Refining the Elysian E9X Cabin Concept

Creating the SkyConsole

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TU Delft

ELYSIAN

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Creating the SkyConsole

MSC Graduation Thesis
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Preface

Introduction

Dear reader,
If you had asked me years ago what my 'dream design challenge' would look like, it would involve exactly what you are holding in your hands right now: a complex mobility puzzle where human experience meets rigid technical constraints. This report marks my final milestone as an Industrial Design Engineering student, focusing on 'Refining the Elysian E9X Cabin Concept.'

My fascination with mobility began with a realization: the difference between a Citroën DS3 and a Volvo XC90. I remember driving at 130 km/h in the Citroën, my legs burning because the seat heating was on the highest setting. I tried to find the button to switch it off, but it was hidden somewhere completely out of sight under the seat. In the Volvo, however, every control felt intuitive. I could almost find the buttons with my eyes closed. That moment of frustration, and the simple question of "Who designed this?", was the spark for me.

Almost nobody travels for the sake of travelling, we do it to get somewhere, and the journey itself is often a "necessary evil." As a design student, I am fascinated by how we can make this journey as pleasant as possible, often under strict limitations like dimensions, spatial constraints and, especially in the case of aircraft, weight and regulations. It is an interesting puzzle where all aspects of design come together: technology, human factors and business.

Solving this puzzle was incredibly interesting but also turbulent. Making trade-offs down to half a centimeter was a constant challenge. I sometimes struggled to accept that a positive decision in one direction often resulted in a compromise elsewhere. Fortunately, I was not alone in this process.

I would like to thank my supervisors: Stephanie, for always reminding me that “complete is the enemy of good”; Peter, for stepping in, his enthusiasm, and his valuable contributions; and Erik, for providing insightful guidance and introducing me to the world of aviation. Thank you all for your involvement, the great collaboration, and for giving me the freedom to approach this project in my own way.

I also want to thank my mentors at Elysian: Daniel, for this amazing opportunity and to gain insight into such an inspiring company and Tosca, for always being available to answer my questions and asking me the right questions at the right time. Her own thesis was a major source of inspiration and provided me with crucial insights. I would also like to thank everyone at Elysian for their openness.

A special thanks goes to the men of the PMB, especially Kevin, Don and Carlo, for thinking along with me and helping me build my prototypes. I also want to thank Sabine and Patrice for answering all my questions about cabin crew operations. Finally, to my dear housemates: Rozemarijn, Carolien, Rixt, Vera and Tessa and other friends and family. Thank you for the practice rounds, testing, mental support and shared meals.

I hope this report provides a clear vision of how the future of flight can become not only more sustainable, but also go hand in hand with an improved passenger experience.

Femke Moolhuizen
Delft, 01-04-2026

Executive summary

This project focuses on refining the Elysian E9X aircraft cabin design, which resulted in a concept named SkyConsole.

Assignment
The primary challenge for the E9X cabin design is achieving the right balance between passenger comfort, efficiency, and sustainability while remaining lightweight and technically feasible within the strict limits of aviation design and regulation.

This graduation project is based on Van Duivenboden's (2025) cabin concept, which presents an innovative solution but still requires further refinement to fully meet the needs of both passengers and airlines.

Design Goal
The design goal was set to:

> *"Create a **compact**, **intuitive** and **inclusive** aircraft interior that enhances passenger **comfort** and crew **efficiency** on short-haul flights by rethinking how **personal space**, **luggage** and **interaction** coexist within limitied cabin dimensions."*

Design approach
Using the Double Diamond Method, the project explored various concepts, including Van Duivenboden's Floorcontainer Concept and adjusted the layout based on desirability, feasability and viability. Several prototypes were created to test the functionality and ergonomics of the SkyConsole.

Analysis and Final design
The design of the storage, dividing, and armrest console for the E9X evolved from a thorough analysis of passenger needs and the requirements of other key stakeholders, such as cabin crew, airlines, and aircraft leasing companies. The design process also addressed the technical challenges specific to aircraft environments, including the use of lightweight materials, dimensional and weight constraints, and compliance with certification requirements. This analysis led to the development of the SkyConsole, available in three different variants to provide an optimal experience for future passengers.

SkyConsole
by ELYSIAN

Executive summary

Relax Class

Business class (more comfort - seat width)

- *36" seatpitch*
- *45.4 cm seat width*
- *20 x 35 x 55 cm suitcase per person*

Nomad class

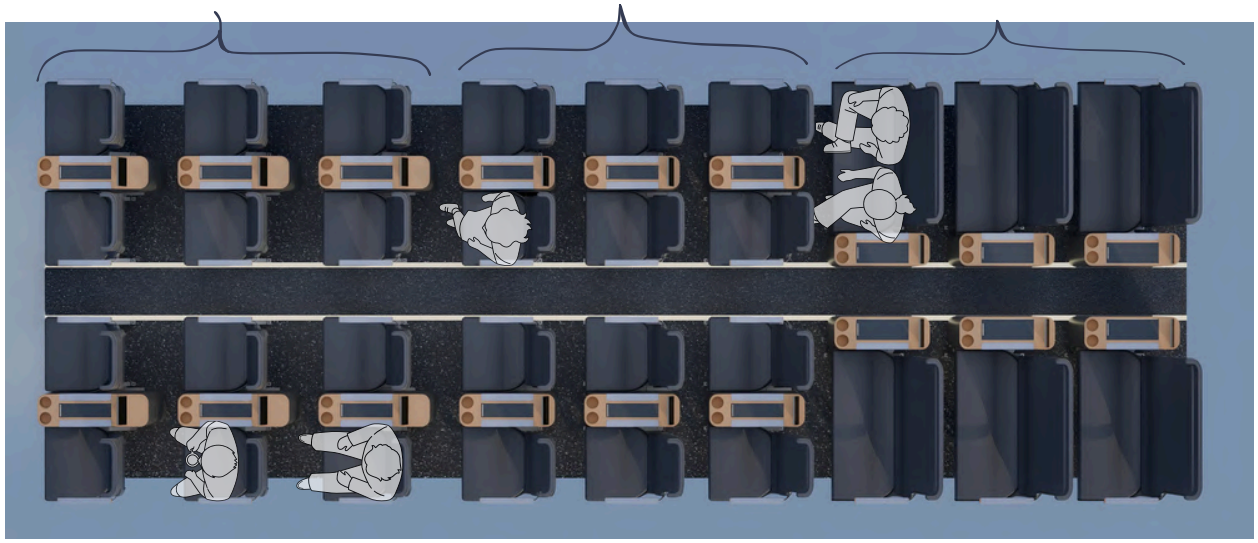
Economy class

- *32" seatpitch*
- *45.4 cm seat width*
- *20 x 30 x 55 cm suitcase per person*

CloudNest

Family class

- *32" seatpitch*
- *90.8 cm seat width (for 2 passangers)*
- *40 x 60 x 55 cm storage space (for 2 passengers)*



Conclusion and Recommendations

The project concluded that the SkyConsole successfully enhances the passenger experience by providing more personal space and better luggage management. User tests were conducted to evaluate the design, confirming its effectiveness in improving comfort and functionality. Future developments should focus on further ergonomics optimization, conducting FEM analyses for structural safety, and testing alternative materials for better sustainability.

Glossary

Certification	The process by which an aviation product (like SkyConsole) meets safety standards and is approved by relevant authorities.
Cost per Seat-Mile	A financial metric used in the aviation industry to measure the cost of operating an aircraft for each seat per mile traveled.
Desirability	The degree to which a product meets user needs and desires.
E9X	The model name of the electric aircraft designed by Elysian.
Ergonomics	The design of products and workspaces to optimize user comfort and minimize discomfort or injury.
FEM Analysis	Finite Element Method analysis, a computational technique used to test structural integrity.
Feasibility	The practical viability of a design, considering technical, economic, and operational factors.
Floorcontainer Concept	A concept where luggage is stored under seats in containers to create a more spacious cabin feel.
Luggage	Refers to the carry-on bags and personal items passengers bring aboard the aircraft.
Mock-up	A model or prototype used for testing or demonstration.
OEM	Original Equipment Manufacturer, companies that provide original aircraft parts.
Overhead Bins	Storage compartments above the passenger seats in an aircraft, used for storing carry-on luggage.
PSU (Passenger Service Unit)	A system controlling lighting, air circulation, and other passenger services.
Seat Pitch	The distance between a point on the seat to that specific point on the seat in front, measured along the aisle.
SkyConsole	An innovative console design developed for the E9X aircraft, offering storage, passenger separation, and armrest features.
Viability	The long-term sustainability of a product, including cost and production capacity.

Disclaimer

Due to confidentiality, certain sections of this report are not visible.

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Chapter 1

Assignment & approach

1.1 Introduction

Global CO2 emissions are causing the planet to warm. In 2015, 195 parties signed the Paris Agreement, with the overarching goal: “limit the temperature increase to 1.5°C above pre-industrial levels” (United Nations, n.d.-a).

In 2024, the aviation industry accounted for approximately 2% of total global CO2 emissions (see figure 1).

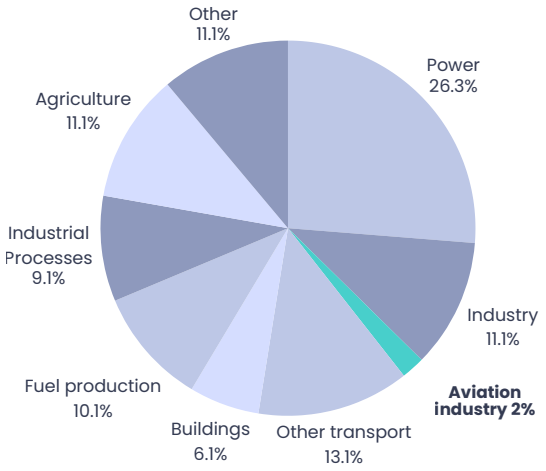


Figure 1: Percentage of global CO2 emissions from aviation in 2023 (information from (enviro.aero, 2024))

Over the past decades, the aviation industry has grown significantly and projections indicate continued growth in the coming decades (CO2-emissie Van De Luchtvaart Op De Lange Termijn, 2020).

Without impactful innovation, aviation will remain a sector with rising emissions. Meeting the goals of the Paris Agreement therefore requires a transition towards cleaner aviation.

Elysian is working on the development of an electric aircraft to make zero-CO2 flights a reality. The company is currently developing the E9X.

Figure 3: Logo Elysian (Vraka, n.d.)

Figure 2: Elysian’s E9X aircraft

1.2 Project brief

In 2024, Tosca van Duivenboden started a project titled “Cabin interior Elysian Aircraft E9X.” (Van Duivenboden, 2025). She created a concept in which carry-on luggage was placed under the seats and the overhead bins were removed, resulting in a more spacious feel and faster boarding and disembarking (Van Duivenboden, 2025).

Figure 4: van Duivenboden's concept (Van Duivenboden, 2025)

This concept has not yet been fully developed and there are still unanswered questions. At the same time, Elysian wants to explore other possibilities for improving the passenger experience. This led to this new project called: “Refining the Elysian E9X Cabin Concept.”

The Assignment
Create a concept design to improve the passenger experience and interior functionality for Elysian Aircraft in the context of lightweight, integrated aircraft cabin interiors.

Problem definition
This graduation project builds directly on Van Duivenboden’s (2025) cabin concept: a promising concept, but one that still requires refinement to deliver full value to both passengers and airlines.

The key challenge for the E9X cabin is to balance comfort, efficiency, and sustainability while remaining lightweight and technically feasible within the strict limits of aviation design and regulation.

Approach
The project starts with an evaluation of Van Duivenboden's ”Floorcontainer concept”. This concept is tested to explore its feasability and define what users like and dislike. These insights will be used to optimize the carry-on luggage storage system, leading to a more detailed design, which is tested again.

1.3 Methods

The double-diamond method was used during the project. There are many forms of the double diamond method described in the literature (Kochanowska & Gagliardi, 2021). This method was combined with several other methods (see figure 5).

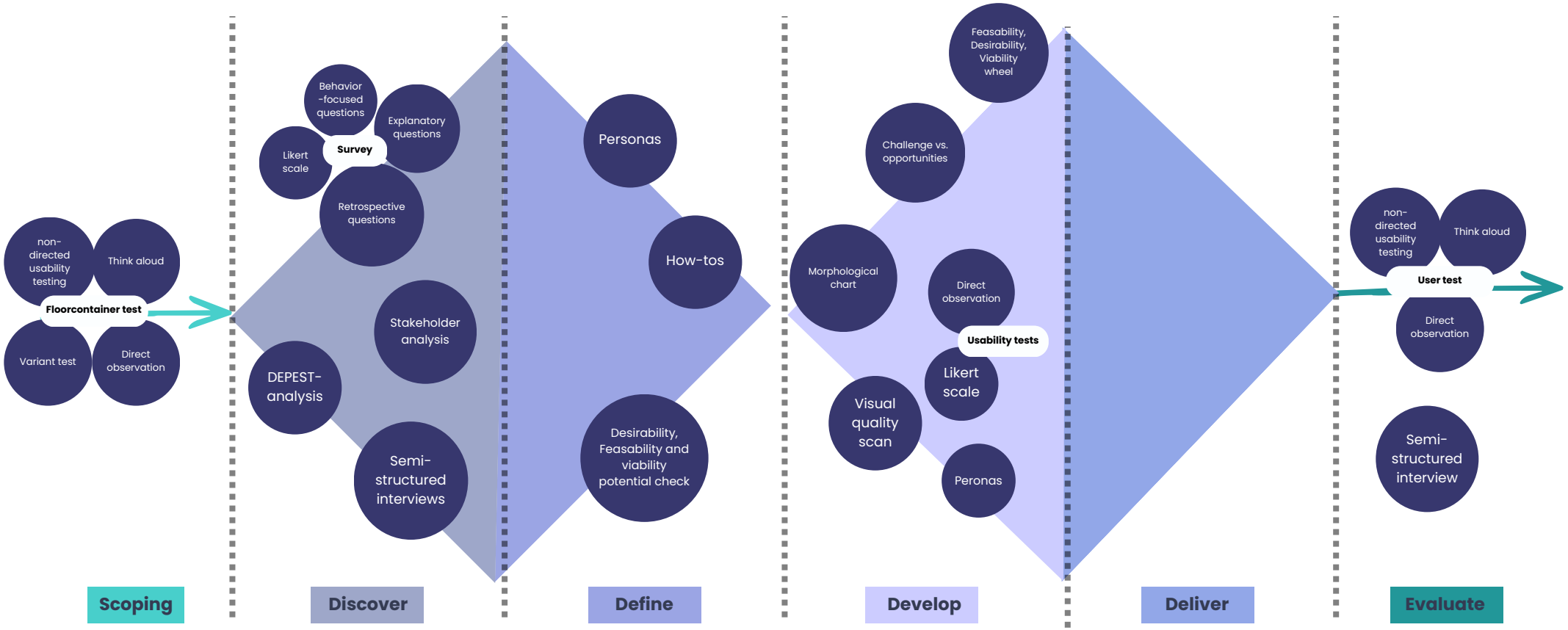


Figure 5: Methods used within the Double Diamond process (existing, adapted and self-developed)

1.4 Project relevance

“The 1950s saw an explosion in passenger transport and an emphasis on the quality of the travelling environment where top car and aircraft interiors were roughly comparable (epitomized by Cadillac and PanAm). The pace of change in the aircraft industry has slowed down and now there appears to be a significant gap between the two experiences.” (Hall et al., 2013) (see figure 6).

Passengers are the primary users of an aircraft cabin, but they have little direct influence on its design. With changing needs and expectations driven by new market pressures such as efficiency demands, high-speed rail and evolving mobility experiences, it is important that the aircraft manufacturer anticipates these developments (Hall et al., 2013). Other airlines are also working to upgrade their economy offerings (VML Intelligence, 2025).

For Elysian, there is a crucial opportunity for the E9X cabin to stand out through comfort, innovation, and sustainability.

