish surface finish to make it more elegant. The cushions will be made out of white transpirable leather in order to be elegant while comfortable for the passenger with dark brown seams to make it more sporty. The seat will have incorporated headrests with adjustable settings in order to achieve the most comfortable position for each passenger.

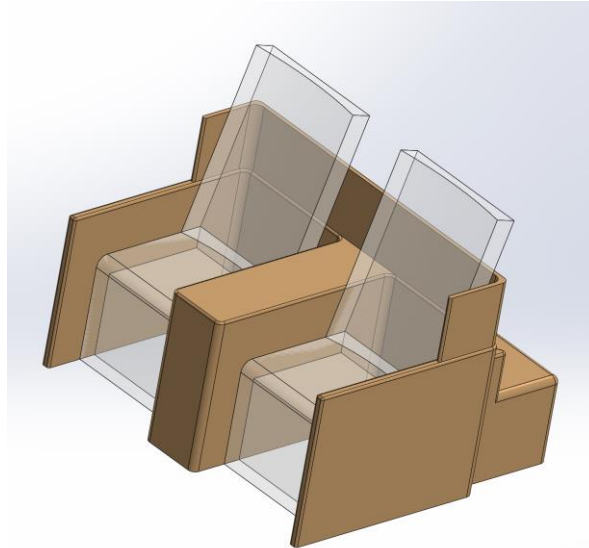


Figure 11: Isometric view of the first seat design

The problem of this first design is that it has a very squarish shape and it must be redesigned in order to be more comfortable, to fit better inside the aircraft and to be safer in case of someone falling. It is better to have rounder surfaces to prevent a more severe injury.

The second design shown in *Figure 12* differs mainly in the shape of the back cushions and slightly in the seat case's design. The case's shape has changed; the wall that gives privacy and separates the seats from the row in the back is lowered.

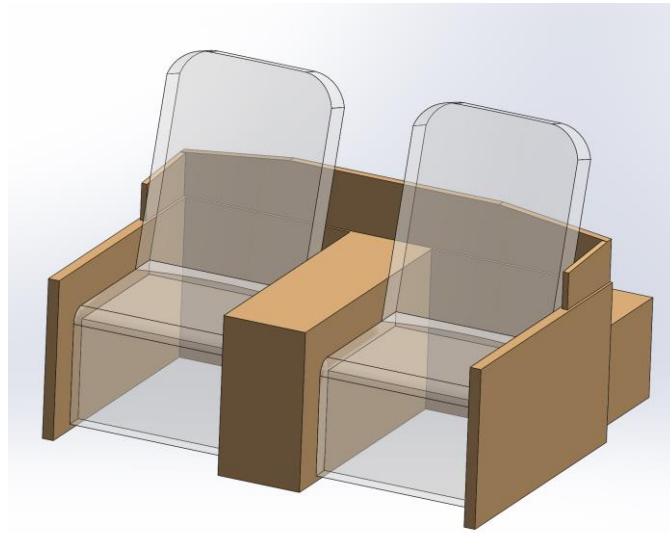


Figure 12: Isometric view of the second design

When comparing against the shape of the A321 cross section, the seats slightly exceed its width and cannot be narrowed down because it would result in a loss of comfort. The upper shape of the seat must be redesigned in order to fit the seats within the cross section while also being as wide as possible so that comfort is not sacrificed.

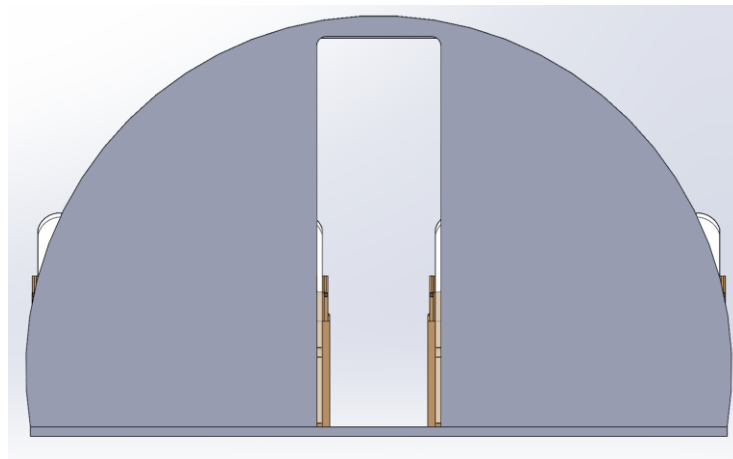


Figure 13: Cabin Cross section view with second design seats

The final seat design has a rounder shape not only in the back cushion but also in the case. At the exterior side of the seat's case it has a rounder shape in order to fulfill the upper dimensions of the cross section.

Although it might look very asymmetrical, the reason why the side next to the aisle doesn't have the same roundish shape is to have more support surfaces in the interior side for safety

reasons. In a normal aircraft configuration, flight attendants and passengers lean on the seats or the overhead compartments to move through the aisle and it's especially helpful in case of turbulence. For Royal Skies' interior, the seats are further away from each other than the ones of economy class. In addition, there are not going to be overhead compartments to make the cabin feel more spacious and because of the ceiling curved screen installation. Therefore, the lack of roundness on the interior of the seat case is necessary as an alternative form of support.



Figure 14: Isometric view of the seat's final design (aircraft's left hand side)

All of the seats follow the same configuration except for the ones in the last row. They do not have the extra seat in the back because there are not any other rows behind them.

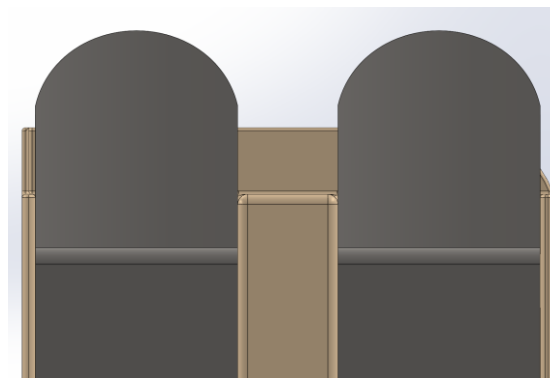


Figure 15: Front view of the seat's final design (aircraft's left hand side)

In this following *Figure* it is shown all the important measurements of the customers' seats. When the seats are in a completely flat position the total length of the seat is 1.95 m. The seat length without being flat is 1.41 m.

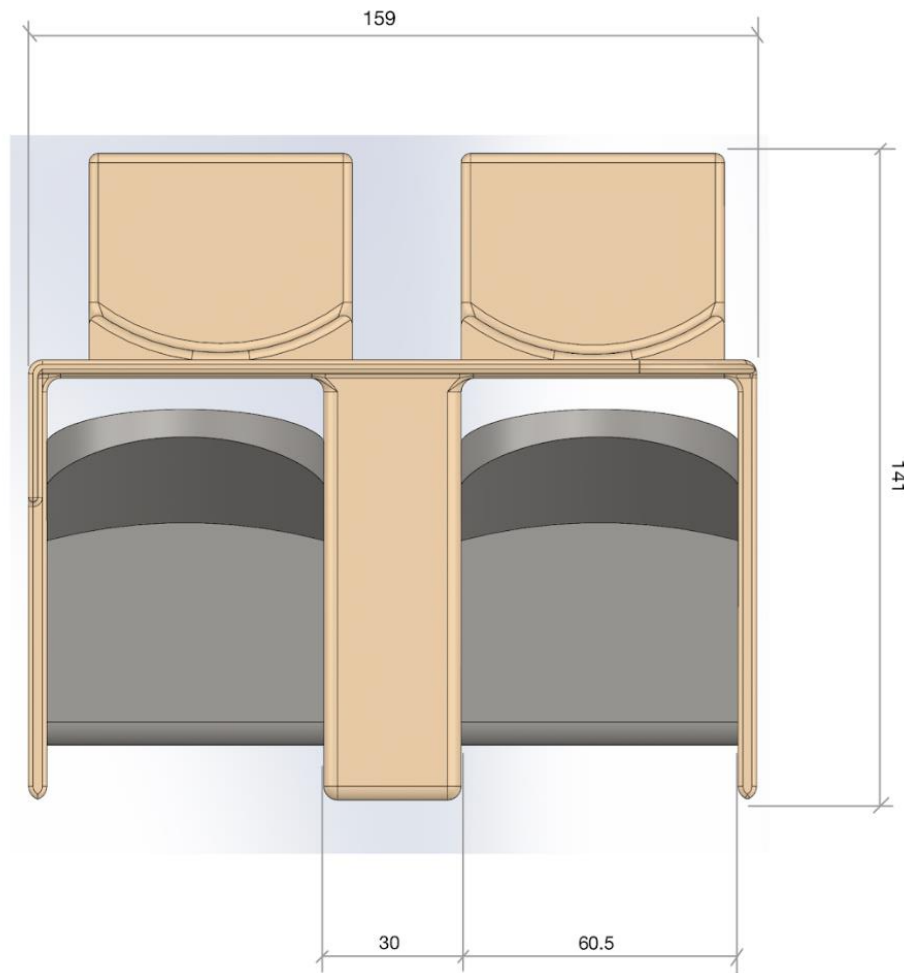


Figure 16: Top view of the seat's final design and its measurements in cm

6.2.2. Crew seat design

These seats will be used by extra crew members that might be needed in certain charter flights and for live performers that will entertain the organized trip flights. They follow the commercial airline's shape. It has a width of 18 inches and a seat pitch of 30 inches. It has bigger measurements than a low cost carrier's width and pitch so that the extra crew or performers can fly comfortably as well.

[Hussain, 2023]



Figure 17: Crew members' seat design

The color palette of these seats is darker, it was chosen like this because it is more practical and it needs less maintenance time. The material of cushions is transpirable leather as well as the passengers and the armrest and legs have a matte black finish.

6.3. Bathroom design

Royal Skies is committed to design a bathroom that everyone is able to use. Consequently, it must have enough space to fit a wheelchair.

Royal Skies will have two big and spacious restrooms for the customers and a small conventional one for the crew members. The color palette will be white and light wood finish surfaces so that it matches with the whole interior design palette of the aircraft. In addition, the use of light colors will make everything look clean and spacious.

Both bathrooms have the same configuration, a spacious lavatory compared to a commercial airlines version, the WC and a shelf where Royal Skies will keep cosmetic products for passengers so that they can hydrate and clean their face and hands, and even put face masks during flights. The shelves have restraints so that the products do not fall during certain maneuvers during flight.

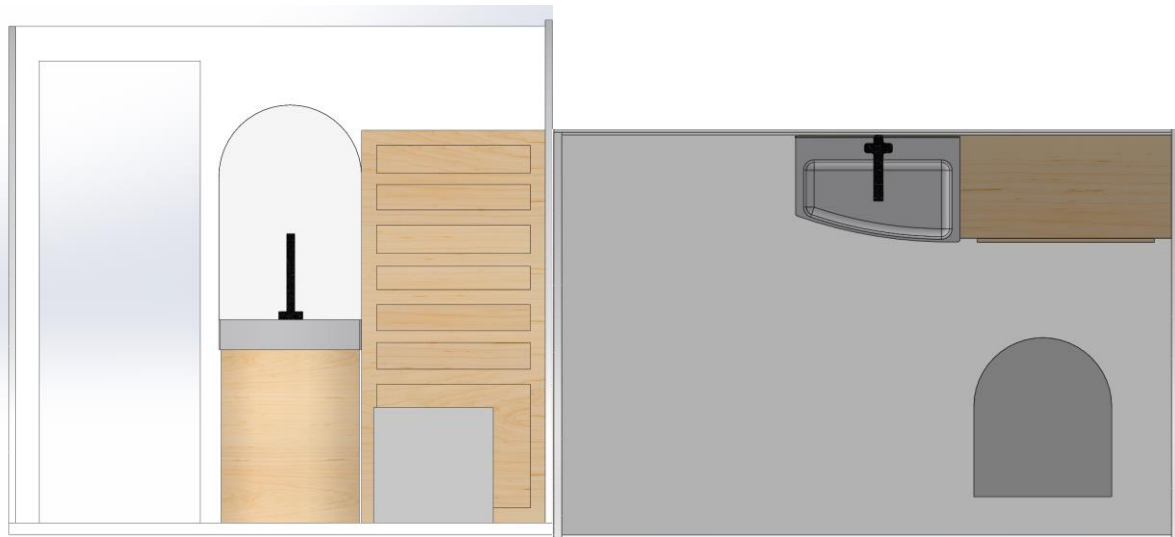


Figure 18: Top and front view of the customers' bathroom

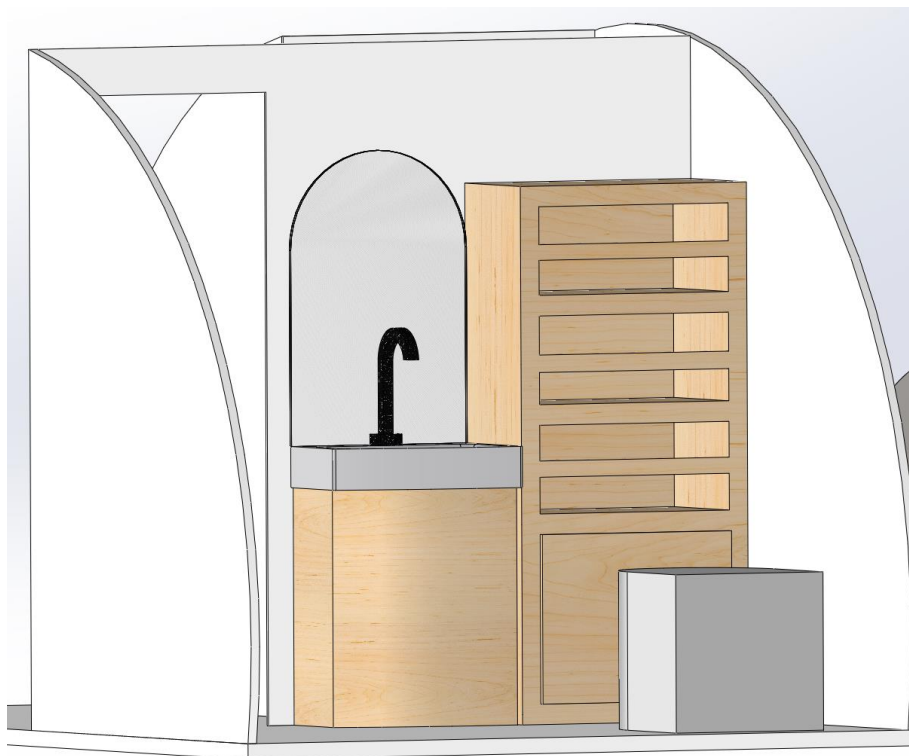


Figure 19: Isometric view of the customers' bathroom

The first idea was to put one customer's bathroom at the front, one in the middle and at the back the one intended for crew members. The issue with this configuration is that if a pilot needs to go to the restroom, he/she will have to go across the whole aircraft. But it would have been beneficial in terms of weight distribution.

The final configuration is one crew bathroom and one customers' bathroom located at the front in order to be easier for a disabled person to maneuver with the wheelchair to the bathroom. There will be a free space in front of the door to ease the entrance by wheelchair. In addition to this, there will be another bathroom in the middle of the aircraft in front of the galley. The measurements of the customers' restrooms are 2.3 m wide and 1.52 m long. The crew's bathroom will have a smaller size but the interior design is similar to the one for the customers. It is located in front of the first customer's bathroom.

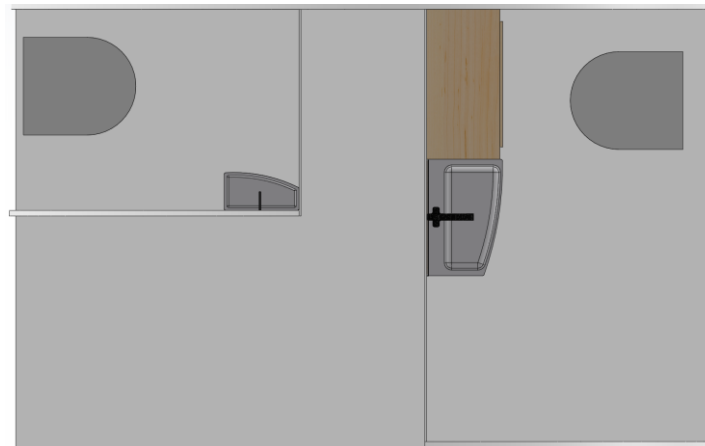


Figure 20: Free space to maneuver the wheelchair to enter the bathroom and crew members' bathroom

The crew members bathroom has slightly larger measurements compared to a commercial airline bathroom. Its length is 1.51 m and it is 1.07 m wide. The design is similar to the one for the customers, however it won't have a shelf inside and the lavatory is considerably smaller. [Aratani, 2018]

6.4. Galley's design

The galley of an aircraft is equivalent to a kitchen. For Royal Skies it's a very important feature because they offer the full in-flight food service. The galley must be big enough so that the crew can provide food for all the passengers in a short period of time so that no customer has to wait a considerable amount of time for his food.

For a narrow body aircraft it is common to have two galleys, one at the front and other at the back. However, Royal Skies aircraft will have only one galley but bigger than the ones used in commercial aircrafts.

As mentioned before, it would have been beneficial to have the galley at the front to ease the loading and unloading of food and drinks but because of the Royal Skies' style and configuration it will work better in the middle of the aircraft. One positive point for this location is the closeness to the entertainment area. The drinks will be kept and prepared in the bar leaving more space for the food in the galley. In addition to this, the galley, which is the less aesthetic feature of the aircraft, won't be the first thing that the passengers will see when boarding the aircraft. And it is a heavy part that will help move aft the center of gravity of the aircraft.

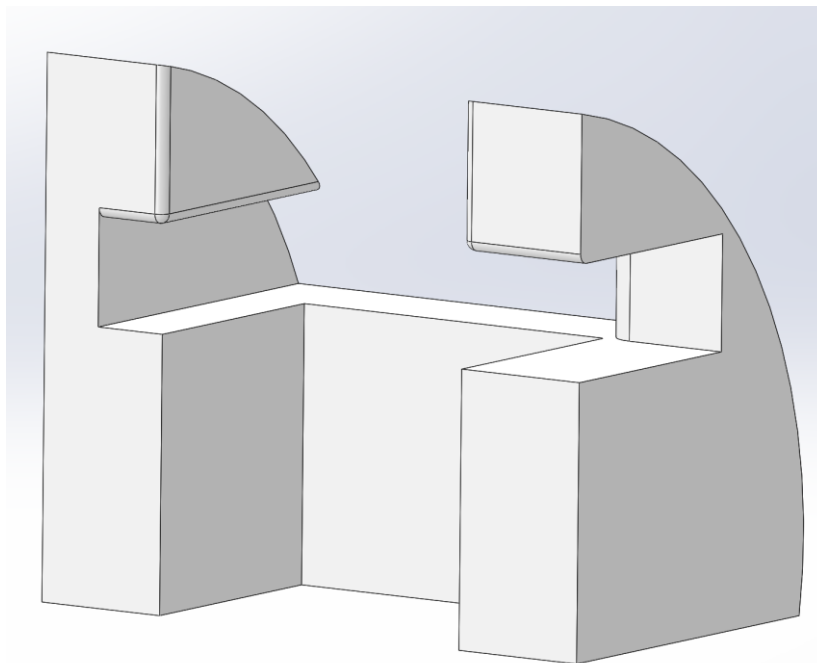


Figure 21: Galleys final design

It has a width of 2.5 m and it has plenty of counter space so that the flight attendants can prepare all the dishes comfortably. It has a white color so that it looks more spacious, stylish and cleaner. The spaces at the top will be used for keeping all types of kitchenware. At the two peninsulas, there will be ovens to warm and finish the food. At the central lower space, there will be a big fridge to keep the food fresh during flight. The aft side of the galley is connected with the bar of the entertainment area. It is connected for easier communication between crew members and to pass the drinks to take them to the customers in the relaxing area.