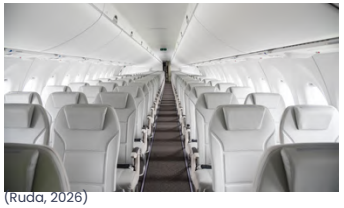
Aircraft interior - 1950s

(Garcia, 2020)

Car interior - 1950s

(Chilton, 2022)

Aircraft interior - 2025



(Ruda, 2026)

Car interior - 2025

(Chilton, 2022)

Figure 6: Change of Aircraft interior over time vs. car interior

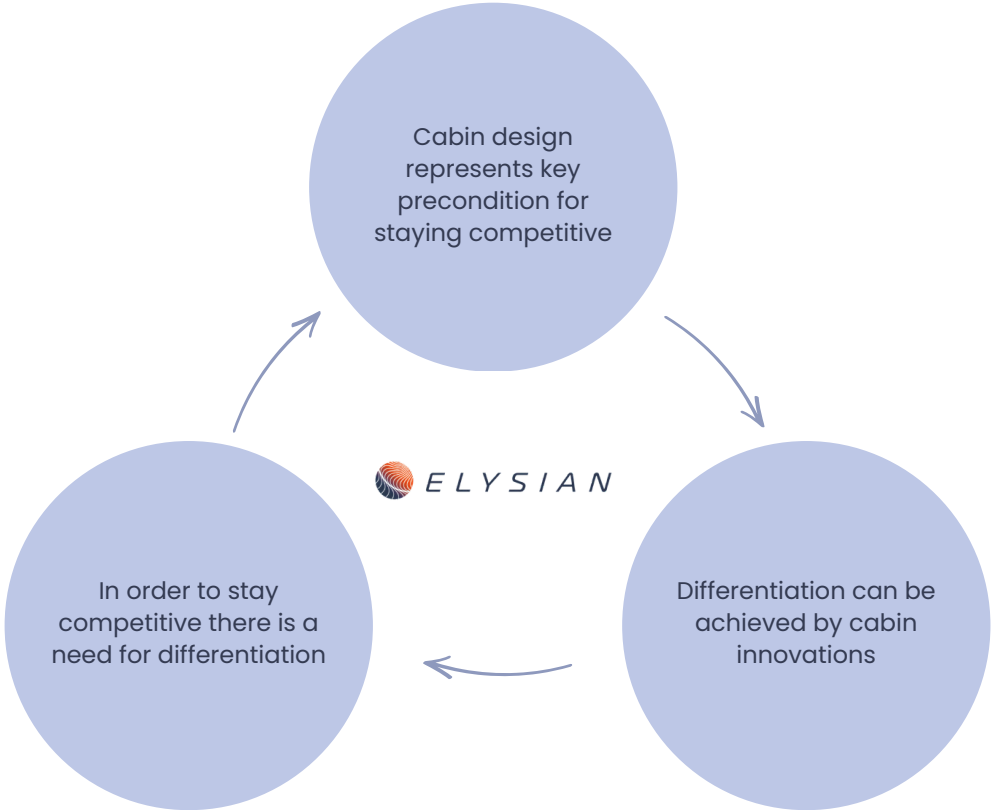


Figure 7: Cabin innovation to stay competitive (information from Hall et al., 2013)

1.5 Elysian E9X

Elysian has established several specifications for the E9X, as shown in figure 8. It is important to note that these specifications serve as a guideline, and adjustments to the light purple blocks are possible to create a new passenger experience.

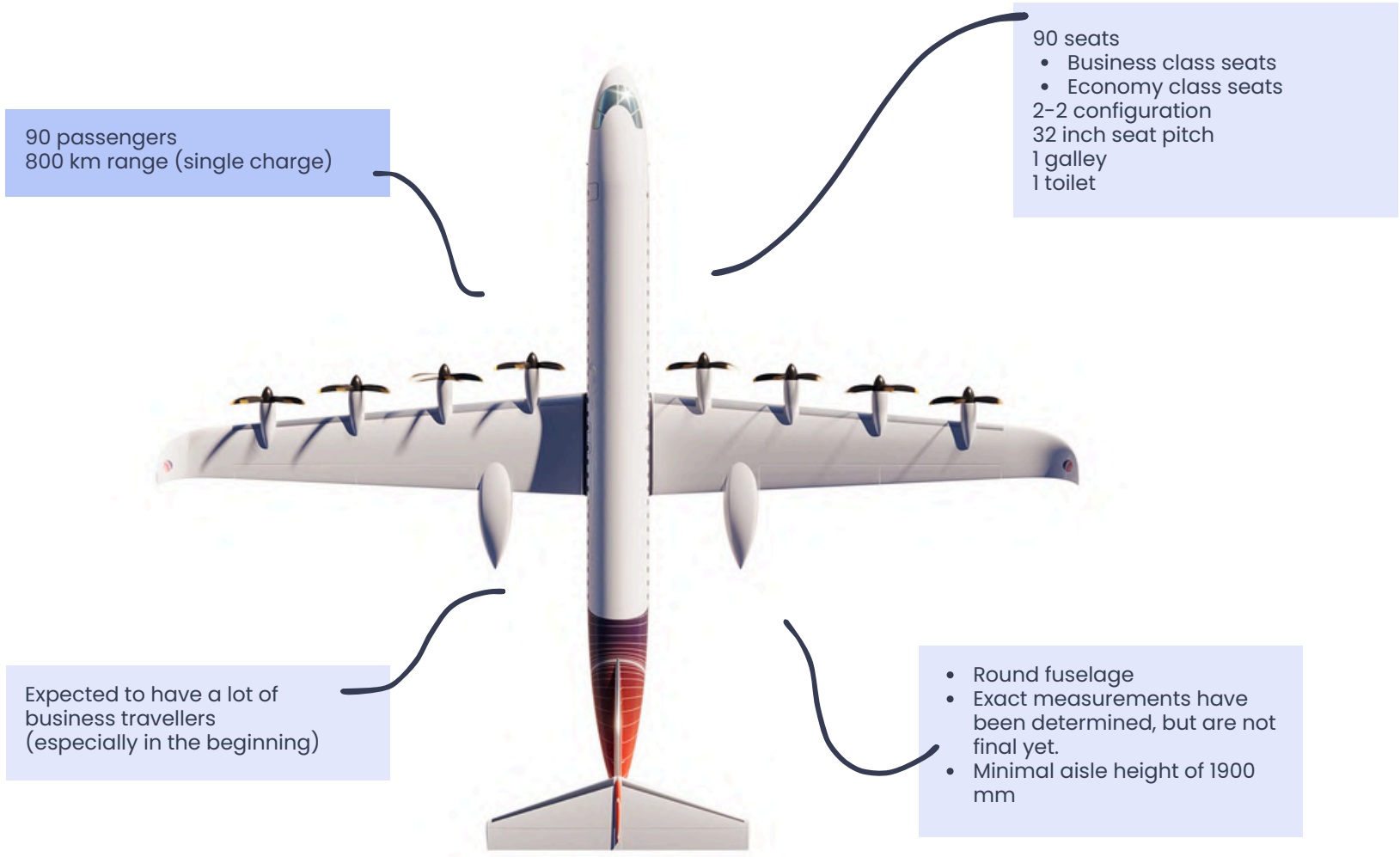


Figure 8: Elysian's E9X aircraft topview and specifications

Chapter 2

Scoping

2.1 Floorcontainer concept

2.1.1 Introduction

This project builds upon Van Duivenboden's 'Floor Container' concept as its starting point. The following section details the principles of the design.

The concept: "The interior design features a cabin where luggage is stored in containers under the seats to enhance the sense of spaciousness in the cabin. An additional false floor has been installed above the structural floor. This extra layer creates space for luggage containers between the two floors." (Van Duivenboden, 2025).

How does it work?: "You board the aircraft and walk to your seat. Once seated, you slide open the luggage container beneath you and place your luggage in the container. If you need to access your belongings during the flight, you can do easily from your seat." (Van Duivenboden, 2025).

Advantages:

- ***For the future passenger:*** The new design creates a more spacious cabin where passengers can enjoy an unobstructed view. Increased legroom and easy luggage access provide greater convenience and a bigger sense of control during the flight.
- ***For future airlines:*** Faster boarding reduces turnaround times as passengers store luggage at their seats. More open space improves movement for both passengers and crew. Flexible seat configurations and customisable luggage compartments allow airlines to adapt the layout to their own needs. Thereby, the design eliminates the need for extra construction materials, making it a more sustainable choice.
- ***For the system:*** This concept integrates seamlessly into existing aircraft fuselages without big structural changes. It maintains the supply chain while offering aircraft manufacturers or airlines the option to lower the floor for an even more open and spacious cabin feel (Van Duivenboden, 2025).

Limiations:

- Container design | The slope shape design of the container must be compared with other storage designs. Thereby, it is jet not tested whether the handle can be easily used while using hands or feet.
- New floorplan | The new floorplan of the E9X aircraft is designed to accomodate 90 passengers. The cabin crew has not been included in the new floorplan design. For this thesis, the maximum possible seat pitch (38") that the aircraft can achieve has been assumed (Van Duivenboden, 2025).

Some of the recommendations:

- Handle | An investigation should be conducted into the ease of opening the handle (of the slide of the container) using hands and feet. How intuitive is the process?
- Cost and weight estimation | Research into materials and weight estimation is required.
- Certification | The process of certification of the container, double floor, and the attachment of seats to the false floor should be initiated, ensuring that the crash forces from the seats are properly transmitted to the structural floor (Van Duivenboden, 2025).

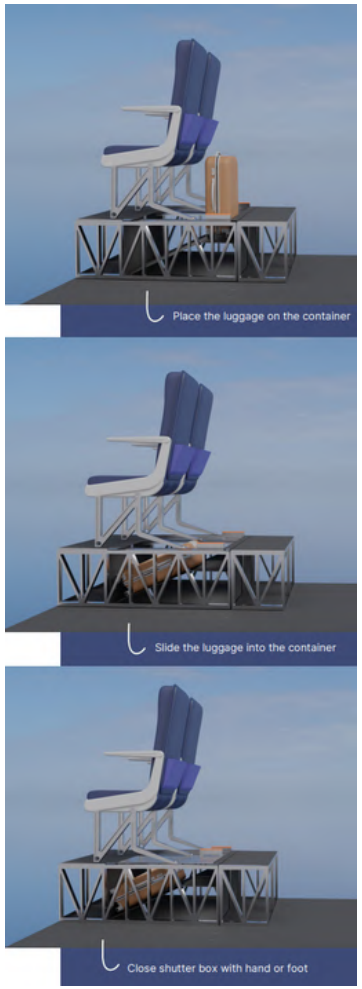


Figure 9: How to use the floorcontainer concept (Van Duivenboden, 2025)

2.1 Floorcontainer concept

2.1.2 Dimensions

Cross-section
Most of the carry-on luggage is at least 25 cm in the shortest direction (Briggs & Riley, n.d.). To allow for clearance in terms of angle and material, a minimum floor height of 300 mm is required.
The current cross-section of the E9X does not allow for a double floor with a minimum height of 300 mm (see figure 10).

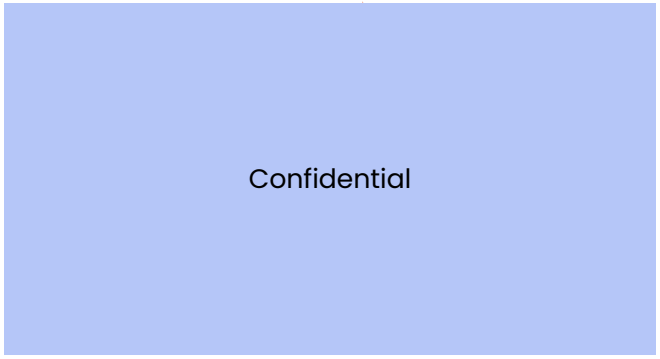


Figure 10: 300 mm double floor in current cross-section, leaving insufficient space for the aisle height

Various options are being considered to solve this problem. For example, instead of a full double floor, a partially raised floor could be used (see figure 11).

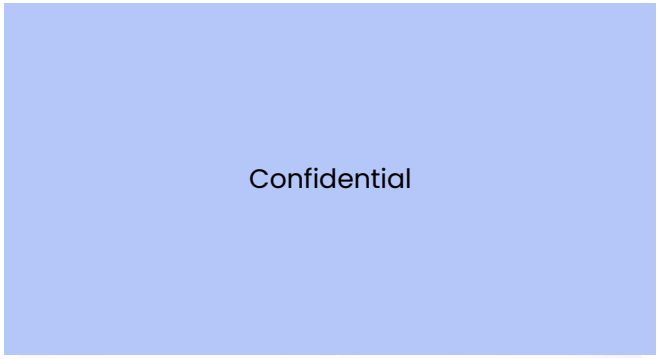
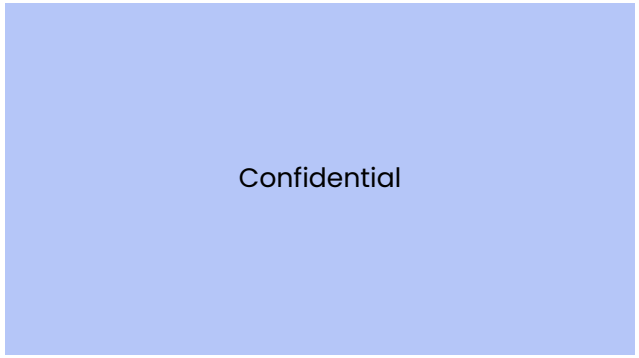


Figure 11: creating lower aisle

The rising question here is if this causes any problems with evacuating the aircraft (because of the min. 300 mm step that is created).

Alternatively, the aircraft fuselage would require a minimum enlargement of [redacted] (see figure 12). As illustrated in figure 12, this specific increase is necessary to accommodate the required aisle height.



This would result in an aircraft with a larger surface area, which increases air resistance and also adds to the overall weight. Another option is to reduce the space beneath the cabin. However, this would limit the available space for checked luggage and is therefore not desirable, given the existing structural design of the aircraft (see figure 13).

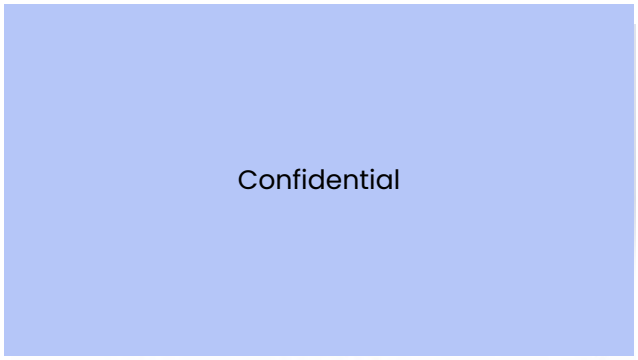


Figure 13: reducing space in cargo compartment

2.1 Floorcontainer concept

2.1.3 Setup

To gain insight into the possibilities and limitations of the floor container concept, a prototype was created to be used for user testing.

The prototype
The prototype consists of four platforms. The seats are attached to the platforms and the compartments can be interchanged. This means that the prototype can be used for as many variations as possible, is easy to move, and can also be reused for other concepts.

Two rows of three aircraft seats were available. As the E9X has a 2-2 configurations only two seats parallel to each other were used. The seat pitch used is the most updated one from the E9X: 32".

Figure 14: Floorcontainer concept prototype

Figure 15: Floorcontainer concept prototype top view

Variations
Angle of the slide
The angle at which the hand luggage can be placed in the floor was varied to test the experience of passengers

The original concept had an angle of 25°.

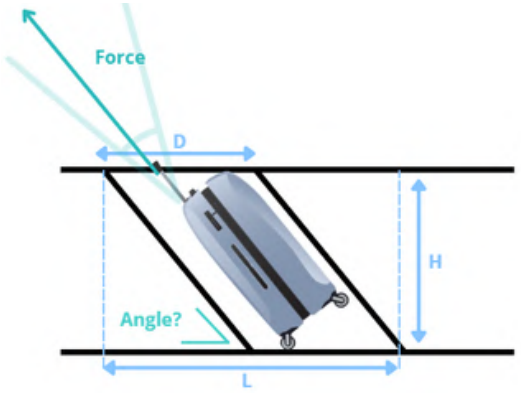


Figure 16: Situation sketch

Two alternative angles were added as the handling might be more comfortable at different angles.

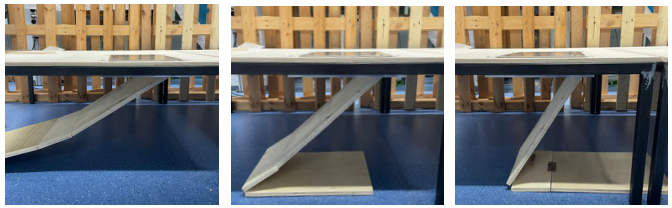


Figure 17: Different slide angles on the prototype

Distance hatch to seat
To examine the reachability, three different variations were made in terms of the distance between the compartment and the seat.