6.5. Extra interior design elements

In order to obtain a differentiation with the business class of commercial airlines' cabins, Royal Skies has introduced interior design elements that will give extra comfortness and style to the cabin, most of them are located in the entertainment area.

The bar of the entertainment area is the first thing that customers will see. The design started with a concept of a L-shaped bar all in satin dark gray. Then this design was improved and an interior space was created to keep all the necessary things like bottles, glasses, ice, etc. These two designs have a total length of 3 m and they are 1.1 m wide. These two first ideas were designed thinking that the bar will be separate to the galley, it will be alone in the entertainment area.

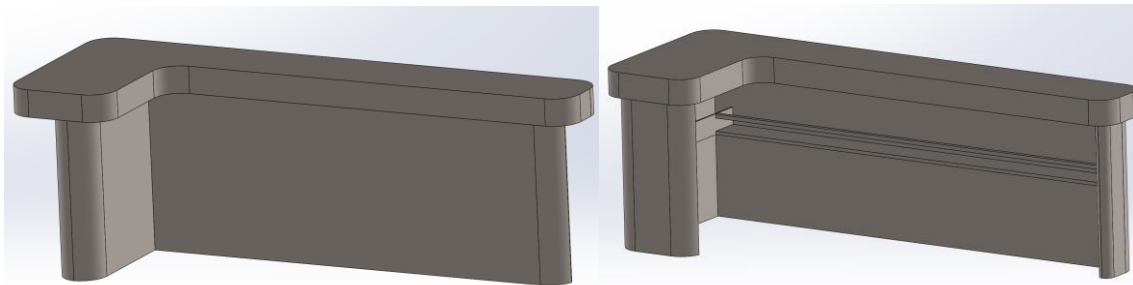


Figure 22: First and second designs of the bar

After deciding that the galley was going to be located in the middle of the aircraft the concept of the bar changed and it was adapted to the galley's design. The final design has a C-shape. One of the peninsulas is connected with the galley to provide the drinks for the seating area. The bar has a light woodish finish to match with the style of the rest of the cabin. There are ten glass positioners, which are small holes on the bar to put the glass while preparing the drink so that in case of sudden turbulence or aircraft maneuvers, the glasses don't slide through the bar. Inside the bar, there is a large space to keep all the glasses and bottles to prepare all the cocktails. The bar will also be equipped with a coffee machine. This shelf has a security bar to prevent the bottles and glasses from falling.

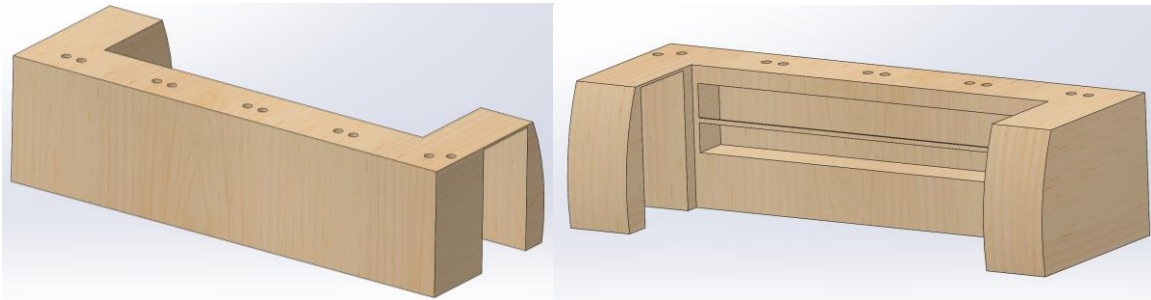


Figure 23: Isometric view of the outside and inside of the bar

On the opposite side of the galley, the bar is kept open so that the member in charge can leave or enter the bar through that space. The bar has a total length of 4.2 m and its total width is 1.37 m, the width of the C is 52 cm; it will be enough space to serve all the customers.

Another feature will be the sofas. There are two sizes but the design is the same. Both of them are made of satin gray transpirable leather, the same used for the customers' seats. It has round surfaces to fit with the shape of the cabin. One of the sofas is 3.5 m long and 1.16 m width, the smaller one is 2.5 m long and the same width as the big one, 1.16 m.

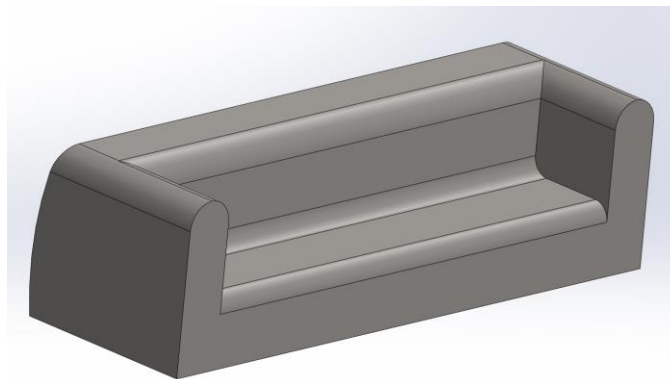


Figure 24: Isometric view of the sofa

While customers sit at the sofas, they can leave their drinks in small coffee tables specially designed for Royal Skies. The color palette goes perfectly with the rest of the cabin, the base will have a wood finish and the top will have a clean white finish. It will have six coasters to leave the drinks and prevent them from falling, a similar concept to the one of the bar.

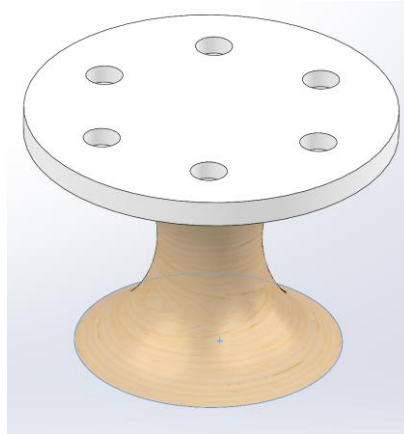


Figure 25: Coffee table design

In addition to these coffee tables, there will be a high long table so that passengers who prefer to be standing up, can leave their drinks there while socializing or dancing. It has a light wood finish, it has space for eight coasters. It has a length of 3.48 m and its width is 44.3 cm. It is held by the surface that goes against the fuselage.



Figure 26: Isometric view of the high table

The last additional element is a wardrobe at the back. For the two possible service options, customers might bring suit bags and they should not be checked because they can get damaged so there is a space in the cabin to keep them. It is located at the back next to the crew members' seats. It follows the shape of the fuselage and it has two translucent doors.

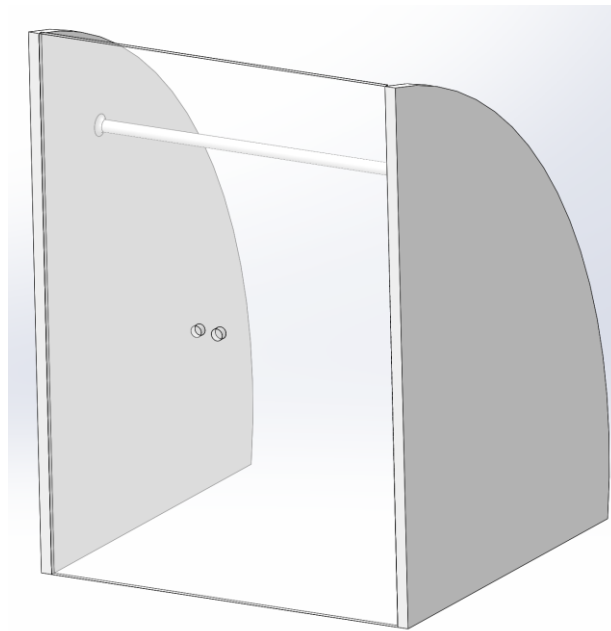


Figure 27: Isometric view of the wardrobe

Because of the shape of the wardrobe, there will be extra space if the crew needs to store additional elements that may be needed to create an unforgettable experience during flight.

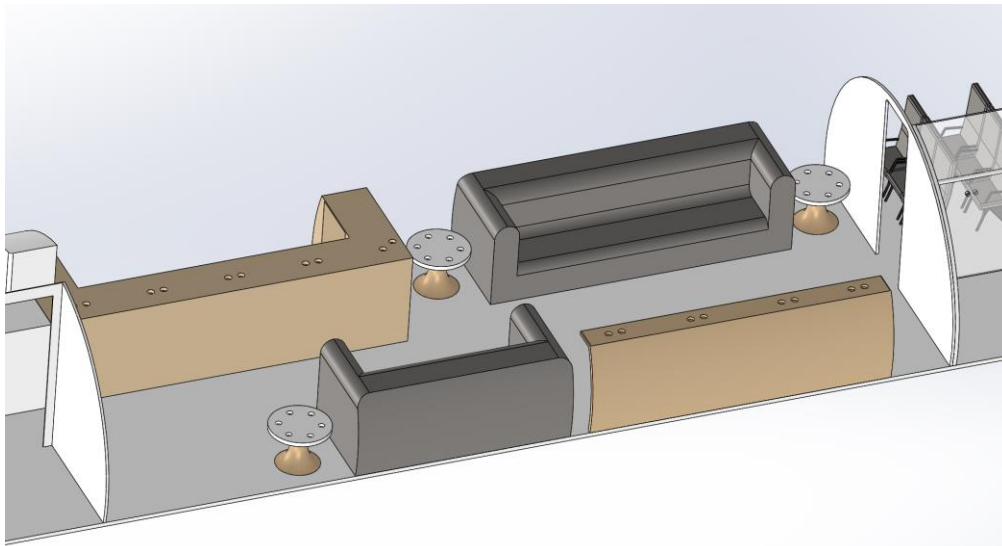


Figure 28: Entertainment area distribution 3D view

In this following *Figure* the galley and second customers' bathroom can be seen followed by the entertainment area. This shows the distribution of this zone where the two sofas are positioned diagonally, and the bar is the first thing that customers see when entering this area. This distribution was chosen to obtain the freest space between all the features and trying to

avoid narrow spaces. If some events of the charter option need more free space in this area, the smaller sofa and its coffee table can be easily withdrawn to leave more free space.