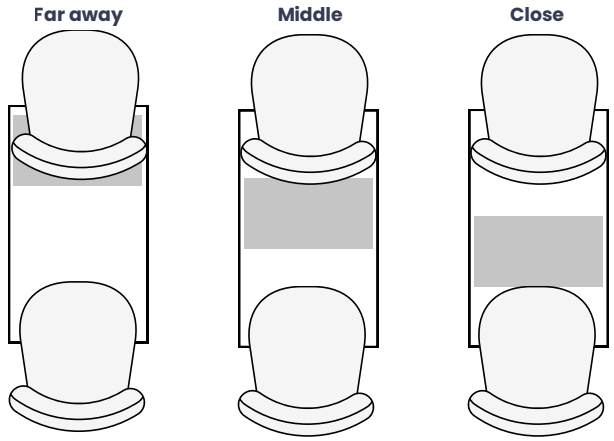


Figure 18: Different distances hatch to seat

2.1 Floorcontainer concept

2.1.3 Setup

Height of the handle
Three differently sized handles were 3D-printed to investigate whether handle size influences the usability of the hatch-opening concept.

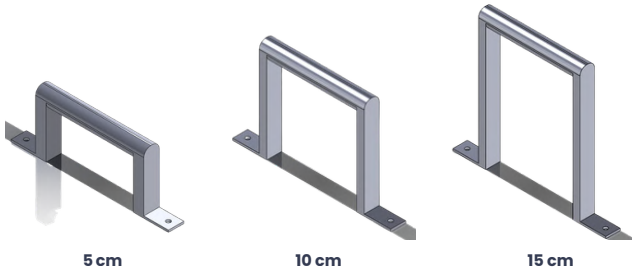


Figure 19: Different handle heights

Backpack
The participants were asked to place a medium sized backpack (see figure 20) in the hatch. The backpack weighed 5 kg to make the simulation as realistic as possible (Zweers, 2025), without the item distracting from the concept's functionality.

Figure 20: Backpack used in the test (Zwart the North Face Rodey Backpack - JD Sports Nederland, n.d.)

2.1 Floorcontainer concept

2.1.4 Test

To analyze the concept, qualitative user tests were conducted with seven test participants. The test involved placing a backpack in the underfloor compartment, first intuitively (non-directed) and then after an explanation of the concept. The emphasis was on the quality of the experiences, not on the quantitative. The answers clearly show how people experience the system in terms of comfort, hygiene, social context (with someone next to them) and possible improvements.

▸ **The document that was used during the tests can be found in Appendix A**

Participant demographics
The participant group consisted of three men and four women, with heights ranging from 160-169 cm to 190-199 cm. Their frequency of exercise varied from none to four times a week. All participants had prior flying experience. Their ages ranged from 18-24 years old to 55-64 years old.

Methods
This user research used a mixed-methods approach consisting of direct observation, non-directed usability testing with a think-aloud protocol, a variant test, and a concluding survey and debriefing. This combination makes it possible to investigate both behavioral and subjective aspects of use.

Results
Distance from hatch to seat
The responses show that this distance has a direct impact on how users experience the system, both in terms of comfort and sense of space and hygiene.

Far away
Five out of seven participants mentioned that they had to lean forward and hit their heads against the seat in front of them.

- Spacious feeling, safest option
- Harder to reach, head bumping against the seat in front

> "Ouch, my head, I bump it when I lean forward, how am I supposed to reach this?"

Middle
Four out of seven participants described this distance as the most natural.

- Natural reach, least disturbance from neighbours
- Risk of accidents if the compartment is open, some found it scary to step on it

> "I could reach it well without really having to lean forward."

Close
Four out of seven participants said they liked being able to reach things easily, but also mentioned not knowing where to put their feet.

- Easy to reach (if you can spread your feet)
- Most disturbance from neighbours, harder for less mobile passengers

> "It is nice that I can easily reach my belongings."

Figure 21: Participant trying to reach their luggage (seatpitch = 32")

The middle distance offers the best balance between ergonomics and personal space (figure 22) with this seat pitch, but passengers are still limited by the seats in front of them. This is a bigger problem with the window seat than with the aisle seat, because at the aisle seat users lean their heads into the aisle instead of against the seat in front of them (see figure 21).

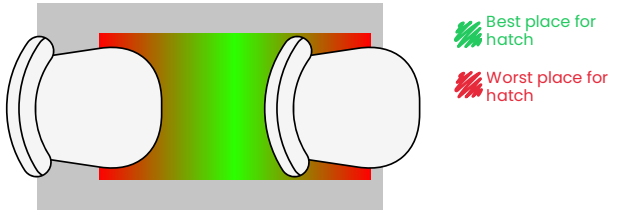


Figure 22: Best placement of the hatch

2.1 Floorcontainer concept

2.1.4 Test

Legroom
All participants experienced the legroom as positive. The average score for legroom was 8.5 out of 10.

Clarity of use
During the non-directed test round, only one out of seven participants stored the bag correctly. The average score for clarity was 2.8 out of 10.

Comparison in comfort with overhead bins
Participants gave an average comfort score of 6 out of 10, using the traditional overhead bins as a baseline score of 5 out of 10.

Standing on the hatches
Observation showed that because the seats are positioned close together, passengers tend to look over the seats in front of them rather than directly down at their feet while walking. As a result, they may not pay close attention to where they are stepping. Raised edges, unexpected obstacles, or gaps could therefore lead to accidents (see figure 23). At the same time, passengers are likely to check the surface beforehand, so the key question is whether they trust the hatch to be strong enough to step on. If the hatch looks unstable, people might avoid it, which could make the experience feel uncomfortable.

Notable discomfort while moving to the seat
During the tests observation showed that participants had to take small sideways steps to reach their seat, this was especially noticable for the window seat. They often combined this movement with holding onto the seats in front of them (see figure 24). This was necessary because the walking space between the seat and the next row was very limited.

Figure 23: Passenger's moving to a window seat

Figure 24: Passenger's view while moving to a window seat

Height of the handle
Participants had no clear preference for the height of the handle, but it was clear that it was often in the way in the middle and close positions. The height of the handle did not appear to be a significant factor in the comfort of operating the hatch.

Hygiene
Four out of seven participants indicated that they would feel uncomfortable touching something located near their feet, especially if it looked dirty or if they could actually see dirt.

> "If it were dirty, I'd rather not touch it."

> "I would find this dirty in an airplane."

> "Because it is under the seat, it feels dirty more quickly"

Social context
Six participants described how they experienced performing the action while someone was seated next to them. Four of them said they felt a bit uncomfortable because of how close they were to the other person especially when the neighbour was a stranger.

Two participants did not mind it or said the feeling went away once they got used to it. The physical distance between the hatch and the seat seems to have a clear effect: the closer the compartments are to the user and to each other, the more aware people are of the person next to them.

Angle of the slide
The users did not have a strong preference, but the 45° angle appeared to be a little easier in use.

Conclusion
Almost all participants were positive about the concept of the system. They found it practical to have their belongings within reach and considered it functional and well designed. Participants also appreciated the ability to keep their items organized and easily accessible. However, reaching the handle was experienced as difficult, as it often resulted in bumping their head against the seat in front of them.

2.1 Floorcontainer concept

2.1.5 Solutions

Space required for comfortable use
To ensure that 95% of the global population can use the interior comfortably, the following anthropometric values are used (from DINED, 2020)

- Body height: 192 cm
- Hip width while seated: 44,7 cm
- Hip joint to top of head: 82,3 cm
- Shoulder width: 55,3 cm

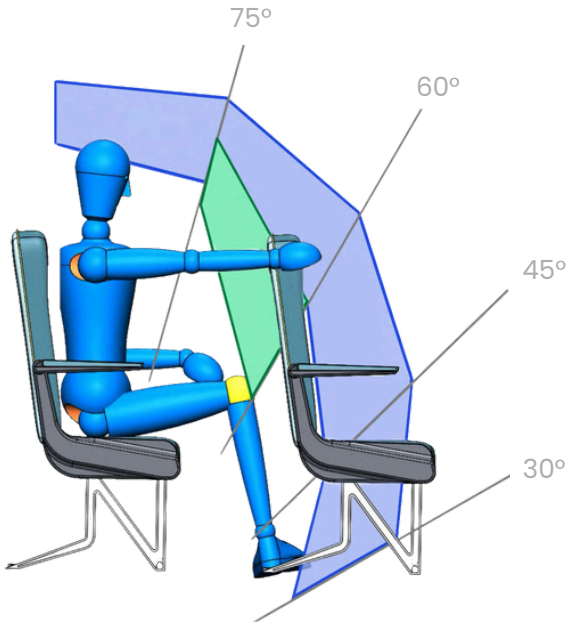
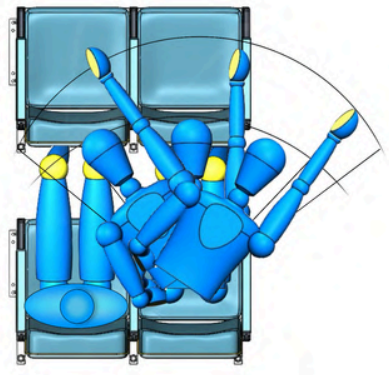


Figure 25: Reach envelope in 32" seat pitch aircraft seat (information from DINED)

Required seatpitch
In the current situation, a seatpitch of at least 36.7 inch is needed for a comfortable use of the hatch (see figures 26 and 27).

At least an **extra 12 cm (4.7 inch)** is needed to bend comfortably to the front (without bending back)

Figure 26: Reaching for something under seat in front in 32" seat pitch aircraft seat - side view



By bending more sideways, there is less space need (bending the neck)

Figure 27: Reaching for something under seat in front in 32" seat pitch aircraft seat - top view

Key insights:

Concerns

- Weight compliance: Not yet proven to fit within the designated limits.
- Certification: Remains a key challenge.
- While seat pitch is adjustable, no solution has yet been implemented to allow the luggage bins to move accordingly.
- It is not (yet) easy to change seat pitch.

Dimensions

- To fit a 30-cm raised floor into the fuselage of the E9X, the aisle must be lowered, the fuselage must be enlarged or the cargo hold must be reduced. All of these solutions have their own drawbacks.

Test

- Having luggage close-by is rated very positively.
- Legroom rated very positive (8.5).
- Usability unclear, only 1/7 used it correctly.
- Comfort slightly better than overhead bins.
- Middle distance felt most natural.
- Handle sometimes in the way.
- Hygiene concerns due to floor context.
- Social discomfort near strangers.
- Limited aisle space caused awkward movement.
- Trust in hatch strength can affect comfort.
- Be careful with designing discontinuous floor, it increases the risk of tripping and reduces floor visibility while walking

Solutions

- Seat pitch p = 95 is at least 36.7 inch.

In this scoping chapter, it has been established that the floorcontainer concept holds significant potential value, but also presents several challenges and limitations. Therefore, further exploration will be conducted into alternative approaches to improve the passenger experience. In addition, potential improvements and refinements to the current concept will be developed and presented.

Chapter 3

Discover

3.1 Stakeholder analysis

The development of an aircraft is never the work of a single company. It is a complex system involving multiple organizations and interconnected processes. Design decisions cannot be made by the OEM alone but must involve the full spectrum of stakeholders through a user-experience-driven approach (Hall et al., 2013). To better understand these interests, conversations were held with Elysian about the key demands and expectations of important stakeholders. The outcome of these discussions is visualized in figure 28.

In conclusion, balancing these distinct priorities is an essential part of this project, and maintaining a clear overview of stakeholders and their interests is therefore crucial.

Key insights:

- Quick conversion is important for aircraft leasing companies.
- Passenger satisfaction is a key priority for airlines.
- The concept should not only be desirable, but also practical to operate, maintain, and certify.

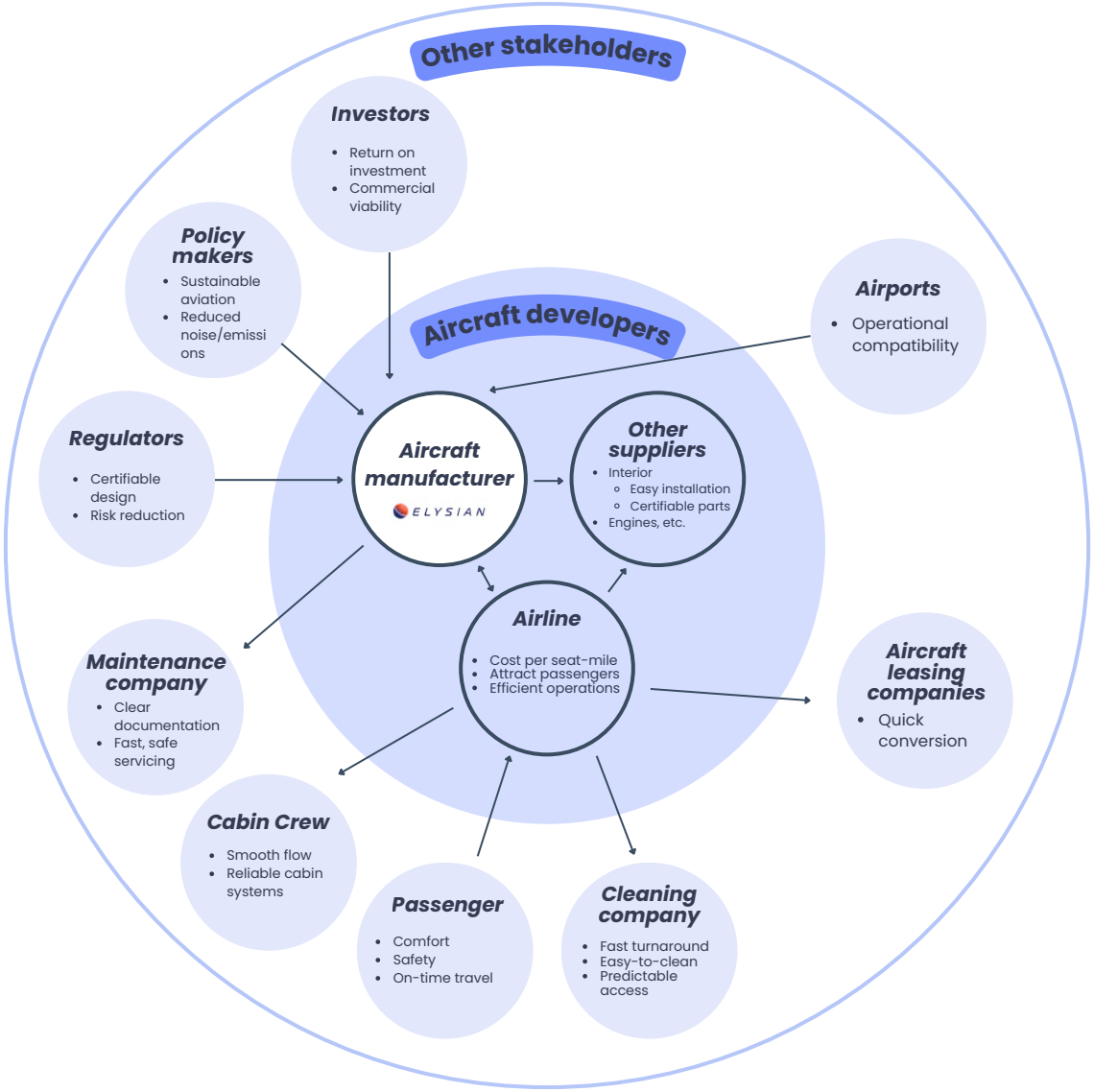


Figure 28: Stakeholder map and key interests per stakeholder

3.2 Trend & development analysis

3.2.1 The world in 2035-2065

Passenger aircraft have an average retirement age of 25 to 30 years (Sustainability in the End-of-life Phase of Aircraft, 2024). Within that lifespan, the aircraft cabin is typically replaced 4-5 times (Daly, 2024). The aircraft's foundation and the interior lay-out must be able to remain relevant for the next 30 years. This requires taking a closer look at what the world will look like during the period in which the aircraft will operate.

Consideration of future trends is critical in aircraft interior design with examples including: more female passengers in leading roles travelling for business reasons, obesity, greying society, rising economic giants, the cultural influence of BRIC countries, all potentially influencing future cabin design and service (Hall et al., 2013). To ensure the interior is optimally adapted to these future conditions, several strategic analyses were conducted: a DEPEST analysis, an evaluation of aviation industry trends, and an assessment of evolving passenger expectations.

- **Full DESTEP analysis can be found in Appendix B**
- **Full Aviation industry trends analysis can be found in Appendix C**
- **Full Evolving passenger expectations KPMG research can be found in Appendix X**

The key highlights from these analyses are presented in this chapter.

Growing overweight and obesity
"In 2022, 43% of adults aged 18 years and over were overweight and 16% were living with obesity." (World Health Organization: WHO, 2025). "Assuming the continuation of historical trends, by 2050, we forecast that the total number of adults living with overweight and obesity will reach 3·80 billion over half of the likely global adult population at that time." (GBD 2021 Adult BMI Collaborators, 2025).