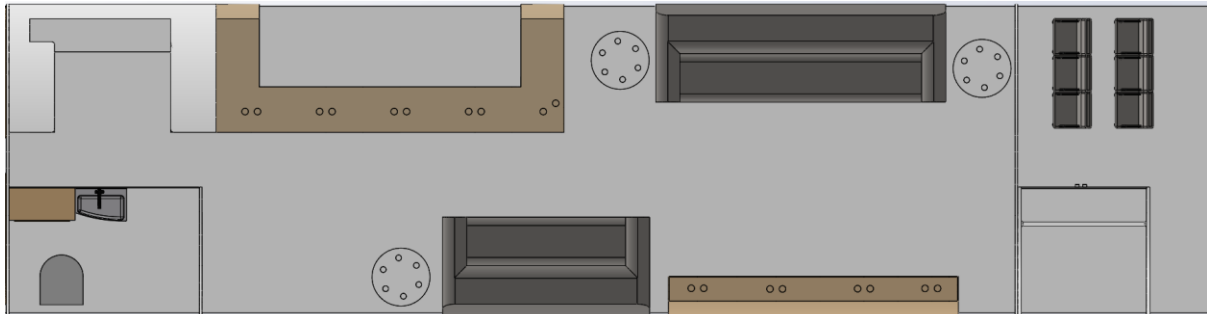


Figure 29: Top view of the second half of the aircraft

This last *Figure* of this chapter shows the top view of the final and total distribution of the whole cabin. If more storage space in the cabin were to be required, it could be created with a smaller wardrobe at the front next to the crew's restroom.



Figure 30: Top view of the final and total distribution of the whole cabin

6.6. Final weight and center of gravity location

Royal Skies' interior has changed completely from the neo commercial version. This could have several effects on the performance of the aircraft. It could affect the maximum weight that the aircraft will carry and it could affect the center of gravity's position. A proper analysis must be done to see how the new items and its distribution along the cabin affect the weight and position of center of gravity.

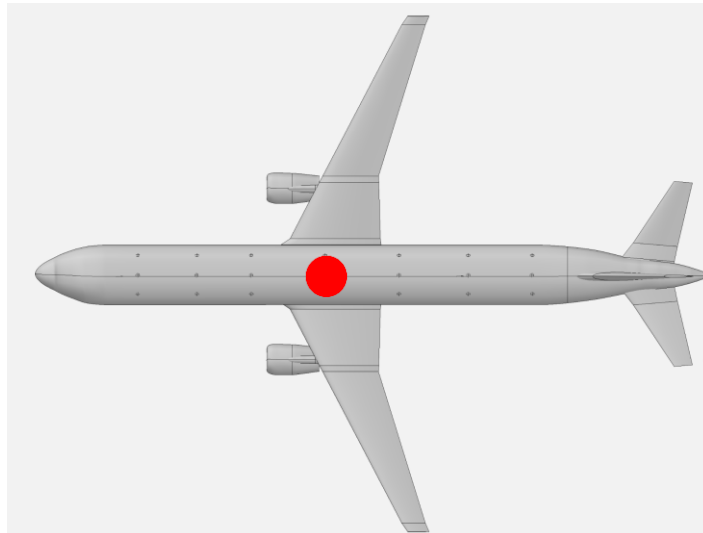


Figure 31: Position of center of gravity A321neo at MTOW

The center of gravity of the A321neo at MTOW is located at approximately 19.3 m for the purposes of this calculation. It is important to mention that this measure and the rest that are going to appear on the analysis have their origin as the forwardmost point of the nose. The center of gravity is obtained using the following formula:

$$CG = \frac{\sum weight \times position}{\sum weight}$$

Note that the following weights were obtained from Iberia's DOW A320 data sheets.

Object	Weight (kg)	Position (m)
Galley	1025	5.69
		37.69
WC	295	5.69
		36.69
		36.69
Seat (222)	2553	8.07 (x37 0.78 pitch)

Table 13: A321LR list of interior elements and weights

With this data, the center of gravity obtained for the interior of the A321LR is 24238 kg located at 21.79 m. Therefore, the location of the COG of the aircraft without its interior elements will be 72762 kg at 18.47 m. This last COG will be approximately the same for the Royal Skies version, given that only the interior elements are changed.

Object	Weight (kg)	Position (m)
Customer's WC	410	7.19
		25.63
Crew's WC	295	6.39
Customer's seat (36)	60	8.07 (1 st row)
		10.02 (2 nd row)
		...
		23.67 (9 th row)
Galley	1025	25.63
Bar	370	28.69
Coffee table	20	28.69
		29.69
		32.69
Sofa	65	31.39
	55	29.69
High table	35	31.39
Crew's seat (6)	15	35.69
Closet	120	35.69

Table 14: Royal Skies list of interior elements and weights



With this data, it can be calculated that the COG of the interior elements of Royal Skies is 9359 kg at 21.61m. This is similar to the commercial version's interior elements COG, but the truly important difference lies in the total COG displacement. Since Royal Skies' total COG is 82121 kg at 18.76 m, this translates into a displacement of the total COG 0.542 m forward.

To analyze whether this displacement in COG is valid, the following table from Iberia's Weight and Balance Manual will be employed:

CG TABLES WV 006

FORWARD CG LIMITS

A/C Weight		A/C CG		
		Takeoff (L/G, slats, and flaps down)	Flight (L/G, slats, and flaps up)	Landing (L/G, slats, and flaps down)
(kg)	(lb)	(%MAC)	(%MAC)	(%MAC)
47 500	104 720	12.00	9.50	12.00
71 000	156 528	12.00	9.50	12.00
75 500	166 448	-	-	14.30
83 000	182 983	17.50	15.50	-

AFT CG LIMITS

A/C Weight		A/C CG		
		Takeoff (L/G, slats, and flaps down)	Flight (L/G, slats, and flaps up)	Landing (L/G, slats, and flaps down)
(kg)	(lb)	(%MAC)	(%MAC)	(%MAC)
47 500	104 720	29.04	42.00	41.00
75 500	166 448	-	42.00	41.00
79 200	174 606	-	42.00	-
80 300	177 031	40.60	-	-
83 000	182 983	39.70	40.75	-

Table 15: COG limits for the maximum weight configuration of the manual

To analyze this, the MAC must be calculated using the Open VSP 3D model. The MAC obtained is approximately 3.5 m. For cruise flight, the maximum forward COG limit is 15.50% of MAC which results in 0.543 m. The Royal Skies version moves the center of gravity 0.542 m. This is not a coincidence; the distribution of Royal Skies has been changed until the new center of gravity complies with the limits. In addition to this, the cargo of the passengers will be located at the back of the aircraft to prevent moving the COG forward.

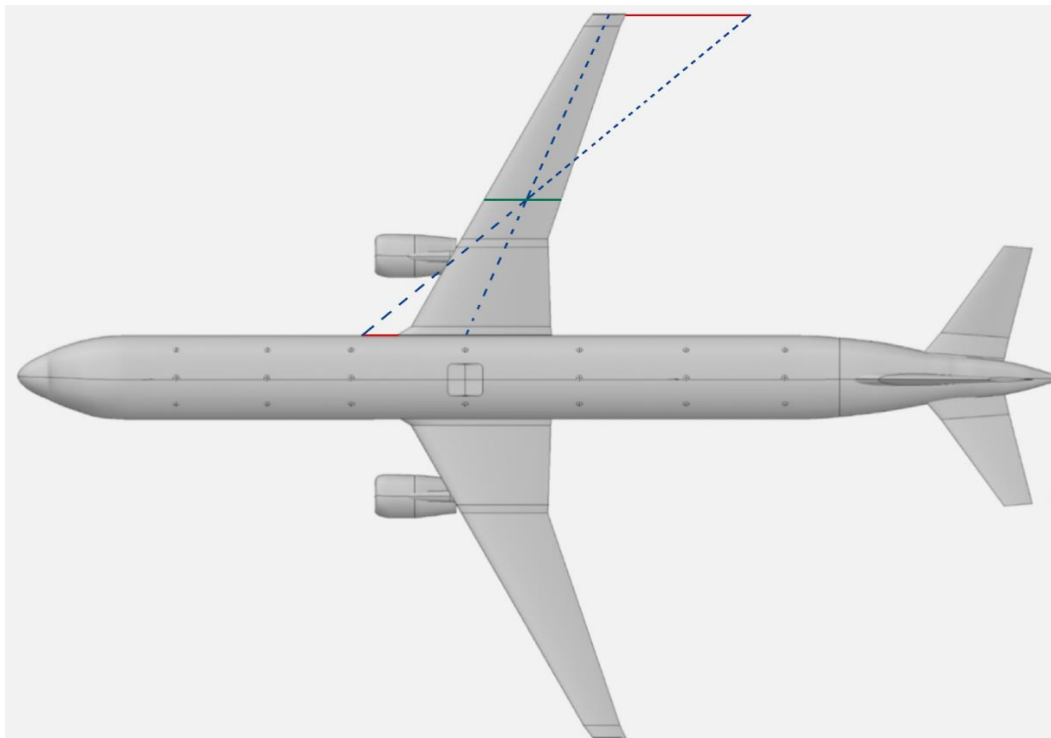


Figure 32: Schematic location of MAC (represented in green)

Chapter 7. ADDITIONAL FEATURES

All of the In-Flight Entertainment systems (IFE) will increase the maintenance hours for Royal Skies, increasing the costs considerably, but it will give them the advantage to be differentiated from other charter airlines and create an unforgettable and unique experience. In a normal wide body commercial aircraft, the maintenance hours for the IFE systems can go up to 30 man-hours per week to check all the IFE. Although Royal Skies is a narrow body aircraft, the amount of hours of maintenance can be compared to a widebody because of all the additional features that it will have. However, the amount of total TVs located in the seats will be considerably lower than wide body commercial aircraft.