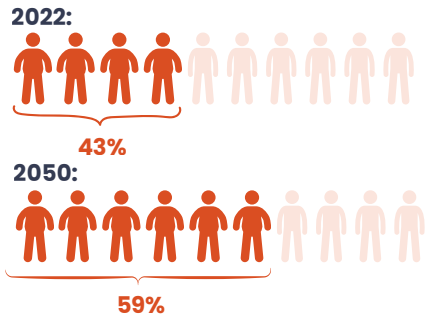


Figure 29: Increasing bodyweight worldwide

On the other hand a trend is:

Rise of weight loss medicine
The GLP-1 weight loss drug market has grown by 300% between 2020 and 2023 (Aziz, 2024). This includes, for example, the drug Ozempic, which reduces users' desire to eat by 20-30%. This could have a major impact on the average body type in the future, but there is still little clarity about the long-term health impacts of these drugs (VML Intelligence, 2025).

So the average body weight is likely to increase the coming decades. Adoption of rising weight loss medicin is likely to vary significantly across regions, especially in countries where rising prosperity is only now contributing to higher obesity rates. Any projections should therefore be interpreted with caution.

Individualism
People are increasingly focusing on themselves (Ipsos, 2024). Factors such as AI and algorithms that create personalized experiences, exponential technologies that reduce required work, and on-demand learning further accelerate this trend (Olsen, 2021). As a result, the number of solo travellers is expected to grow. Improving the solo travel experience will require enhanced connectivity, community support, better safety measures, and more personalized services (Scoot, n.d.). Since 2010, the share of people living alone has also risen in 26 out of 30 high-income countries (The Economist, 2025). So the the number of solo travellers is expected to grow.

Aging population
Due to declining fertility levels and people living longer, the percentage of elderly people in the population is increasing (United States Census Bureau, n.d.) . This is referred to as aging and has a major impact on the aviation industry: diversity in body types is increasing, which can greatly influence design criteria such as accessibility and comfort. This trend can impacts design criteria like accessibility and comfort in the aviation industry.

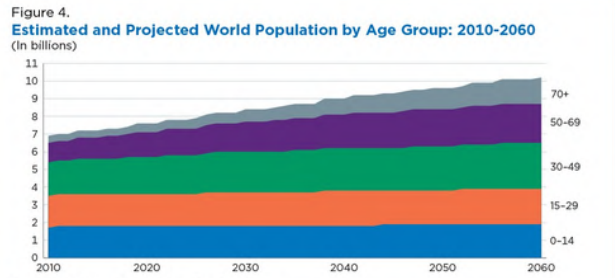


Figure 30: Aging population worldwide (United States Census Bureau, n.d.)

3.2 Trend & development analysis

3.2.2 The aircraft industry in 2035-2065

As stated in the introduction, the aviation industry is accounted for approximately 2% of total global CO2 emissions (enviro.aero, 2024). By 2050, the number of passengers is expected to exceed 9 billion. Airbus predicts the global commercial aircraft fleet will more than double by 2030, requiring over 27,800 new aircraft to meet demand (The Future of the Aviation Industry – a Glimpse Into 2050, 2025). To ensure that the interior of the E9X maintains a strong competitive position within the aviation industry in the future, an examination is conducted into the developments within the sector that will shape the future of the aviation industry.

Economic growth in developing countries
The economy of the African region is growing by an average of 4.2% in 2025, while Asia is expected to grow by 4.5% (International Monetary Fund, n.d.). This expansion is driving exponential growth in the aviation industry across these regions. In Africa, air traffic is forecast to increase by approximately 6.0% annually, while South Asia and Southeast Asia are expected to experience even higher growth rates of around 7.0% per year (Boeing – Commercial Market Outlook, n.d.).

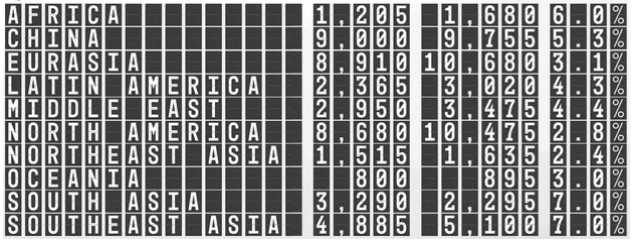


Figure 31: Aviation growth in different regions (Boeing – Commercial Market Outlook, n.d.)

Rising ticket prices due to sustainability costs
Traditional aviation is trying to reduce emissions, but this is expensive and will affect ticket prices (Granatstein & Ng, 2021). This price increase may influence who will be able to fly in the future. Or lead to the rise of sustainable alternatives like Elysian.

High-speed rail
High-speed trains are likely to offer lower prices, shorter door-to-door travel times, and more space per passenger than airplanes for short distances in the future (ALG, 2024). This will force the aviation industry to improve cabin comfort and the overall experience in order to remain competitive.

Different classes
Although fewer First Class seats are being sold, new classes are emerging. Airlines are increasing their mid-range class. Emirates announced plans to revamp some of its airplanes to include more premium economy seats. This suggests that more travelers are shifting to the middle of the market (VML Intelligence, 2025). Some airlines now operate up to four classes. “Some industries, even aviation itself, have evolved business models that are very user-centric.” (Pelanda, 2018).

CabinOK initiative
The IATA's Cabin OK initiative aimed to standardize carry-on luggage requirements across airlines, with guidelines for a carry-on size of 21.5 x 13.5 x 7.5 inches (54.61 cm x 34.29 cm x 19.05 cm) to fit in overhead bins (Ramakrishnan & Meenar, 2015). However, the initiative was paused due to concerns in North America. Several airlines, including Avianca, Azul, Emirates, and Lufthansa, had expressed interest in joining, while Air Canada and WestJet chose to maintain their current policies. Boeing introduced "space bins" that year, designed to fit luggage without shrinking its size.

3.2 Trend & development analysis

3.2.3 The passenger expectations in 2035-2065

Developments in the automotive industry, evolving mobility options and broader global changes are expected to result in new customer expectations by 2035 (Calder et al., n.d.) Therefore it is important to understand what passengers will expect during their travels in 2035.

Godlike journeys & gen alpha vacations
Epic journeys and complex itineraries that offer learning, discovery, adventure, and self-actualization were once the preserve of the 1%. Now they are on the calendar for affluent families as parents seek to educate and entertain kids on vacation (VML Intelligence, 2025). Hilton's "2025 Trends Report" found that 70% of global respondents who travel with their children pick their vacation destination based on their kids' needs and interests. The majority (63%) also let their kids pick where they dine, while 56% choose hotels based on youth programming options. It is no longer enough to cater to the needs of the parents, travel brands need to very specifically meet gen alpha's demands (VML Intelligence, 2025).

Artful stays
As the intersection of art and hospitality deepens, leading hotels and travel experience providers are redefining what it means to provide a memorable stay. Brands are moving beyond standard luxury to collaborate with artists, transforming spaces into immersive, art-filled environments that engage guests on an emotional and sensory level. Artful stays reflects a broader shift in the hospitality industry toward more personalized and emotionally resonant experiences. By partnering with artists and pushing the boundaries of design, these hotels and travel experiences meet the growing desire among travelers for unique, meaningful stays (VML Intelligence, 2025).

KPMG research
In their 'Aviation 2030' series, KPMG analyzed evolving passenger expectations. Figure 32 illustrates a summary of the conclusions.

The findings presented a conflict with the Cabin OK goals, as the data pointed toward an expansion of cabin storage capacity.

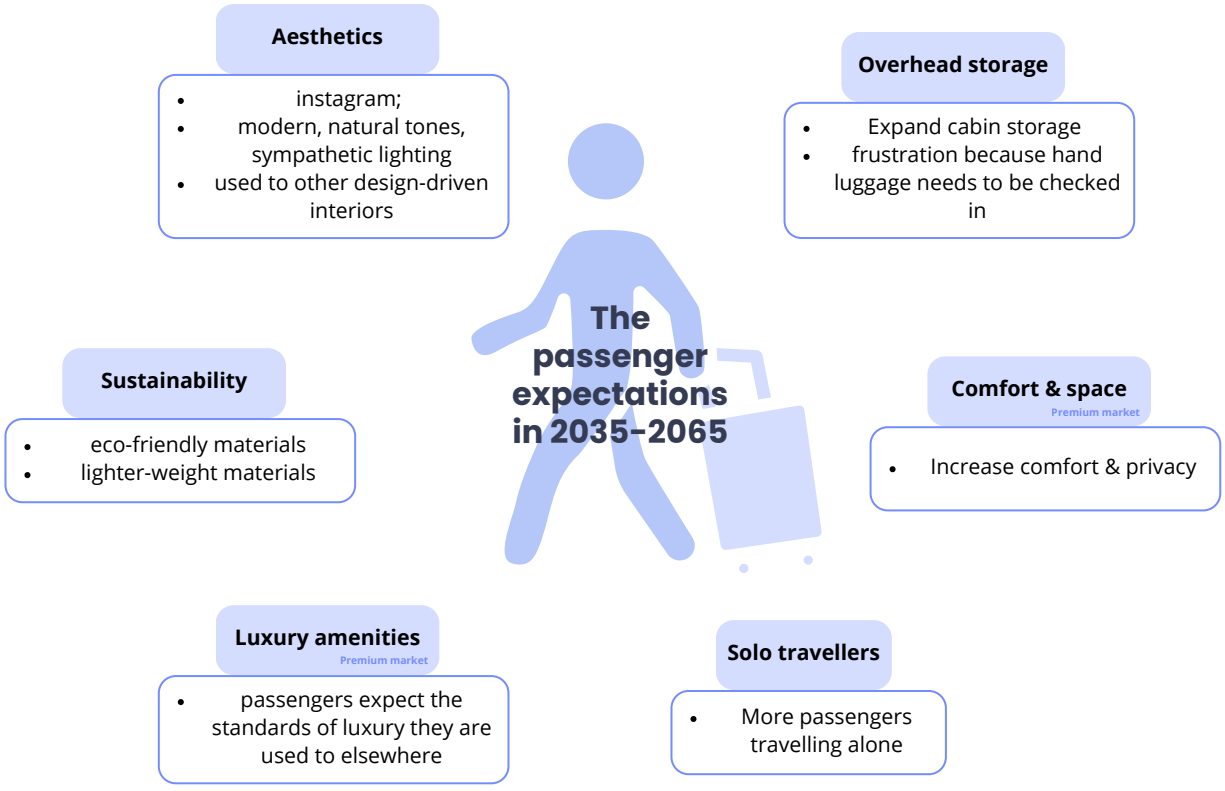


Figure 32: Evolving passenger expectations based on KPMG research (KPMG & KPMG International Limited, 2025)

3.2 Trend & Development analysis

3.2.4 Conclusion

Future outcomes are shaped by many factors. While exact predictions for 2035–2065 are impossible, trend and development analysis reveals several key insights.

Key insights:

- Aircraft last 30 years; interiors updated often.
- Over 50% of adults will be overweight in the future.
- Aging populations require better accessibility and comfort.
- Rising individualism leads to more solo travelers.
- Developing regions drive exponential air traffic growth.
- High-speed rail competition demands superior passenger experiences
- Airlines are introducing more classes
- Passengers expect high-end cabin aesthetics.
- Sustainable materials and light weight design are essential.

3.3 Literature review

3.3.1 Passenger comfort

To improve the passenger experience, enhancing passenger comfort is an important aspect. A literature review was conducted on the influence of aircraft design on passenger comfort, and the most relevant findings are outlined in this chapter.

Various factors influence the experience of comfort and discomfort. According to Vink and Brauer (2011), feelings of comfort, no discomfort, or discomfort result from sensory input, shaped by both the participant's history and current state (see figure 33).

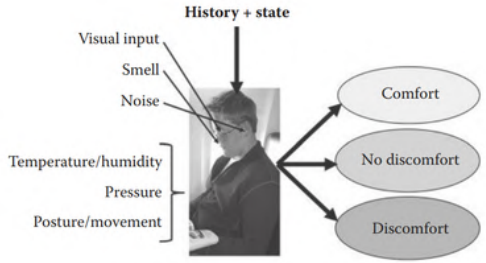


Figure 33: The comfort input/output schema (Vink & Brauer, 2011)

Bubb (2008) developed the discomfort pyramid (see figure 34), illustrating that certain environmental factors strongly influence passengers' overall perception of comfort. If these basic conditions are not met, improvements in higher-level factors have little effect.

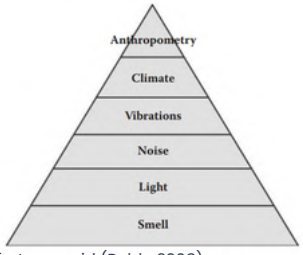


Figure 34: Discomfort pyramid (Bubb, 2008)

Seat design

Width of seat

According to Anjani et al. (2021), the comfort level of sitting in an 18-inch-wide seat was nearly equal to that of sitting in a 17-inch-wide seat with an additional 4 inches of seat pitch. This suggests that increasing seat width is an effective way to improve comfort while using cabin space more efficiently. Compared to adding pitch, widening a 17-inch seat by 1 inch requires the same additional floor area as increasing seat pitch by 2 inches. However, achieving a similar increase in comfort through pitch alone would require 4 extra inches, resulting in twice as much additional floor area.

Airbus advocates that regional jets economy seats whould have a minimum width of 18-inches (see figure 35). This recommendation is supported by a study conducted by the London Sleep Centre on behalf of Airbus (Experience, 2016). The results of this study revealed that an 18 inch-wide seat improved passenger sleep quality by 53% compared to a 17-inch seat. Additionally, passengers fell asleep on average 4.7% faster in the wider seat.

Figure 35: Long haul economy seat widths research Airbus (B) (Experience, 2016)

Seat pockets

Placing the seat pockets at headrest level is perceived positively, as it improves accessibility and cleanliness (Vink & Brauer, 2011).

Leg support

The way people are able to sit is another key factor for comfort. As shown in figure 36, people prefer sitting with their feet off the ground when watching a screen, suggesting the value of (adjustable) foot or leg support even in compact seating (Vink & Brauer, 2011)

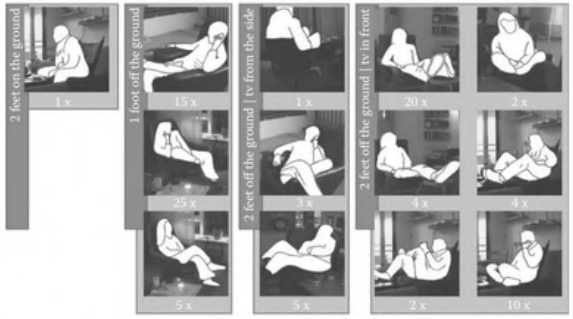


Figure 36: Comfortable position while watching a screen research observations (Vink & Brauer, 2011)

Visual impression importance

In an experiment involving newly developed BMW automobile seats, one prototype incorporated multiple coloured blocks and was perceived negatively purely based on its visual appearance (Bubb, 2008, as cited in Vink & Brauer, 2011). This study demonstrates that visual impression influences the overall comfort experience (Vink & Brauer, 2011).

3.3 Literature review

3.3.2 Passenger comfort

Key insights:

- Comfort is influenced by sensory input, history, and state.
- Before factors like smell, light, noise, vibrations, climate, and anthropometry can create comfort, they must be met.
- Increasing seat width is a powerful way to enhance comfort.
- Visual impression is important for comfort.

3.4 Survey

3.4.1 Passenger behaviour on short-haul flights

Since little is known about the motivation behind passengers taking short-haul flights, a survey was conducted among 132 individuals to gain deeper insight into their experiences, expectations and behaviour. The respondents varied in age, gender, height, weight, amount of exercise per week, number of flights per year, and worked across different sectors. This diversity allowed for a broader perspective and the identification of potential relationships between various factors.

The survey was distributed digitally through personal networks and channels such as LinkedIn, Instagram and WhatsApp.

Methods

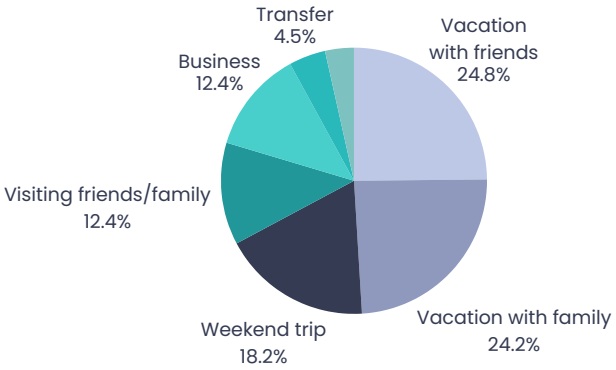
The survey included questions to obtain an understanding of the passenger behaviour. Retrospective questions encouraged participants to recall a specific moment, helping to capture concrete memories and emotions. Likert scale questions were used to measure attitudes and levels of satisfaction & priorities: ranging from 'not important at all' to 'very important'. Explanatory questions aimed to uncover underlying reasons and motivations, while behavior-focused questions concentrated on actual travel habits and routines of the respondents.