[Clark, 2001]

7.1. Curved Screen

Royal Skies' aircraft won't have a conventional aircraft ceiling, instead it will have a curved screen. The relaxing and entertainment area have two independent screens, which show different images according to the area they are on.

Royal Skies contacted a manufacturer of curved screens, Lemon LED, and their way of fabricating these types of screens is by panels of 1 m² maximum. However, the ideal, most modern, and most aesthetic option would be to have a full curved screen with the specific measurements to cover the whole ceiling of the relaxing area and another for the entertainment area. This full screen will provide better image quality than one made from panels. However, with a curved screen with the dimensions of the whole ceiling area and supported by two longitudinal brackets, there is a danger of deformation caused by vibrations during flight that must be analyzed.

Given that the common vibration frequencies that the fuselage may face during flight are around 25 Hz for a windmilling stress configuration [Stress Department Aciturri, 2023], it is important to perform a modal analysis to ensure that the natural frequencies of the screen are not in this range. The analysis was performed using Ansys and it consists of analyzing the size of a full screen and compare it to the size of a panel, evaluate the deformation of the two models and the frequencies of their modes.

Mode	Frequency (Hz)	Deformation (m)
1	59.635	0.048174
2	59.73	0.05265
3	61.124	0.036135
4	62.948	0.037576
5	65.523	0.040243
6	68.799	0.042371

Table 16: Modal frequencies and their deformation for the full screen

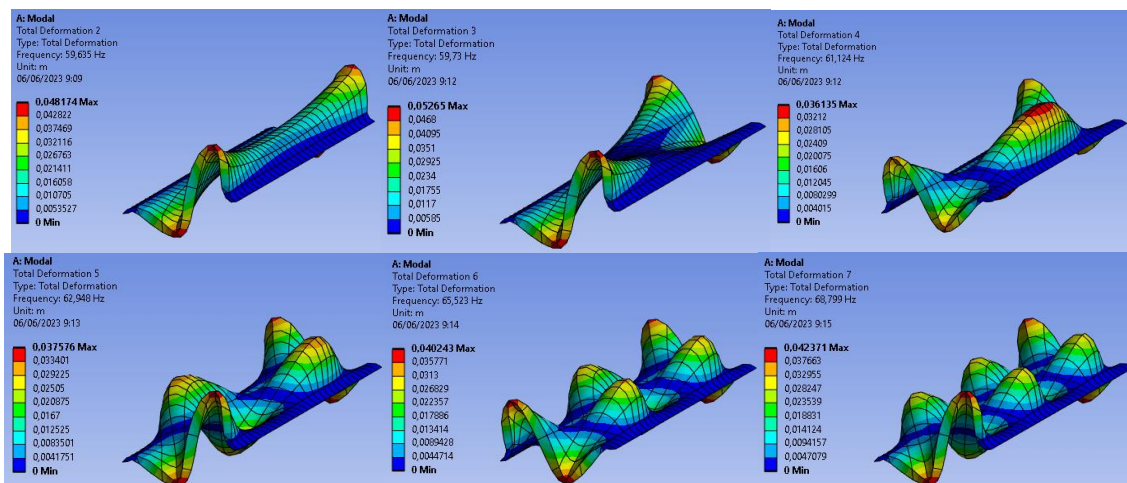


Figure 33: Deformation diagram for each mode for the full screen

Note: It is important to highlight that the deformations are exaggerated in the diagrams to offer more visual results, but the maximum deformation is 5.2 cm. Focus on the values shown in the scale on the left.

The analysis shows that the lower natural frequency is 59.635 Hz and it generates a maximum deformation of 0.048174 m. This frequency, initially, is acceptable because it doesn't coincide with the windmilling value. But because of the danger its position above the passengers poses, Royal Skies wants to use a safety factor of 2. With this safety factor, the frequencies are close to each other, and Royal Skies will analyze other safer options which will be easier to certificate and manufacture.

In the case of the single panel analysis the natural frequencies are shown in the following Table. They are considerably higher compared to the ones of the full screen.

Mode	Frequency (Hz)	Deformation (m)
1	496.68	0.048174
2	526.99	0.05265
3	676.57	0.036135
4	902.12	0.037576
5	972.24	0.040243
6	1003	0.042371

Table 17: Modal frequencies and their deformation for a single panel of the screen

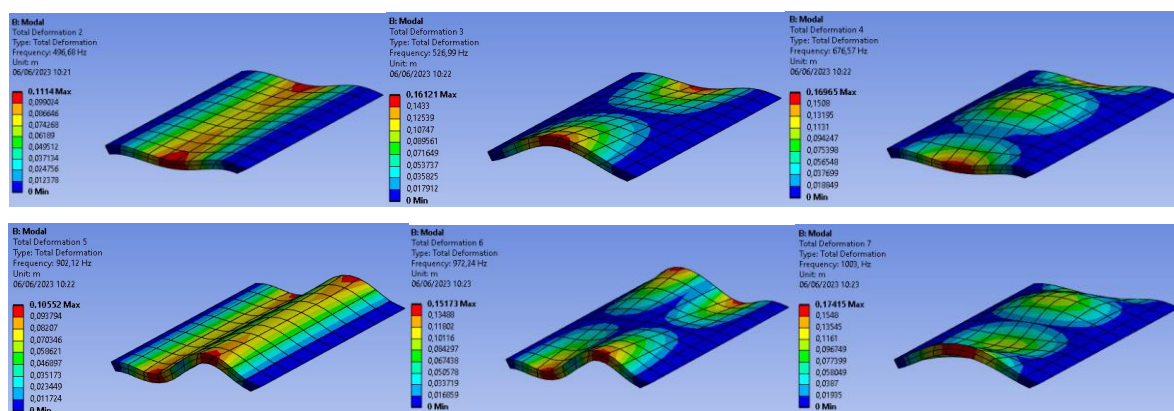


Figure 34: Deformation diagram for each mode for a single panel of the screen

Because of the higher frequencies which are more difficult to reach, since they are not in the range of frequencies that a fuselage faces during flight, it is a safer and better option to have the curved screen made from panels. In the future, were there to be an improvement in curved screen materials, the full screen option may be considered.

For now, Royal Skies will have a curved screen formed by plastic screen panels with a maximum of one meter square. The surface density of the screen is 5 kg/m². The curve screen will add a total of 122.1 kg of the entertainment area's screen and 218 kg of the relaxing area's screen. [LED Lemon]

The process for the assembly of the two screens will be the same. First, position the two longitudinal supports and install the countersunk blind rivets to hold it with the fuselage. These

two holders will work as two rails where the panels will slide between them. In *Figure 33* the cross section of these supports is shown.



Figure 35: Cross section of middle and end screen's holder

Between the holder and screen panel there will be a tiny gap that will need the application of shim to prevent movement between the two parts. The shim will help absorb the vibrations that the whole screen will suffer during its life.



Figure 36: Gap between screen panel and holder

Both screens will have four supports for each of the two areas and three panel rows as it is shown in *Figure 35*.

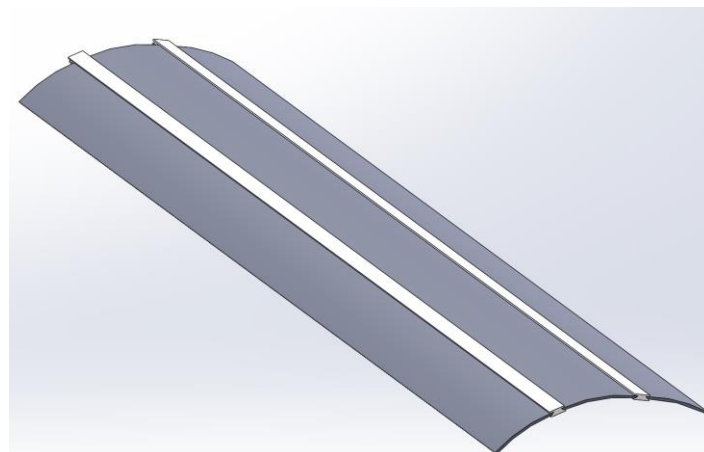


Figure 37: Isometric view of the screen

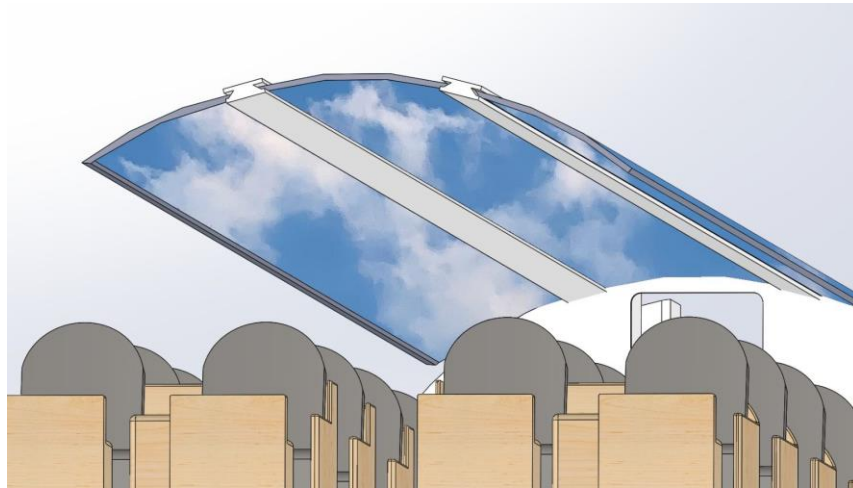


Figure 38: How passengers will see the ceiling of the aircraft during flight

7.2. Starlink antenna

Royal Skies thinks that having great Internet connection during flight could be something very beneficial for its customers. In the case of the charter option for example, instead of the flight time being a 'waste', online meetings could be taken during flight or any type of streaming. If brands want to do an event while flying, content creators could share everything about the event in real time instead of having to wait until they land. Like the organized trip option, Royal Skies' customers are very busy people that could use the time during the flight to do some work or to contact their families to tell them everything they have enjoyed in the last destination through video calls. They could also use Virtual Private Networks with Starlink Aviation.

The current Internet connection offered by conventional airlines during flight does not work as well as customers expect, and they also have to pay extra money in order to have said connection.

The reason why this is possible with Starlink is because of the low-cost reusable rocket technology developed by SpaceX. This technology allowed SpaceX to send to space a constellation of over 3000 satellites. All these satellites will allow powerful Internet connection coverage over land, sea and polar regions.

On the other hand, the current satellite internet connection, the one used in flights, uses a geostationary satellite that has an orbit height of 35786 km. The main difference between Starlink and current satellite connection is that the orbit height of Starlink's satellites is 550

km. The distance that the signal must cover is considerably lower. The intensity of the signal decreases with the distance squared [Satellite design notes, 2022]. With this affirmation, the importance of being in a closer orbit is explained, as it will improve the intensity of the signal and the responses will be faster.

[Next Travel Stream, 2023]

In *Figure 36*, the number of roundtrips of the signal when using Starlink satellites is compared to one round trip to a geostationary satellite.

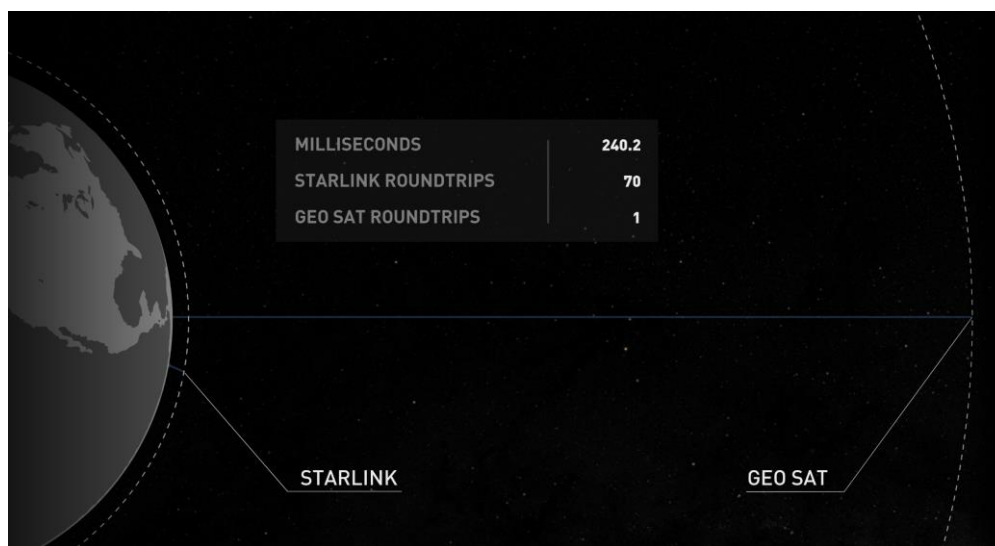


Figure 39: N° round trips Starlink vs Geostationary

The terminal has a great aerodynamic shape so that it does not considerably affect the performance of the aircraft. The installation times are very short so that it can be performed in a short period of time when the aircraft is down. The routine maintenance is simplified as well so that it doesn't add a lot of man-hours to check it. In addition to the maintenance costs, the hardware's purchase will be 150.000\$ and the subscription will be 13.000\$ per month [Starlink]. All of the plans offer unlimited data, and the hardware is in warranty while being subscribed to the plan. It is a considerable investment in terms of costs for Royal Skies, but it will provide the best internet service for its passengers.

7.3. Sound system

The sound system in commercial airlines does not work well. Royal Skies wants to go further and improve the sound inside the cabin.

At first it was considered to install a surround sound system in the two areas, the relaxing and entertainment, but this configuration could annoy some customers that wanted to relax or did not like the ambience sounds. However, Royal Skies believes that directional audio technology will be a much better idea for the relaxing area.

The directional audio technology used in Royal Skies aircraft consists of two directional ultrasound speakers integrated in each customer's seat. It is the best sound system solution for the relaxing area. This technology will be able to focus the audio to a precise location, the passenger's ears. The seats will have incorporated a small joystick to adjust the direction of the audio to each customer's ear height. With this technology, each customer will be able to choose what they want to hear; relaxing sounds, music, podcasts, etc. without disturbing the person next to them. In addition to this, they won't need to use headphones to watch movies on the seat's TVs. The crew warnings will be communicated through this channel.

This technology works by using ultrasound waves to send sound unlike conventional speakers. Ultrasound waves have high frequency which provides huge sound control. To give a definitive decision on the use of this technology, Royal Skies would outsource a study on the effects to passenger health of long exposure to ultrasound waves.

The surround sound system will be installed in the entertainment area. It will help the performers to create a more impressive show by playing with the direction of the sounds. Customers will feel the sound coming from all directions creating an enveloping ambience.

7.4. Aerodynamic study of the exterior of the aircraft

In order to see how the Starlink antenna and the exterior cameras that will feed the curved screens with images of the exterior affect the performance of the aircraft, Royal Skies modeled the A321LR using Open VSP. Using this program, an aerodynamic analysis is performed to compare the performances with and without these elements. In total, 20 cameras will be installed.



Figure 40: 3D model of the Royal Skies A321neo

The analysis goes from -5° to 10° , the aircraft speed is M0.8 for both aircraft models. The graphs are efficiency (L/D) vs alpha, lift coefficient vs alpha and total drag coefficient vs alpha. The maximum efficiency in both models is at an angle of attack of 3.33° .

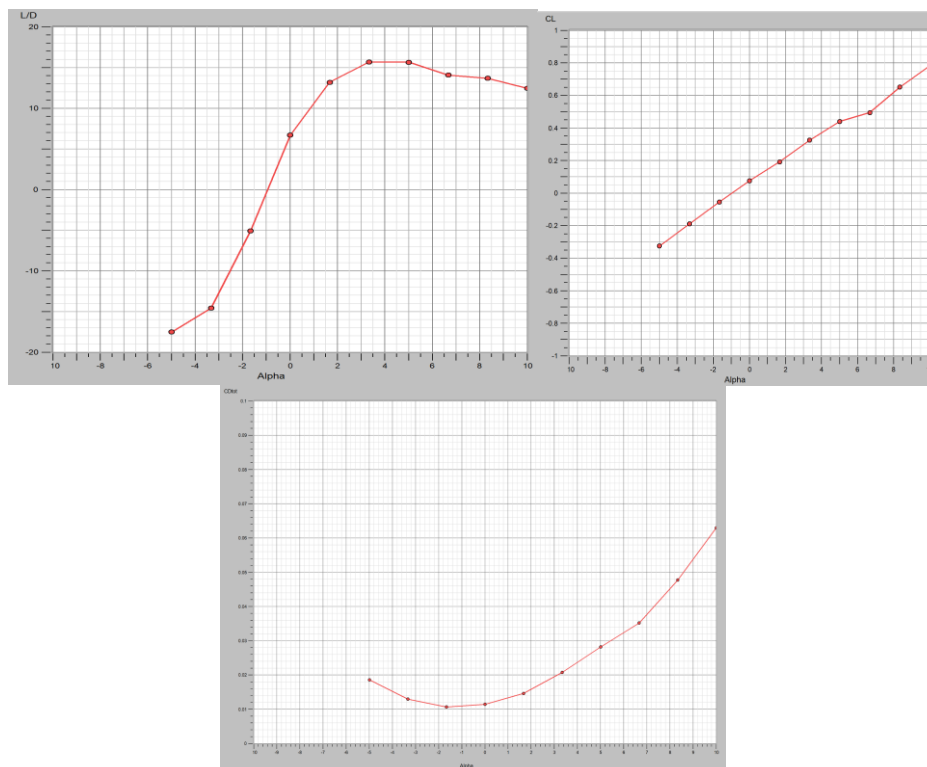


Figure 41: Efficiency, lift and drag coefficient vs alpha Royal Skies version

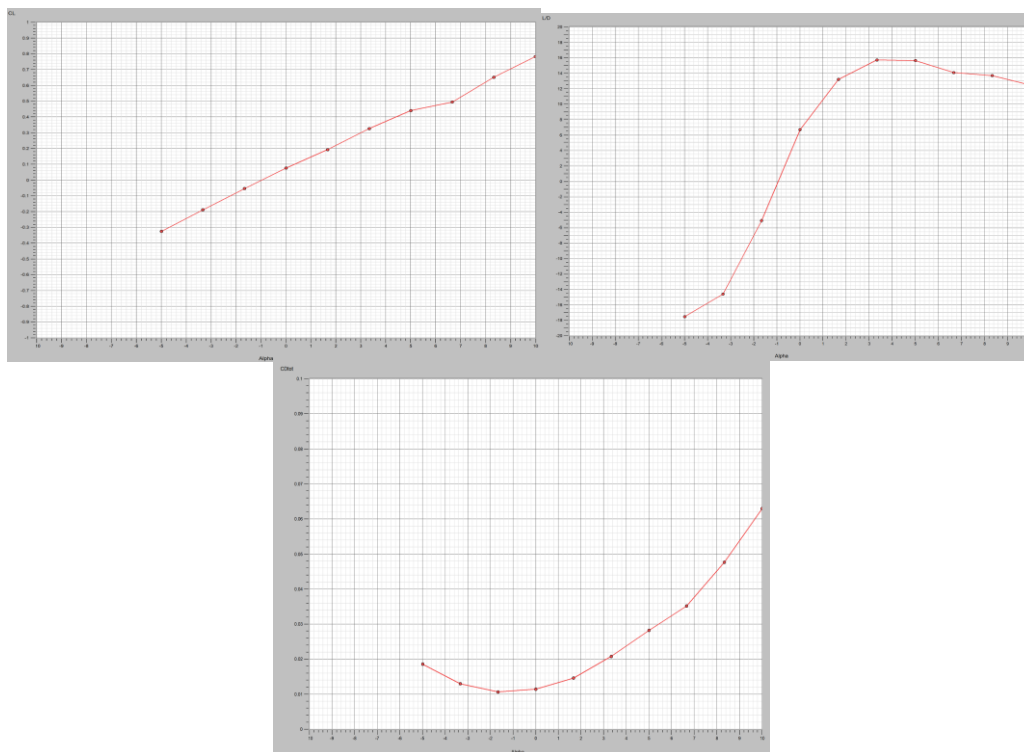


Figure 42: Efficiency, lift and drag coefficient vs alpha commercial A321neo

All the data recorded on the following Table is for the optimal angle of attack which is 3.33°.