The first question verified that the participant had read and agreed with the informed consent statement, following the guidelines of the Human Research Ethics Committee of the TU Delft.

The results are based on a dataset of 253 individual flight experiences, as respondents were invited to evaluate two seperate flights. Participants were allowed to select multiple answers at most questions.

Outcomes

Reasons to take a short haul flight



The proportion of business passengers in the E9X is expected to be higher (see chapter 1.5). In the Netherlands, 30% of flights are for business purposes (Kennisinstituut voor Mobiliteitsbeleid (KiM), 2021).

Figure 37: Reasons to take a short-haul flight

Activities during the flight

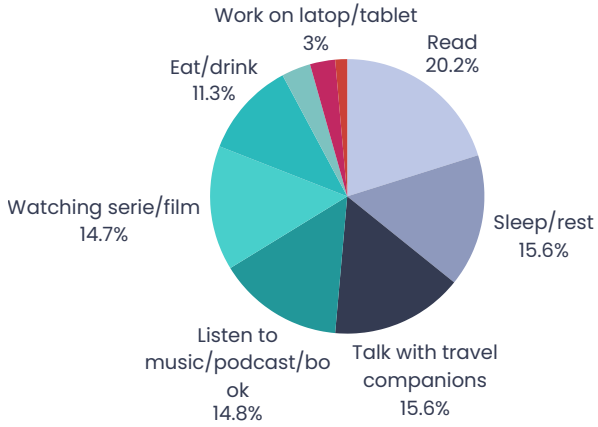


Figure 38: Activities on a short-haul flight

Seat location preference (aisle or window - 2-2 configuration)

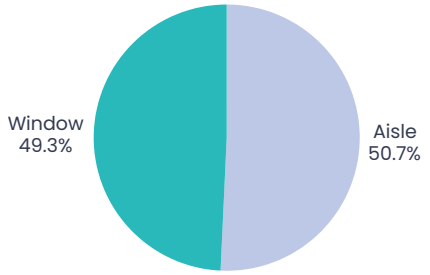


Figure 39: Seat location preference

Priorities

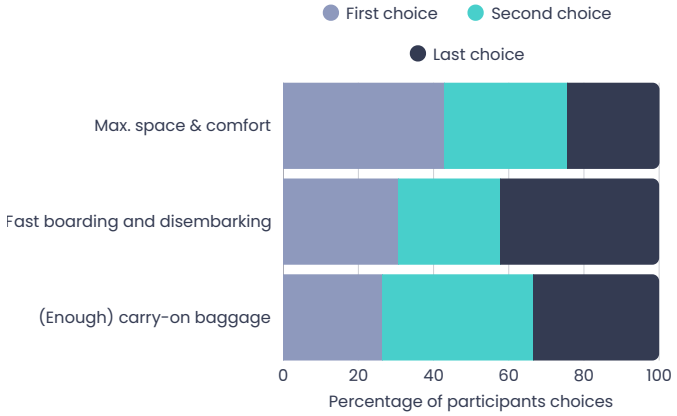


Figure 40: Ranking on importance: Max. space & comfort, fast boarding and disembarking or (enough) carry-on luggage

3.4 Survey

3.4.1 Passenger behaviour on short-haul flights

Priorities

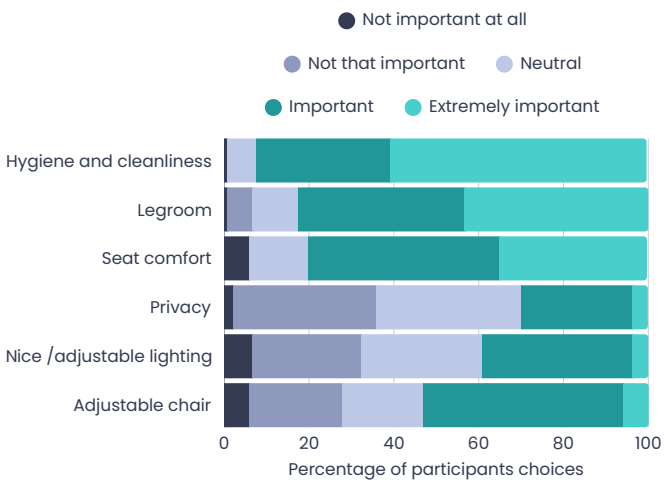


Figure 41: Priorities of passengers during a short-haul flight

Legroom
Legroom appeared to be a highly important aspect: 44 participants (31%) mentioned legroom in a negative way when reflecting on their flight experience, 8 participants (6%) mentioned it positively, and none referred to it in a neutral way.

In total, about 37% of respondents referred to different aircraft types with varying seat designs and seat pitches, legroom still clearly emerged as an important factor, as it was the most frequently mentioned aspect in the open-ended responses regarding overall flight evaluation.

Moreover, this aspect showed a strong correlation with body height, the taller the participant, the more likely they were to express dissatisfaction with the available legroom.

Mentioning legroom in a negative way

Percentage of respondents within each height category who mentioned legroom negatively.
No participants taller than 200 cm completed the survey

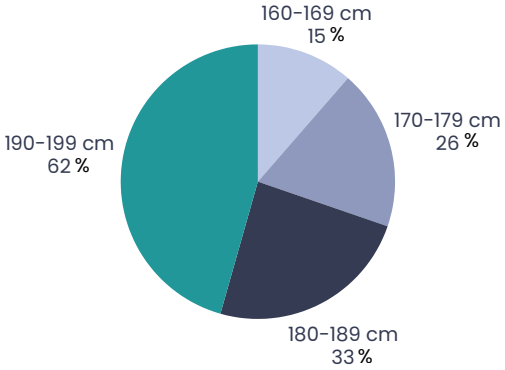
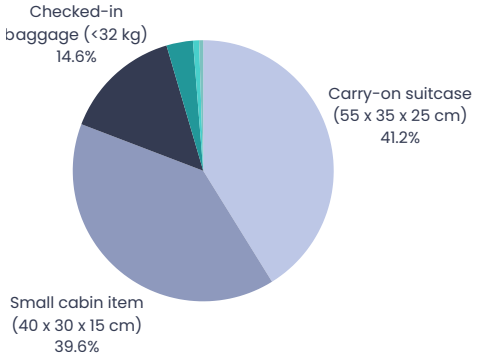


Figure 42: Percentage of respondents who mentioned legroom in a negative way when substantiating their flight rating

Positive mentions were generally rare, but relatively higher in the group of 170-179 cm. Shorter passengers <160 cm rarely mentioned legroom, suggesting that it is a greater concern for taller passengers.

luggage
In order to estimate the expected luggage volume for the E9X, participants were asked what luggage they had taken with them on their last two flights.



Other small percentages are: odd-sized checked in luggage & heavy checked-in luggage (<32 kg)

Figure 43: Percentage of respondents who travelled with certain items of luggage

Estimated luggage load for E9X

Based on the data, an estimate can be made of how much carry-on luggage will be brought on board of the E9X.

Carry-on suitcase	52x
Small cabin bag	50x
Checked-in luggage	18x
Shared checked-in luggage	5x
Odd-sized luggage (cabin)	2-3x
Odd-sized luggage (cargo)	1-2x

3.4 Survey

3.4.1 Passenger behaviour on short-haul flights

Estimated luggage load for E9X - 90 business passengers

This calculation is made based on 36 business purpose flights.

Carry-on suitcase	81 %	73x
Small cabin bag	55%	50x
Checked-in luggage	25%	23x

Quotes

***Legroom*:**

"I often choose seats with more legroom because I'm quite tall and otherwise I can't really stretch my legs."

"Small plane with little legroom. But I didn't expect anything else, as many flights are so cramped."

"Limited legroom and narrow seats."

"Quite little legroom. On short flights, many passengers only have cabin luggage, which means there is little space in the overhead bins."

"Great flight, if it had been longer I would have liked a little more legroom, also because my luggagewas at my feet."

***Seatwidth*:**

"It is always awkward with armrests when someone you don't know is sitting next to you. Who is going to use it?"

"There was a row of two seats, and my travel companions and I did not have seats together. As a result, I was sitting next to a stranger. The person next to me was so big that the armrest couldn't be lowered. She also had two or three pieces of hand luggage, on the floor and on her lap, which also took up space."

***Activities*:**

"I was sitting next to someone who wanted to talk a lot, while I wanted to listen to music."

***luggage*:**

"I want to have my bag nearby, but then you always have less legroom."

"I was one of the last to board, so there was no room for my suitcase near my seat, which made disembarking a bit more difficult."

"There is always hassle about hand luggage. Sometimes you still have to check in your suitcase before boarding due to lack of space."

***Noise/smell*:**

"There were three crying children behind us, one of whom had pooped in his pants and could not be changed until after takeoff, so it smelled really bad. They were also screaming and crying, which made the flight really unpleasant."

"I always find it so much more comfortable to fly with noise canceling."

"The biggest problem is noisy fellow passengers who do not respect privacy and cause noise pollution (cellphones)."

"Noise from the plane and fellow passengers (crying children) is unpleasant."

***Efficiency*:**

"I enjoyed the flight because I could get on and off quickly and I got my luggage very quickly."

***Overall experience*:**

"The outbound journey was pleasant because there was a lot of visual space above my head. This made it feel spacious. The return journey was in a similarly sized but more modern aircraft. There, the visual space was restricted by light lines and dark colors. This felt cramped and oppressive. Even slightly claustrophobic."

"Okay, but traveling in economy class remains an unpleasant experience. "

"It was okay, but flying economy is never pleasant because you feel like a sardine in a can."

3.4 Survey

3.4.1 Passenger behaviour on short-haul flights

Key insinghts

- Legroom is considered very important, especially for taller passengers.
- Seat width significantly impacts comfort: narrow seats are often criticized (little flexibility for different body types).
- Most passengers travel with cabin luggage on short-haul flights.
- Hygiene is really important
- Space & comfort is the most important factor compared to efficiency & luggage. Respondents reported feeling claustrophobic and cramped on the plane (especially in the window seat)
- Respondents are negative about: smell, noise, flying with an overweight neighbour, placement of luggage and efficiency while (de)boarding.

3.5 Interviews

3.5.1 Cabin Crew

To gain insight into the operational aspects of the aircraft, two interviews were conducted with experienced KLM flight attendants. Both participants had over 30 years of professional experience as flight attendant.

Methods
The interviews followed a semi-structured format, which is effective for gathering in depth information. This method allows for flexibility to ask follow-up questions based on the answers, making it easier to explore specific experiences. The questions were divided into five categories: Background, Luggage Bins & Usage, Safety & Incidents, Frustration & Annoyances, Future & improvements. At the end the floorcontainer concept is evaluated.

▸ Interview set-up in Appendix X

Background
The cabin crew has a standard sequence of actions, as shown in figure 44, which is based on conversations with the two flight attendants.

Luggage Bins & Usage
Kind of luggage
KLM does not always strictly check passengers' hand luggage. As a result, passengers bring too much, oversized or odd-sized luggage into the cabin.

> "People bring guitars, strollers, wedding dresses, if they don't fit in the overhead bins or in the wardrobe, they still have to go in the hold, this takes time."

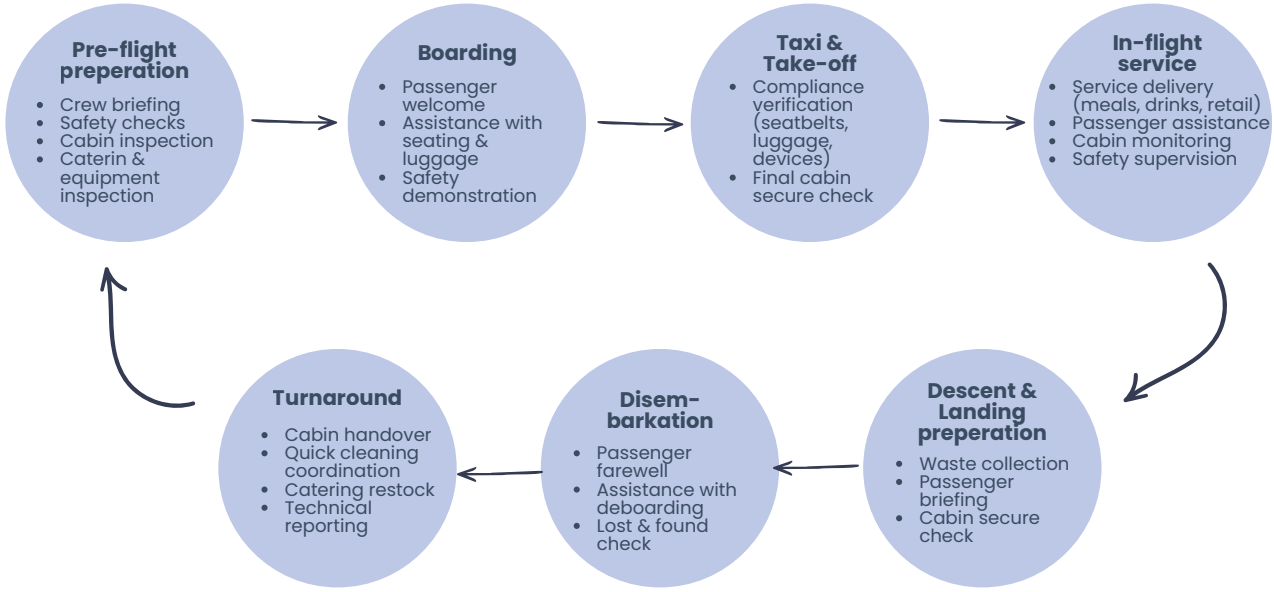


Figure 44: Operational cycle cabin crew

Lost luggage
Before the flight the crew performs a safety check (to make sure everything that needs to be on board is there). After the flight, they do a lost and found check to ensure no items have been left behind. This means that all overhead bins are checked, sometimes with the aid of a mirror (see figure 45). They also walk along the seats to see if anything has been left behind under the seats, and seat pockets are checked at random.

> "Passengers forget most things in the seat pockets, then in the overhead bins and fewest under the seat in front of them."

Figure 45: Mirror in overhead bins to help cabin crew check for lost luggage (Map, n.d.)

Safety & Incidents
Physically demanding overhead bins
Both flight attendants independently mentioned that operating the overhead bins can be physically demanding. The older-style bins, which require

3.5 Interviews

3.5.1 Cabin Crew

lifting the full weight upward to close, were described as particularly heavy and uncomfortable to handle (figure 46). They expressed a clear preference for fixed bins (figure 47), where the door itself moves upward to close the compartment, requiring less physical effort.

Figure 46: Pivot bin (Demos, 2023)

Figure 47: Fixed bin (United Airlines, 2024)

> "Many cabin crew members experience back problems due to the pivot bins & moving heavy luggage."

Inclusivity

Cabin crew also assist passengers who require help with certain actions on board.

> "Visually impaired passengers receive additional explanations, but much is still not accessible."

Furthermore, mobility aids need to be both easily accessible to the passenger and safely stored somewhere on board.

> "Passengers with crutches or wheelchairs often need assistance, and their belongings must be stored properly."

Frustration & Annoyances

Unpractical toilet facilities

Cabin crew members often have to work around passengers queuing for the lavatories, which leads to irritation and awkward situations. In addition, the lavatory spaces are very small. Passengers frequently use them for changing clothes, applying make-up, or standing while urinating, all of which cause delays and hygiene issues.

Lack of personal control over Air and Light

> "Lighting and air conditioning, passengers like to be able to adjust them themselves, but in many aircraft this is no longer possible."

> "In the 787, the climate feels more comfortable due to a different air control system."

Wear and tear

It is important to make the system vandal-proof. Passengers often do not use systems as they are intended and do so with excessive force.

> "Hatches get stuck, people use things roughly, things break, it has to be vandal-proof"

Future & improvements

Feet support

Similarities to the findings of Vink and Brauer (2011) were identified:

> "I often see passengers with their feet off the floor, they find it comfortable."

Other topics that came up

Hygiene & maintenance

The toilet has to be cleaned once an hour by the cabin crew, passengers enjoy a more pleasant flight when the toilets are clean.

In case of incidents on board, such as a baby vomiting or drinks beings spilled, the maintenance team is notified, and the affected component is subsequently replaced.

> "Crew members report which seats are dirty, and the complete part is replaced."

Crew seats

Flight attendants can rest/sleep on the crew seats. At KLM there are two types of seats, both considered not very comfortable (see figures 48 and 49)

Figure 48: 'Normal' crew seat(Aircraft Seats for Sale | Airline Seats | Pilot Seat | Skyart, n.d.)

Figure 49: 'High comfort' crew seat

3.5 Interviews

3.5.1 Cabin Crew

Weight & balance restrictions

"Weight and balance are very important, especially during take-off, passengers are not allowed to move to another seat at that point, and everything must be precisely correct."

Floorcontainer concept evaluation with flight attendants
By showing some renders & explaning the concept, some feedback was gathered for this concept.

"How do you perform the lost and found check with this system?"

"It must be very intuitive to use and extremely strong."

"How does the concept work if you're sitting next to someone you don't know? is it still comfortable?"

"What about the windows and emergency exits that must be at the same height as the floor?"

"What about oxygen masks? If they come down from the ceiling, they'll probably dangle too much."

"I hate it when the designer uses another kind of close in the galley, especially if you can not see it, you are not used to it."

Figure 50: Wardrobe in KLM cabin, used for odd-sized or important cabin luggage

Key insights

Bagage & storage:
- Some pieces have irregular shapes or need special care.
- Passengers put bags that are to heavy in the overhead bins.
- Passengers frequently leave items behind in seat pockets.
- Bags are often slightly too large for the cabin.

Seating & comfort
- Passengers prefer putting their feet up.
- The seating must be vandal-proof.

Toilets & cleaning
- Toilets are small, creating queues and poor hygiene.
- Passengers use toilets for changing clothes and putting on make-up.

Inclusivity & safety
- Visually and physically impaired passengers need support.
- Mobility aid storage is required.
- Safety equipment access must remain clear.

Climate & durability
- Passengers want individual air and light control.
- The 787's cabin climate is appreciated.

Maintenance & durability
- Cabin components experience high wear.
- Fast cleaning and part replacement is essential.

General
- The cabin feels cramped and impersonal.
- Use standard components the cabin crew knows.

3.5 Interviews

3.5.1 Cabin Crew

Floorcontainer concept

- The system must be intuitive and vandal-proof.
- It is a problem if the aircraft can not fly because of a stuck hatch.
- Sharing space with strangers is a comfort concern.
- Windows and exits must align with new floor levels.
- Oxygen masks might hang too low from the ceiling. Hard to reach.
- Crew must still be able to assist passengers with luggage.

3.6 Design language analysis

3.6.1 Electric Vehicles

With the rise of electric vehicles, a new standard in mobility design has emerged, influencing design language, passenger expectations, and associations with modern transport. To design an interior for an electric aircraft, the design language of electric vehicles is explored (figure 51). However, little scientific research exists on the coherence of design language in electric vehicles. Therefore, relationships between electric vehicle design languages have been explored, and a survey is conducted.

Design language

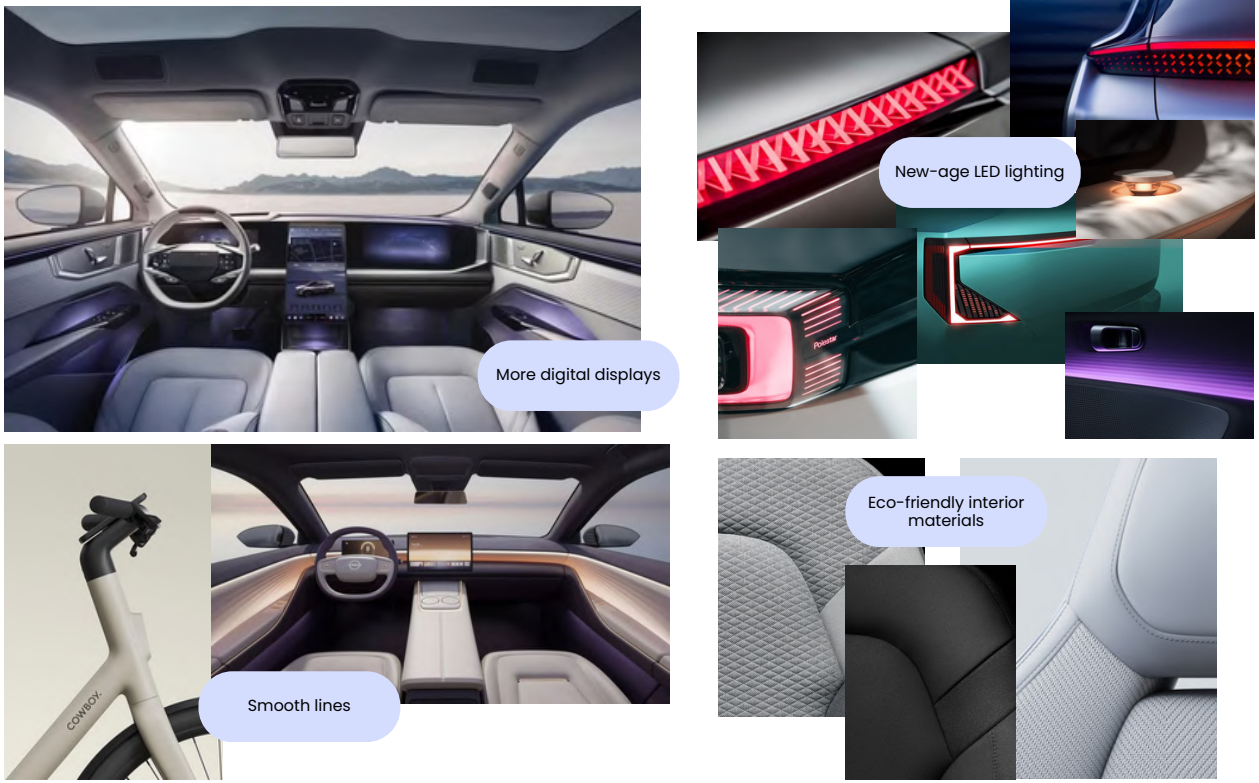


Figure 51: Results of EV design language analysis

Associations with electric vehicles

An online survey was conducted among 20 participants to explore their initial thoughts regarding electric vehicles. Each participant was asked to provide a maximum of three keywords, and the results are shown in figure 52. Notably, 23% of the responses (11 out of 47) focused on the design of the vehicles, suggesting that their visual appearance is a defining characteristic.

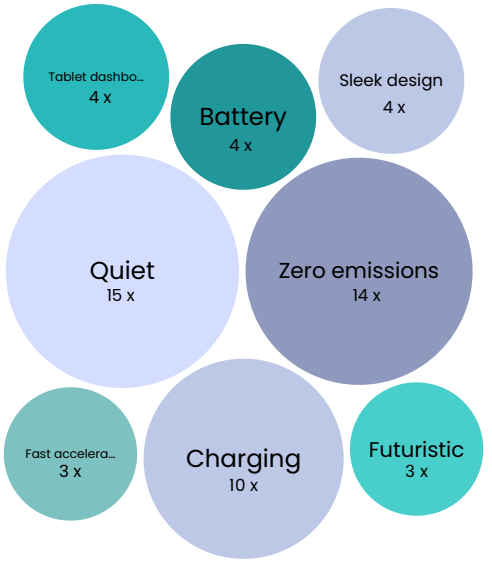


Figure 52: Results of the questionnaire on associations with electric vehicles among 20 participants

Key insights:

- Research on electric aircraft design is limited.
- EVs provide the blueprint: digital displays, smooth lines, green materials, and spacious, LED-lit interiors.

Chapter 4

Define

4.1 Personas 2025

To ensure that a crucial stakeholder, the passenger, is not overlooked during the design process, it can be helpful to give them one or more faces by creating personas. “Personas have the potential to help us achieve the adage fundamental to user-centered design: ‘Know the user, for she is not you’”(Miaskiewicz & Kozar, 2011). The five personas below are based on the ***Key Insights*** of the survey (see chapter 3.4) and therefore represent travelers on short-haul flights in 2025 (figure 53).

	 **Mateo** The efficient Business traveller	 **Sofia** The social holiday traveller	 **John** The comfort seaker	 **Liam** The practical low-cost traveller	 **Aisha** The Quiet Comfort Seeker
Information	35-45 years old Male 190-199 cm Consultant	25-35 years old Female 170-179 cm Communication professional	65+ years old Male 180-189 cm Retired	18-24 years old Male 180-189 cm Student	45-55 years old Female 170-179 cm Teacher
Trip type	Business meeting (day trip)	Citytrip with partner	Family visit	Weekend trip with friends	Relaxing solo trip
Seat pre-ference	Aisle - quick entry/exit, access to luggage	Window - peace and view	Aisle - freedom of movement and toilet access	No preference	Window - silence and privacy
Bagg-age	1 laptop bag/slim backpack	1 carry-on suitcase & 1 small item 1 shared checked-in suitcase	1 small item & walking stick 1 checked-in suitcase	1 backpack (little oversized)	1 small item & neck pillow 1 checked-in suitcase
Behaviour	• Board late, uses overhead compartment directly above seat • Works on laptop, wants peace and a clear overview • Minimalistic, goal-oriented, not very tolerant for hassle	• Arrives on time, calm and organized • Attaches great importance to cleanliness and atmosphere • Avoids physical contact with surfaces	• Calm, seeks balance and support • Wants a stable, comfortable environment	• Does everything quickly, follows others • Travels light, few demands	• Reads or listens with noise cancellation • Avoids interaction and physical contact
Preferences & pain points	👍 Speed, overview, space, peace 👎 Waiting for others, slow or unclear mechanisms	👍 Hygiene, visual clarity, personal space 👎 Unhygienic surfaces, strangers too close	👍 Sturdiness, safety, legroom 👎 Narrow seats, cold air, difficult controls	👍 Speed, simplicity, robustness 👎 Fragile parts, waiting for others	👍 Acoustic tranquility, visual simplicity, comfort 👎 Noise, cold air, disturbing mechanical noises
Design implication	Intuïtive, immediately, understandable interior with quick, clear acces. Floor container: opens without bending down, smooth, logical.	Hygienic design, light colors, smooth surfaces. Floor container: clean appearance, low-contact operation	Ergonomic, stable construction with rounded shapes and calm colors. Floor container: non-slip, stable, no tripping hazard.	Robust, foolproof design that can withstand hasty use. Floor container: one sturdy lever or push mechanism with click feedback.	Soft materials, soundproofuing, visually calming. Floor container: silent (soft-close) operation, matte colors.
Quotes	**“I just want to get off the plane quickly and acces my bag easily.”**	**“Too many people in a small space, I find that annoying.”**	**“Is it often rather cold on board.”**	**“Less claustrophobic and more legroom.”**	**“Little noise from other passengers - very important.”**

Figure 53: Personas 2025

4.2 Passenger experience - personas 2025

By utilizing the personas derived from the survey, a passenger journey was developed in which each persona encounters specific pain points (see figure 54). This approach visualizes user frustrations and provides deeper insight into the diverse experiences of different users. Consequently, potential solutions for these issues can be identified and addressed more effectively.

Figure 54: Passenger experience - current aircraft

4.3 Personas 2035-2065

The ***Key Insights*** of chapter 3.2 (trend & development analysis) and personas of 2025 are translated into personas that represent Elysian's passengers in the future (see figure 55) These can be used to design an interior that fits the period 2035-2065 and to evaluate the final solution.

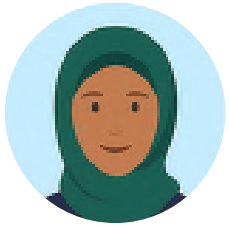
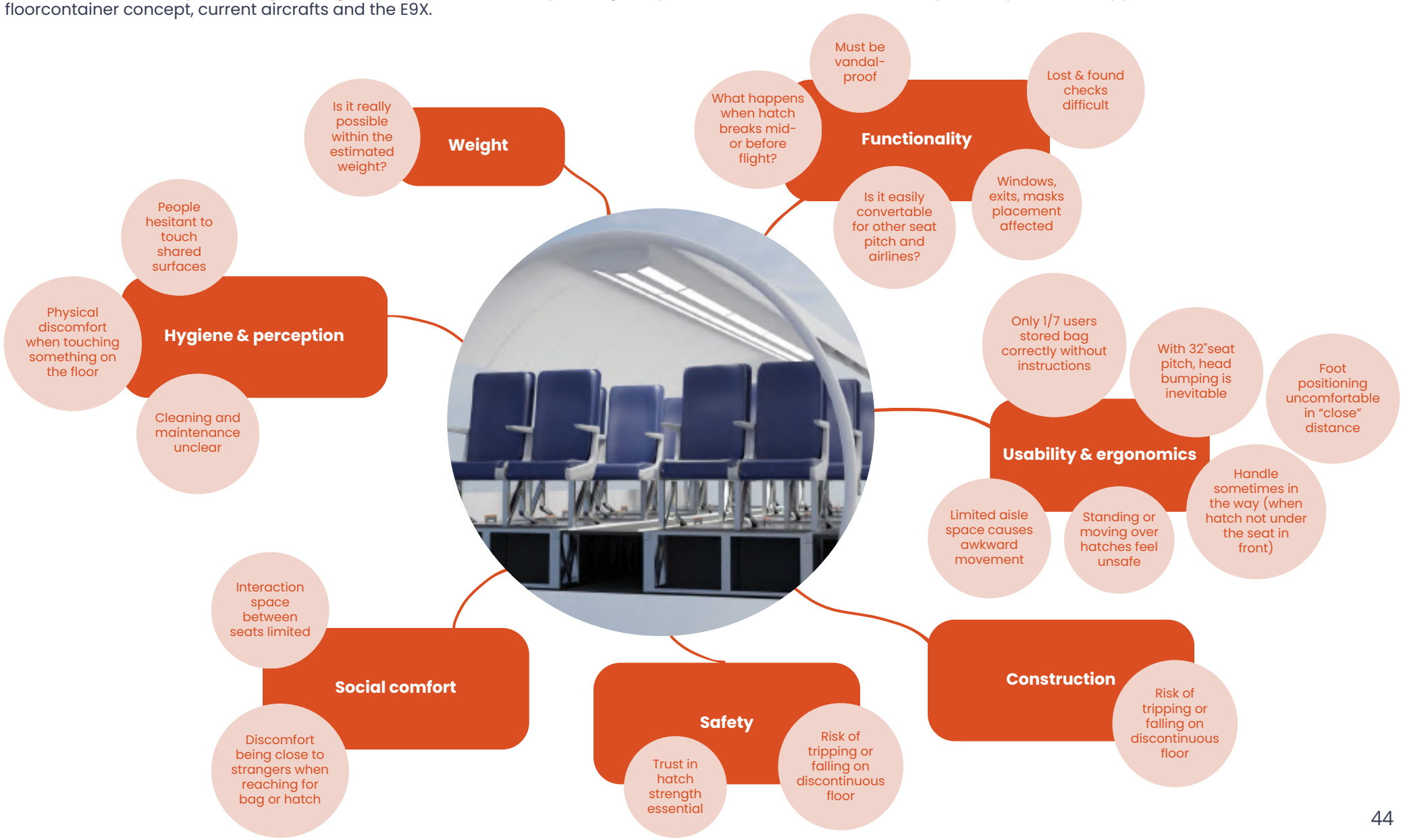
	 **Millie** The Business traveller	 **Grace** The Independent senior	 **Kai** The family-centric parent	 **Amira** The Sustainability-Minded Explorer	 **Elias** The space & comfort seaker
Information	35-45 years old Female 170-179 cm Tech strategy director	75-85 years old Female 160-169 cm Retired nurse	35-45 years old Male 180-189 cm Teacher	25-35 years old Female 170-179 cm Student sustainability	45-55 years old Male 180-189 cm Store manager
Trip type	Short business trip + remote working en route	Visit to children living abroad	Family holiday	Solo trip	Weekend trip with girlfriend
Seat pre-ference	Window - focus & privacy	Window - peace and view	Aisle - freedom of movement and toilet acces	No preference	Aisle - more space
Bagg-age	1 small item + small suitcase	1 small item + walking stick 1 checked-in suitcase	2 children's backpacks 1 checked-in suitcase	1 backpack (little oversized)	1 cabin suitcase 1 small item
Behaviour	• Boards late • Hates waiting • Immediately sets up her laptop • Compares efficiency to high-speed rail	• Arrives on time • Needs stability when walking and seating • Loves to have a chat with her neighbour	• Prepares kids' items, seeks calm boarding, needs visibility and order. • Is busy with the kids during the flight	• Chooses the greenest option • Avoids unnecessary waste • Reads a book during flight	• Boards early, is a bit nervous, because he is obese and doesn't fit in a normal seat • Seeks space
Preferences & pain points	👍 Strong connectivity, good task lighting, charging ports. 👎 Dislikes cluttered storage, noise and visual chaos	👍 Wide aisles, stable handholds, warm cabin climate, calm light 👎 Unclear seat controls, low visibility	👍 Child-friendly features, wipeable surfaces, intuitive storage. 👎 Dislikes tight aisles and overstimulation. Needs space for children's movement.	👍 Visible sustainable materials, modular parts and low noise. 👎 Greenwashing and unclear information. Prefers minimalistic interiors.	👍 Wider seating, adjustable armrests, more legroom. 👎 Dislikes cramped cabins and rigid seat geometry
Design implication	Work-friendly seating, intuitive storage, quiet zones, strong power integration. Clean, professional visual design & privacy	Highly readable icons, stable surfaces, warm ambient light, easy-entry storage, non-slip flooring, comfortable lumbar support.	Kid-friendly details, soft-close mechanisms, hygienic surfaces.	Circular materials, transparent sustainability information, soft acoustics, modular components.	Wider seat modules, space-efficient layout, supportive materials. Clear pathways.
Quotes	**"If I can't work comfortably, I would have taken the train."**	**"I just want to feel safe and steady while moving around."**	**"If the kids enjoy the flight, the whole trip becomes easier."**	**"I want to see the sustainability — not just read it."**	**"I'll choose the airline that gives me real space — just like the train does."**