	L/D	C _L	C _D
Royal Skies	15.7	0.32	0.0208
A321neo	15.72	0.33	0.02077

Table 18: Comparison

This comparison shows that the performance of the Royal Skies version is slightly lower, and the drag is higher but the difference is very small and it won't considerably affect the whole performance of the aircraft. The decrease in efficiency is of 0.127%. This is great news for Royal Skies, since they will have an aircraft with the best connection while keeping its performance.

Chapter 8. CONCLUSION

The luxurious niche that Royal Skies strives to fill is a complicated niche in which to be successful. Most companies that focus only on first class customers are not very competitive because there are not enough customers. What differentiates Royal Skies from other full first class aircraft is that they don't focus on taking customers from one place to another, but instead they focus on their customers' experience flying and making unforgettable memories with them. The uniqueness of elements such as the curved screen will bring in customers that may want to experience this airline and it's expected that the design will become viral in social media, bringing even more customers.

Royal Skies has a fleet formed by A321, the long range version. This option was the optimal for the custom-made itinerary trips while being able to offer transatlantic routes with the charter option. Brands and companies spend huge amounts of money in marketing, traveling, etc. Royal Skies offers with their redesigned aircraft the possibility of creating advertising content while traveling to the needed destination.

Royal Skies created the best configuration for its purpose. Its design is aesthetic, luxurious and spacious. In addition, all the safety concerns and weight requirements have been checked and complied with in order to be an excellent design. The aircraft offers the latest technology in terms of internet connection and futuristic design features. Thanks to Starlink Aviation, the aircraft will always be located by satellite signal without sacrificing too much aerodynamic efficiency.

BIBLIOGRAPHY

Aerolínea Global con Servicio Adhoc de Vuelos Chárter y Acmi Leasing: Privilege Style. (n.d.). Retrieved December 18, 2022, from <https://www.privilegestyle.com/es/home>

Boeing Business jets. (n.d.). Retrieved December 19, 2022, from <https://www.boeing.com/commercial/bbj/#/videos/bbj-777-interior-concept>

Business Insider. (2022, August 23). Inside this VIP Boeing 757 Private Jet – Now Booking for Qatar 2022. Retrieved December 19, 2022, from <https://www.scmp.com/magazines/style/news-trends/article/3189472/biggest-private-jet-you-can-hire-inside-luxury-vip>

Classification of Design Changes to Cabin Interiors of Large Aeroplanes [PDF]. (2021, April 30). EASA.

Clerc, I. (2022, July 01). Luxury Private Jet Interiors: Aeroaffaires Private Jet Charters. Retrieved December 19, 2022, from <https://aeroaffaires.com/the-luxury-private-jet-interiors/>

The Different Types of Aircraft Antennas and Their Function. (2020, July 02). Retrieved December 18, 2022, from <https://aerocorner.com/blog/types-of-aircraft-antennas/>

EASA Pro. (n.d.). Retrieved December 18, 2022, from <https://www.easa.europa.eu/en/home>

Meier-Arndt, S. (2022, February 11). A Guide to Airline Seatbelts and Certification. Retrieved December 18, 2022, from <https://www.aircraftinteriorsinternational.com/features/a-guide-to-airline-seatbelts-and-certification.html>

Stone, T. (2022, December 14). Aircraft Interiors International (A. Gavine, A. Davie, & L. Green, Eds.). *Aircraft Interiors International*. Retrieved December 18, 2022, from <https://aii.mydigitalpublication.co.uk/publication/?m=63715&i=771289&p=1&ver=html5>

A Unique Flying Experience. (2021, June 16). Retrieved December 19, 2022, from <https://www.acj.airbus.com/en>

USA Today Travel. (2016, January 10). This is what it was like to fly in the 1930s. Retrieved March 20, 2023, from <https://eu.usatoday.com/story/travel/roadwarriorvoices/2016/01/10/this-is-what-it-was-like-to-fly-in-the-1930s/83283086/>

Love Exploring. (2021, September 2). How air travel has changed in every decade from the 1920s to today. Retrieved March 20, 2023, from <https://www.loveexploring.com/gallerylist/86315/how-air-travel-has-changed-in-every-decade-from-the-1920s-to-today>

Airbus. (n.d.). A321neo. Retrieved from March 20, 2023, from <https://aircraft.airbus.com/en/aircraft/a320-the-most-successful-aircraft-family-ever/a321neo>

Airbus. (n.d.). A321XLR. Retrieved from March 20, 2023, from <https://aircraft.airbus.com/en/aircraft/a320-the-most-successful-aircraft-family-ever/a321neo#range>

Airbus. (n.d.). A330-900. Retrieved from March 20, 2023, from <https://aircraft.airbus.com/en/aircraft/a330-advanced-to-boost-profitability>

Airbus. (n.d.). A350-1000. Retrieved from March 20, 2023, from <https://aircraft.airbus.com/en/aircraft/a350-clean-sheet-clean-start>

Hawaiian Airlines. (n.d.). Airbus A321neo. Retrieved from May 28, 2023, from <https://www.hawaiianairlines.com/our-services/at-the-airport/our-fleet/a321neo>

T. Dubois. (2020, August 14). Aircraft Passenger Seat Design Gets Smarter. Retrieved from May 28, 2023, from <https://aviationweek.com/mro/interiors-connectivity/aircraft-passenger-seat-design-gets-smarter>

EASA. (2022, November 9). EASA review of standard passenger weights in 2022 shows no significant change. Retrieved from May 30, 2023, from <https://www.easa.europa.eu/en/newsroom-and-events/news/easa-review-standard-passenger-weights-2022-shows-no-significant-change#:~:text=The%20carry%20on%20weight%20is,on%20luggage%20is%2084.0%20kg>

Z. Berdowski, F.N. van den Broek-Serlé, J.T. Jetten, Y. Kawabata, J.T. Schoemaker, R. Versteegh. (2009, May). Survey on standard weight of passengers and baggage [PDF]. EASA. <https://www.easa.europa.eu/sites/default/files/dfu/Weight%20Survey%20R20090095%20Final.pdf>

Delta. (n.d.) Airbus A330-900neo (339). Retrieved from May 30, 2023, from <https://www.delta.com/us/en/aircraft/airbus/a330-900>

SeatMaps. (n.d.) Iberia Airbus A350 Seat Maps. Retrieved from May 30, 2023, from <https://seatmaps.com/es/airlines/ib-iberia/airbus-a350/>

L. Ahlgren, P. Pande. (2022, August 14). How much do Airbus aircraft cost? Retrieved from May 25, 2023, from <https://simpleflying.com/how-much-do-airbus-aircraft-cost/>

Travel Radar. (2020, February 6). Comparisons: A321LR vs 737 MAX-10. Retrieved from May 25, 2023, from <https://travelradar.aero/comparisons-a321lr-vs-737-max-10/>

IAG. (2019, June 18). Airbus A321XLR for Aer Lingus and Iberia. Retrieved from May 25, 2023, from <https://www.iairgroup.com/en/newsroom/press-releases/newsroom-listing/2019/airbus-a321xlr-for-aer-lingus-and-iberia>

A. Curran. (2022, May 4). Airbus delays A321XLR entry to service expectation to 2024. Retrieved from May 20, 2023, from <https://simpleflying.com/airbus-delays-a321xlr-entry-to-service-expectation-to-2024/>

Airnav. (2023, May 18). Kahului Airport. Retrieved from May 13, 2023, from <https://www.airnav.com/airport/PHOG>

Airnav. (2023, May 18). Phoenix Sky Harbor International Airport. Retrieved from May 13, 2023, from

<http://www.airnav.com/airport/kphx>

Airnav. (2023, May 18). La Guardia Airport. Retrieved from May 13, 2023, from <https://www.airnav.com/airport/KLGA>

Airnav. (2023, May 18). Louis Armstrong New Orleans International Airport. Retrieved from May 13, 2023, from <https://www.airnav.com/airport/kmsy>

Airnav. (2023, May 18). Kapalua Airport. Retrieved from May 13, 2023, from <https://www.airnav.com/airport/PHJH>

Airnav. (2023, May 18). Luis Muñoz Marín International Airport. Retrieved from May 13, 2023, from <https://www.airnav.com/airport/TJSJ>

AC-U-KWIK. (n.d.). San José del Cabo International Airport. Retrieved from May 13, 2023, from <https://acukwik.com/Airport-Info/MMSD>

Airport Technology (2010, March 31). Santiago International Airport. Retrieved from May 13, 2023, from <https://www.airport-technology.com/projects/santiago-international-airport/>