Figure 55: Personas 2035-2065

4.4 Key insights

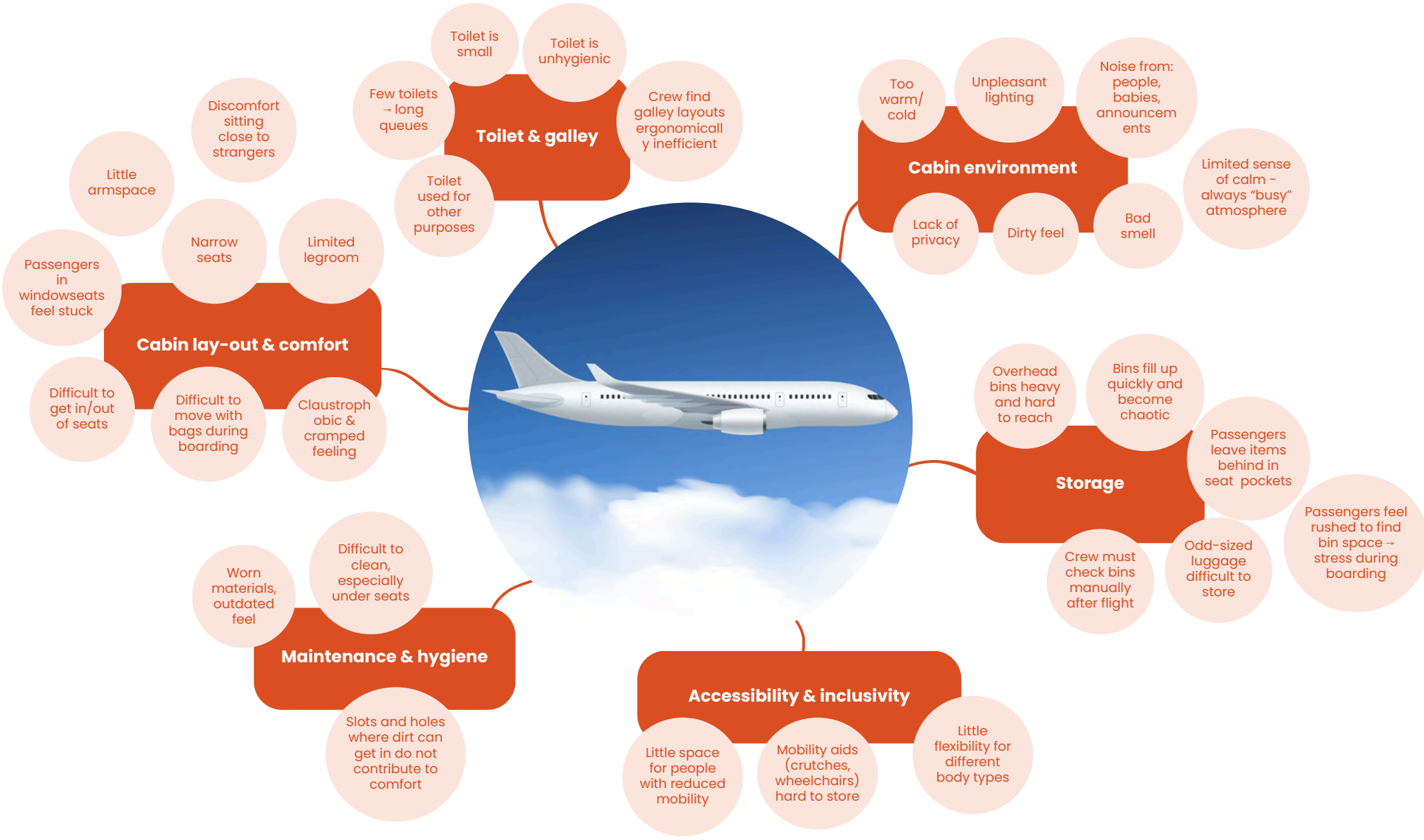
4.4.1 Floorcontainer concept

From the Discover chapter, all ***Key Findings*** that may influence the passenger experience are summarized in three parts: improvement opportunities within the floorcontainer concept, current aircrafts and the E9X.



4.4 Key insights

4.4.2 Current aircrafts



4.4 Key insights

4.4.3 E9X Floorplan

4.5 Desirability, Feasability and Viability

From the ***Key Insights*** drawn from chapter 3 (discover), a list can be created with points of interest in three categories: Desirability (a product that people want or need), Feasability (a product that can be created with new or existing technology), Viability (a product that will be profitable) (Vinney, 2023). This list is later used to evaluate ideas and ultimately select a concept.

Desirability

This aspect prioritizes the **passenger experience** and **cabin crew functionality**. It focuses on creating a comfortable environment for passengers, while ensuring that the design supports easy operation and maintenance for cabin crew.

Passenger comfort
- Seats wider then 17 inch
- Pleasant aesthetics
- Plenty of legroom

Passenger preferences
- Privacy
- Sustainable materials
- Luxury
- Amount of luggage allowed

Cabin crew
- Clear layout
- Comfortable to work in

Feasability

Here, the focus is on the **practicality** of the design. It needs to be **certifiable** and fit within the aircraft's existing framework. The design must also respect **weight and space constraints** to ensure the aircraft's performance and safety.

Technical integration
- Is certifiable
- Integrates with aircraft's structure
- As lightweight as possible
- Space efficiency

Viability

For the design to be implemented, it must align with **airline operations** and be **cost-effective.** The solution must ensure long-term **profitability** and ease of integration into existing (future) systems, ensuring airlines are willing to adopt it.

Airline
- Quick turnaround time
- Multiple configuration options: *higher chance it fits the particular airline*
- Aligns with the current (or future) operations

Cost-effectiveness:
- Maximised passenger capacity
- Return on investment
- Easy cleaning
- Easy maintenance

Marketability:
- Potential for additional revenue
- Competitive edge

Aircraft leasing companies
- Quick reconfiguration

4.6 Design goal

> *Create a **compact**, **intuitive** and **inclusive** aircraft interior that enhances passenger **comfort** and crew **efficiency** on short-haul flights by rethinking how **personal space**, **luggage** and **interaction** coexist within limitied cabin dimensions.*

4.7 Design directions

Floorcontainer concept

1

Refined floorcontainer system

Optimize the existing floorcontainer concept to make it intuitive, ergonomic, and safe for everyday use.

2

Personal Reach & Ownership

Translate the idea of "personal, organized space" into a new storage or seating solution that enhances autonomy and privacy

3

Rethinking electric aviation

Rethink the cabin layout entirely to address diverse passenger needs and future constraints of electric aviation

New concept

4.8 Ideation

Through analysis and defining goals, various ideas were generated to renew the interior, making it better aligned with the needs and expectations of future users and stakeholders.

Methods
By applying different methods, ideas were generated. Combining key takeaways led to the initial concepts, and then a brainstorming session was held with a group of designers, as well as individuals completely outside the design world. During this session, sheets with how-tos (Van Boeijen Annemiek et al., 2013) were passed around, allowing everyone to add their thoughts for 2 minutes per sheet (see figure 56). The ideas were then clustered into three solution directions.

Based on feasibility, desirability, and viability, the most promising ideas were selected for further development into concepts

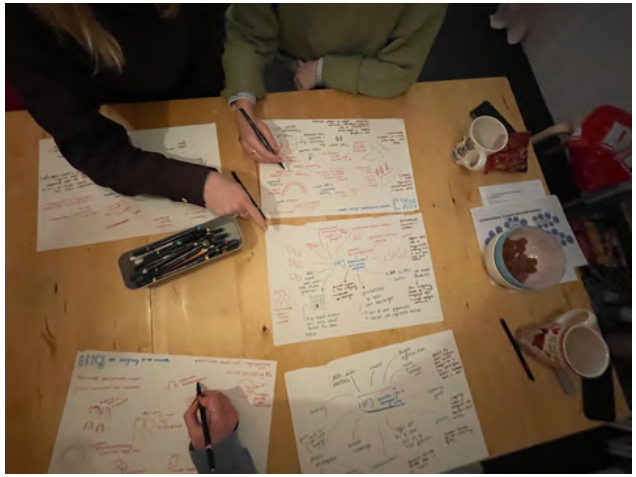


Figure 56: Group session for creating ideas with 'how-tos'

▸ **Ideation sketches can be found in Appendix F**

4.9 Concepts

4.9.1 Concept 1

Based on Key Insights

- Discomfort sitting close to strangers
- With 32"seat pitch, head bumping is inevitable
- Limited sense of calm - always "busy" atmosphere
- Narrow seats

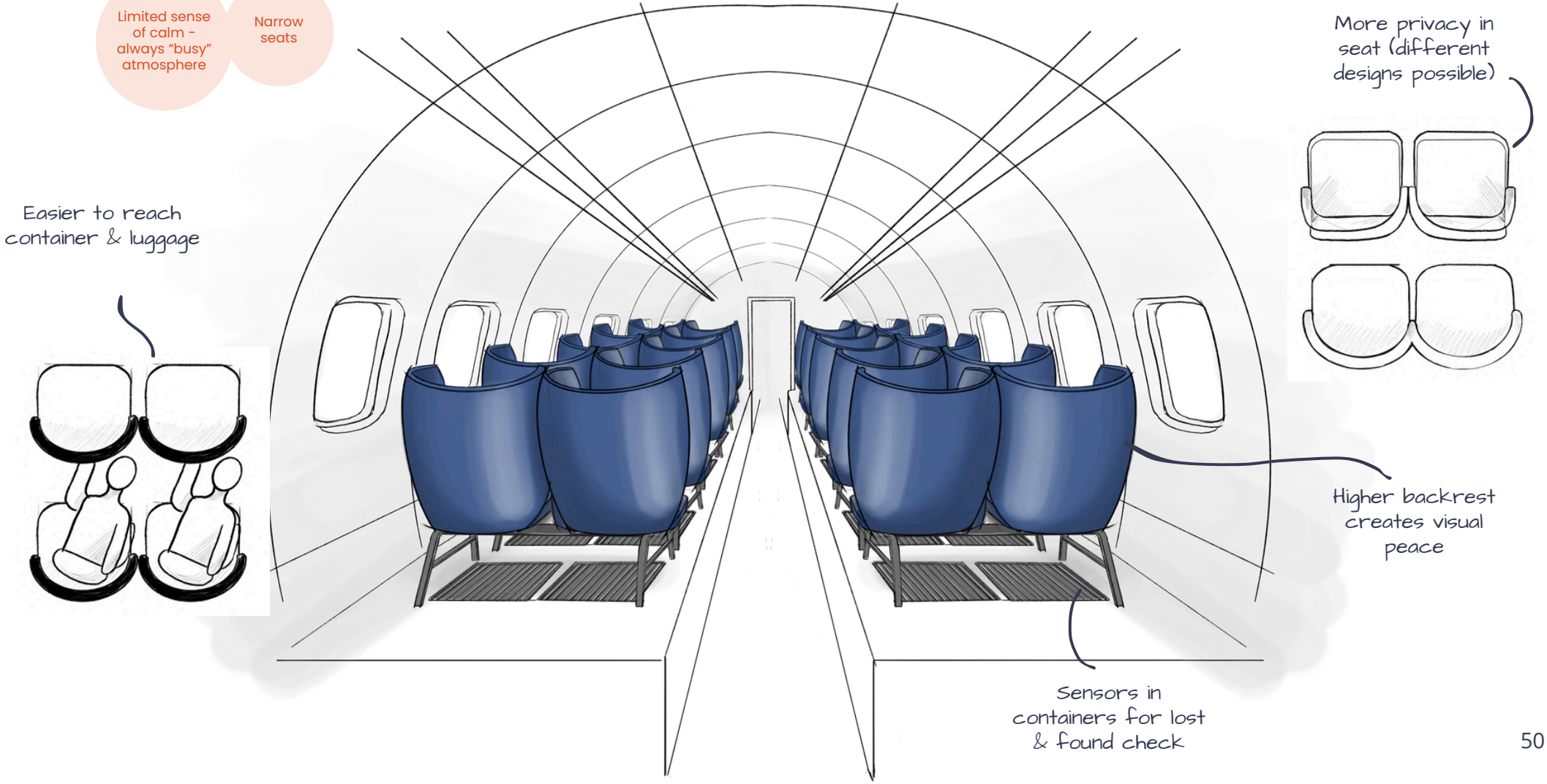
Design direction

1

Reinventing floorcontainer concept

This is a concept in which the curvature of the wider seats creates space for the head of the passenger while bending down toward the floor container.

Seat pitch: 35"
Seat width: 20"
Max seats: 80, =-10%



4.9 Concepts

4.9.2 Concept 2

Based on Key Insights

Bins fill up quickly and become chaotic

Is it really possible within the estimated weight? - Floorcontainer concept

Difficult to move with bags during boarding

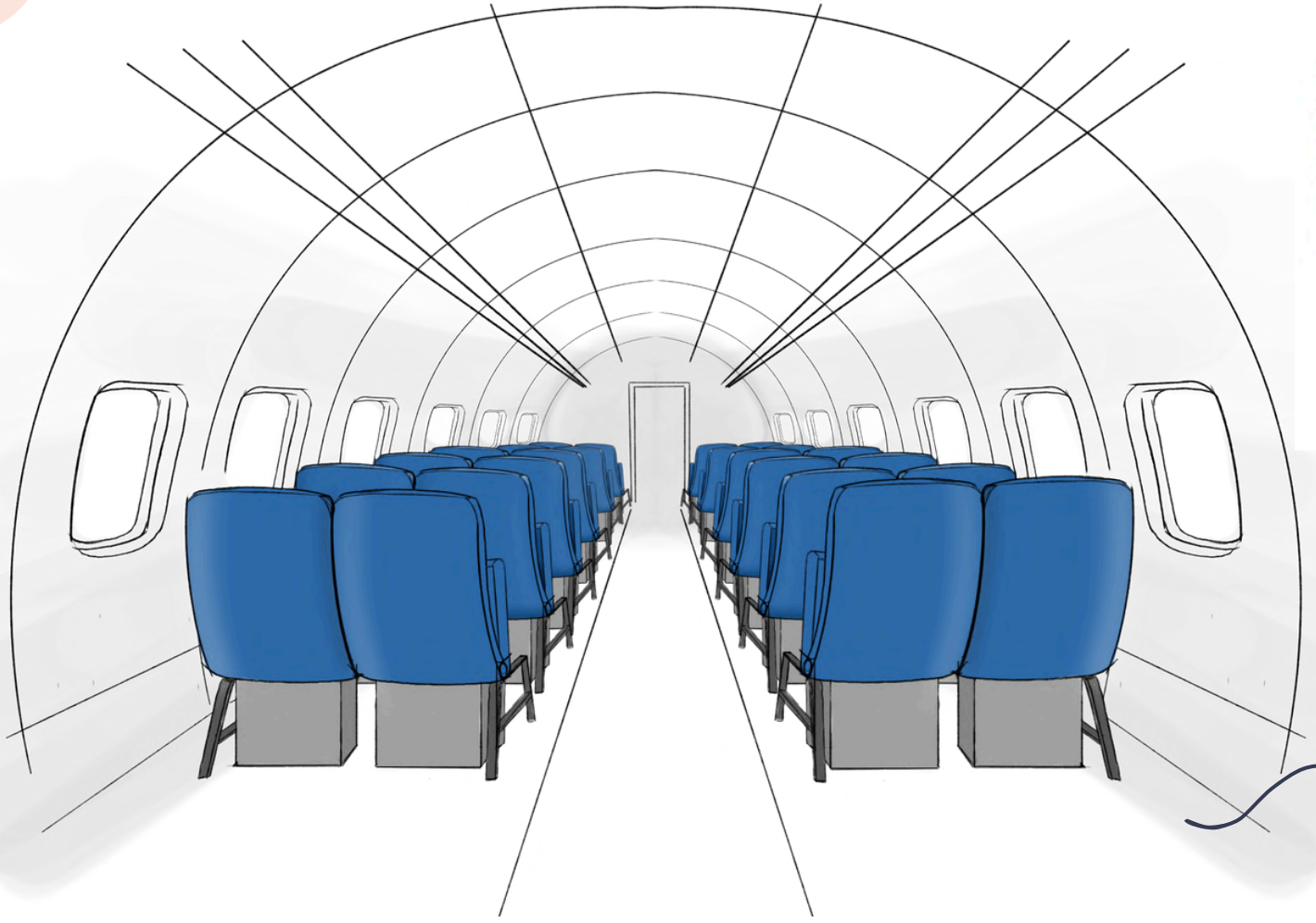
Design direction

2

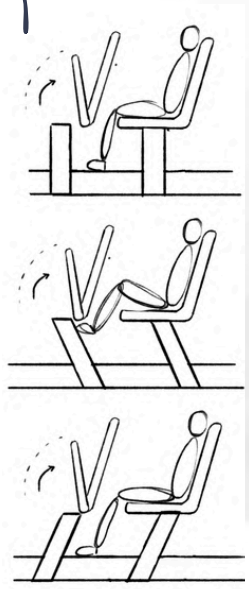
Seatcontainer

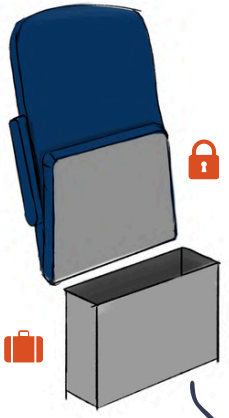
In this concept, folding seats are used, which simultaneously function as the locking mechanism for the console underneath.