Airport Technology (2007, July 18). Benito Juárez International Airport. Retrieved from May 13, 2023, from <https://www.airport-technology.com/projects/mexico/#:~:text=Benito%20Ju%C3%A1rez%20International%20Airport%20>

Hong Kong Airport. (n.d.). The airport that never sleeps. Retrieved from May 13, 2023, from <https://www.hongkongairport.com/en/about-us/#:~:text=Both%20runways%20are%203%2C800%20metres%20long%20and%2060%20metres%20wide>

Skybrary. (n.d.) Tokyo Haneda International Airport. Retrieved from May 13, 2023, from <https://www.skybrary.aero/airports/rjtt>

International Airport Review. (n.d.). Singapore Changi Airport (SIN). Retrieved from May 13, 2023, from <https://www.internationalairportreview.com/airports/63516/singapore-changi-airport-sin/#:~:text=Singapore%20Changi%20Airport%20is%20equipped,Asia%20Airways%20and%20BOC%20Aviation>

AC-U-KWIK. (n.d.). WADD-I Gusti Ngurah Rai/Bali International. Retrieved from May 13, 2023, from <https://acukwik.com/Airport-Info/WADD>

Airports-worldwide. (n.d.). Male International Airport. Retrieved from May 13, 2023, from https://www.airports-worldwide.com/maldives/male_intl_maldives.php

Airports-worldwide. (n.d.). Dubai International Airport. Retrieved from May 13, 2023, from

https://www.airports-worldwide.com/united_arab_emirates/dubai_intl_united_arab_emirates.php

Skybrary. (n.d.) Cairo International Airport. Retrieved from May 13, 2023, from <https://skybrary.aero/airports/heca>

Logistics Cluster. (n.d.) Tanzania Julius Nyerere International Airport. Retrieved from May 13, 2023, from <https://dlca.logcluster.org/221-tanzania-julius-nyerere-international-airport>

Krabi Airport Guide. (n.d.). Krabi Airport Quick Facts. Retrieved from May 13, 2023, from <https://www.krabiairportonline.com/krabi-airport-quick-facts/>

FDOT. (n.d.). Miami International Airport [PDF].

Airbus. (2020, December 1). Aircraft Characteristics Airport and Maintenance Planning [PDF]. <https://www.airbus.com/sites/g/files/jlcbta136/files/2021-11/Airbus-Commercial-Aircraft-AC-A321.pdf>

A. Hussain. (2023, June 3). Ryanair Review- Seats, Amenities, Customer Service, Baggage Fees & more. Retrieved from May 20, 2023, from <https://upgradedpoints.com/travel/airlines/ryanair-review/#:~:text=Standard%3A%20Leather%20seating%2C%2017%E2%80%B3,of%2032%E2%80%B3%2D34%E2%80%B3>

NEXT Travel Stream. (2022, December 6). Starlink Aviation Brings High-Speed Internet to the Plane [Video file]. Retrieved from May 20, 2023, from <https://www.youtube.com/watch?v=D-rfNxSpPGc>

LLM Reporter. (2022, November 4). Last call to Qatar: FIFA World Cup is driving record private jet demand. Retrieved from May 13, 2023, from <https://www.luxurylifestylemag.co.uk/drive-sail-and-fly/last-call-to-qatar-fifa-world-cup-is-driving-record-private-jet-demand/>

C. Doyle. (n.d.). World's first expanding PRM aircraft lavatory launched. Retrieved from May 13, 2023, from <https://www.aviationbusinessnews.com/cabin/st-engineering-first-expanding-prm-aircraft-lavatory-acumen-design-associates-disabled-passengers/>

Air Miles calculator. (n.d.) How far is Miami, FL from New York, NY? Retrieved from May 13, 2023, from <https://www.airmilescalculator.com/distance/lga-to-mia/>

Brown Innovations. (2019, June 17). Best directional sound speaker for museums, digital signage, and bars - Brown Innovations demo video [Video file]. Retrieved from May 27, 2023, from https://www.youtube.com/watch?v=O_0z0Ofhrzo

Holosonics. (2020, June 9). Directional Speaker Demonstration [Video file]. Retrieved from May 27, 2023, from <https://www.youtube.com/watch?v=3ETq3YH8WW>
<https://www.youtube.com/watch?v=3ETq3YH8WWc>

C. Rus. (2021, September 8). LG tiene un nuevo material para las pantallas plegables: flexible como el plástico y tan duro como el vidrio. Retrieved from May 25, 2023, from <https://www.xataka.com/componentes/lg-tiene-nuevo-material-para-pantallas-plegables-flexible-como-plastico-duro-como-vidrio>

Starlink Aviation. (n.d.). Retrieved from May 25, 2023, from <https://www.starlink.com/aviation>

Primal Space. (2022, May 24). SpaceX Announces In-Flight WiFi Service with 500-Mbps Speeds. Retrieved from May 25, 2023, from <https://www.youtube.com/watch?v=80qglUQgDrs>

R. Pickett. (2022, October 19). What SpaceX's Starlink Aviation Service means for aircraft. Retrieved from April 20, 2023, from <https://simpleflying.com/spacex-airline-starlink-aviation-offering/>

EASA. (2018, July 25). Evaluation of aisle width with respect to seat installations [PDF]. Retrieved from April 23, 2023, from <https://www.easa.europa.eu/sites/default/files/dfu/CM-CS-007%20Issue%2001%20rev%2001%20Width%20of%20Isle.pdf>

S. Taylor. (2020, February 12). New aircraft lavatory concept is accessible to passengers in wheelchairs. Retrieved from May 6, 2023, from <https://apex.aero/articles/access-aircraft-lavatory-design/>

P. Clark. (2018). *Buying the Big Jets: Fleet Planning for Airlines*. New York, USA:Routledge

Annex I

Destination	Airport	Runway Length (m)
New York City	La Guardia Airport	2134
Miami	Miami International Airport	2621
New Orleans	Louis Armstrong New Orleans International Airport	2134
Half Moon Bay	San Francisco International Airport	2636
Kapalua	Kapalua Airport	914
Dove Mountain	Phoenix Sky Harbor International Airport	2377

Destination	Airport	Runway Length (m)
Santiago de Chile	Santiago International Airport	3748
Mexico City	Benito Juarez International Airport	3900
Los Cabos	San José del Cabo Airport	3005
San Juan, PR	Luis Muñoz Marin International Airport	2443

Destination	Airport	Runway Length (m)
Hong Kong	Hong Kong International Airport	3800
Tokyo	Tokyo Haneda Airport	2999
Singapore	Singapore Changi Airport	4000
Ubud, Bali	Bali International Airport	3000
Maldives	Malé International Airport	3200



Destination	Airport	Runway Length (m)
Dubai	Dubai International Airport	4000
Cairo	Cairo International Airport	3301
Tanzania	Tanzania Julius Nyerere International	3000
Mascate, Omán	Muscat International Airport	4000

Annex II

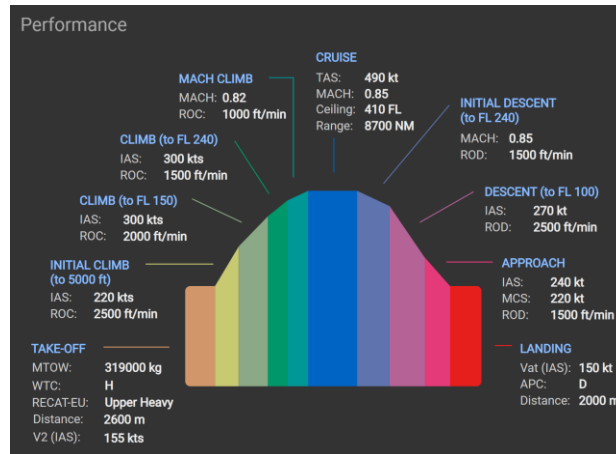


Figure: Performance parameters of A350

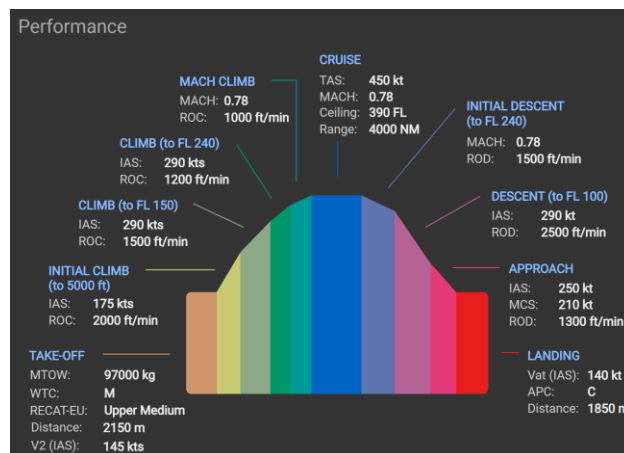


Figure: Performance parameters of A321neo

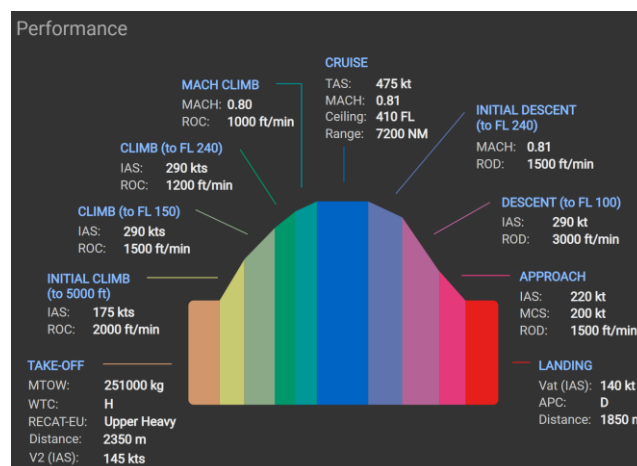


Figure: Performance parameters of A330-900