Seat pitch: 32"
Seat width: 17"
Max seats: 88, =-0%



Different options for container angle





luggage 'locker' and lock with seat

Lower double floor needed than with the floorcontainer concept

4.9 Concepts

4.9.3 Concept 3

Based on Key Insights

Bins fill up quickly and become chaotic

Is it really possible within the estimated weight? - Floorcontainer concept

Discomfort sitting close to strangers

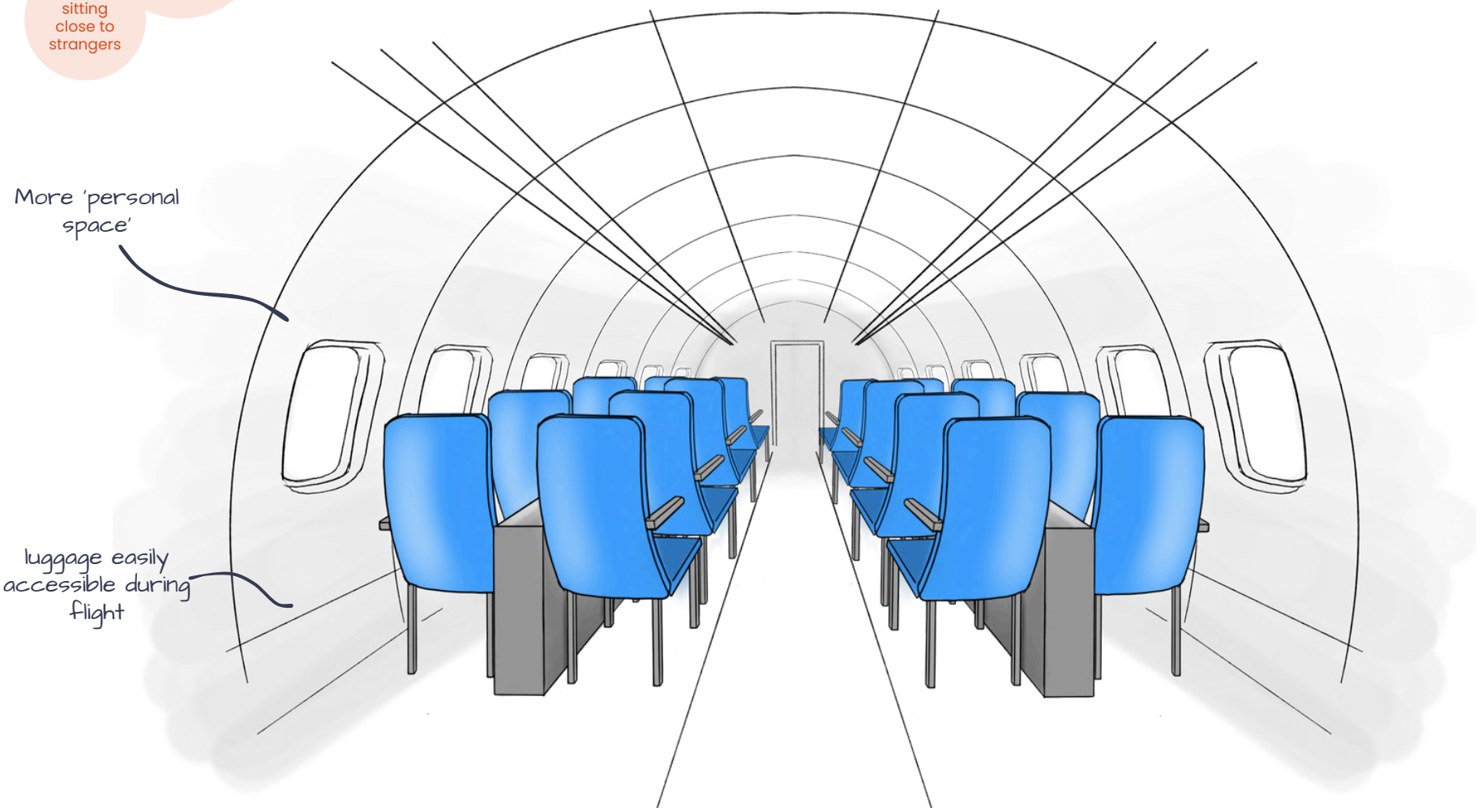
Design direction

2

Armrest console

Using the width of the fuselage to place carry-on luggage in between the seats.

Seat pitch: 32-36"
Seat width: 17"
Max seats: Not defined yet



4.9 Concepts

4.9.4 Strengths & Weaknesses

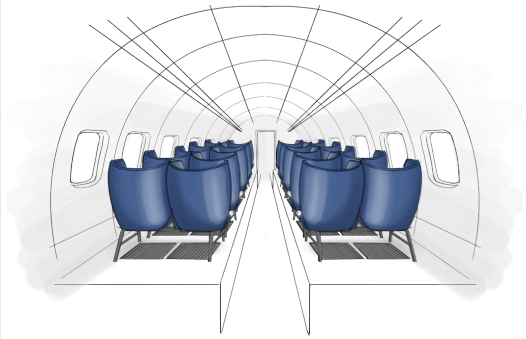
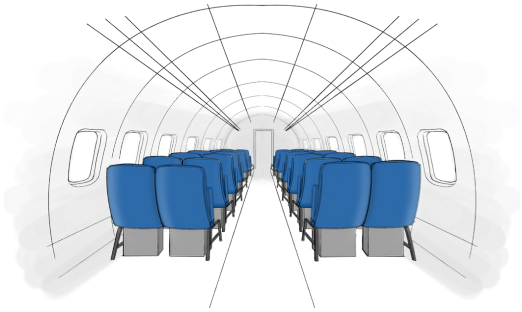
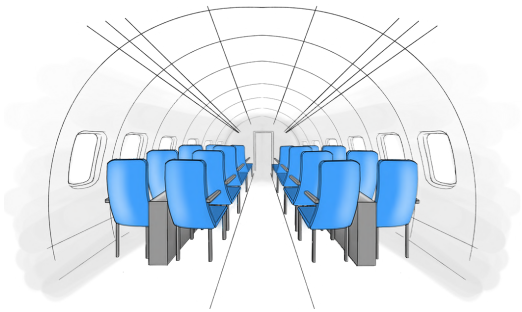
Name	**Concept 1** Reinventing floorcontainer	**Concept 2** Seatcontainer	**Concept 3** Armrest console
Drawing			
Unclear	• Exact weight • Oxygen mask & climate control placement • Certification feasibility • Hatch failure before take-off • Improves social comfort	• Weight reduction • Oxygen mask & climate control placement • Certification feasibility • Hatch failure before take-off	• Weight reduction (compared to overhead bins) • Spacious feel (in width) • Evacuation • People travelling together (wanting to sit together)
Opportunities	• Spacious feel • Passengers like belongings within reach • Wider seats improve comfort and reduce air rage • Faster boarding expected	• Double floor is lower • Better for reduced-mobility passengers • Spacious feel • Passengers like belongings within reach • Less disturbance from neighbour • Faster boarding expected • Ergonomically friendlier	• Weight can be reduced (compared to floorcontainer) • Spacious feel (in height) • More privacy • Faster boarding expected • Ergonomically friendlier • Fast adapting to other airline look and seatpitch
Challenges	• People with reduced mobility • Odd-sized cabin luggage • Hygiene • Changing for other airline/seatpitch	• Less legroom • Odd-sized cabin luggage	• Seatpitch & amount of luggage • Seats can not be very wide

Figure 57: Questions, Opportunities and challenges per concept

4.9 Concepts

4.9.5 Desirability, Feasability and Viability potential check

Name		 **Concept 1** Reinventing floorcontainer	 **Concept 2** Seatcontainer	 **Concept 3** Armrest console
Desirability	**Passenger comfort**			
	• Seats wider then 17 inch	++	+	-
	• Pleasant aesthetics	++	-	+-
	• Plenty of legroom	++	--	+-
	Passenger preferences			
	• Privacy	++	--	++
	• Sustainable materials	+	+	+
	• Luxury	+	-	+
	• Amount of luggage allowed	+	-	++
	Cabin crew			
	• Clear layout	+	++	+
	• Comfortable to work in	+	++	+
Feasability	**Technical integration**			
	• Is certifiable	+	+	+
	• Integrates with aircraft's structure	--	-	+-
	• As lightweight as possible	--	-	++
	• Space efficiency	+	++	+
Viability	**Airline**			
	• Quick turnaround time	++	++	++
	• Multiple configuration options: *higher chance it fits the particular airline*	--	--	++
	• Aligns with the current (or future) operations	+	+	+
	Cost-effectiveness:			
	• Maximised passenger capacity	--	++	+
	• Return on investment	-	+	+
	• Easy cleaning	-	-	-
	• Easy maintenance	-	+	+
	Marketability:			
	• Potential for additional revenue	-	-	-
	• Competitive edge	-	-	+
	Aircraft leasing companies			
	• Quick reconfiguration	--	--	++
Result		***D:*** *13/18* ***F:*** *-2/8* ***V:*** *-8/20*	***D:*** *-1/18* ***F:*** *1/8* ***V:*** *0/20*	***D:*** *7/18* ***F:*** *4/8* ***V:*** *11/20*

Figure 58: Desirability, Feasability and Viability analysis

Explanation:
In this concept evaluation matrix, concepts are evaluated per requirement using the following scores and corresponding values: ++ (2), + (1), +- (0), - (-1), and -- (-2). These values are ultimately summed up per categorie to determine which concept best aligns with the specified requirements in case of Desirability, Feasability and Viability

Concept 1 scores highest in terms of desirability, but lowest in Feasibility and Viability. Concept 2 scores low across all three categories, while Concept 3 scores highest in Feasibility and Viability. Furthermore, this concept also performs reasonably well on desirability.

Therefore, the decision has been made to **further develop Concept 3.**

To improve this concept's score, the following aspects could be addressed in the next phase: seat width, ease of cleaning, integration with the aircraft structure, appealing aesthetics, and legroom.

Chapter 5

Develop

5.1 Areas of development

5.1.1 Overview

The Feasibility, Viability, Desirability development wheel outlined the aspects to be researched in the chosen concept.

▸ **The Feasability, Desirability, Viability wheel is in Appendix G**

Figure 59 shows the overarching components that will be explored within the concept. These topics will also form the basis for the upcoming chapters.

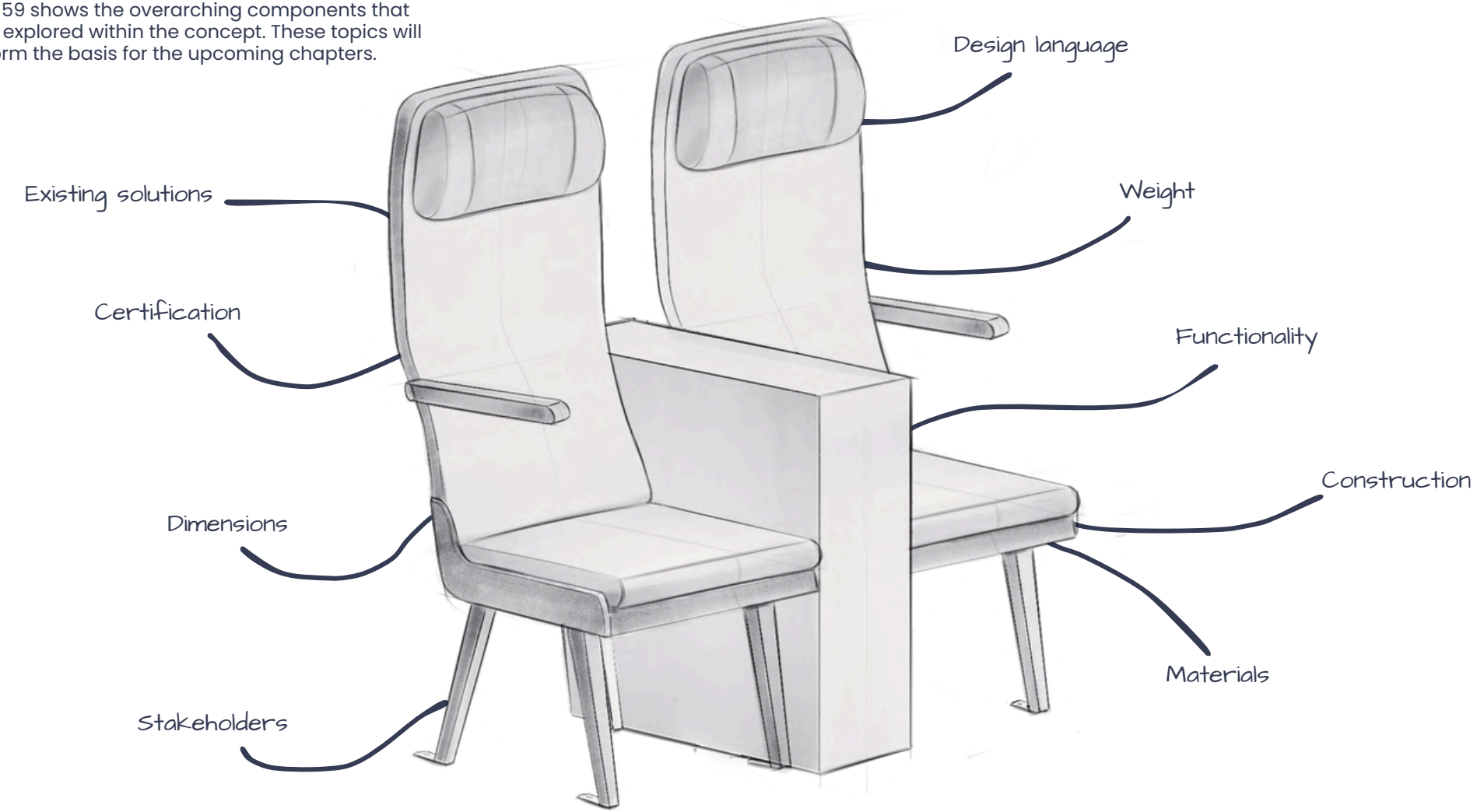


Figure 59: Summary of most important aspects of The Feasibility, Viability, Desirability development wheel

5.2 Existing solutions

5.2.1 Comparable concept review

Before further developing the concept, research is conducted to determine what already exists.

Business class middle console
In various business class cabins, a widened armrest is placed between two seats to provide additional privacy and a sense of luxury. These consoles often include fold-out tables, cup holders, remote control, magazine compartments, and storage space for small personal items (see figures 60 and 61).

Figure 60: A321 Fleet concept (Designworks, a BMW Group Company, 2025)

Figure 61: Businessclass in beOnd Airbus A319 (Hager, 2024)

Airbus A380
The Airbus A380 features two passenger decks. On the upper deck, the curvature of the fuselage is utilized by adding luggage compartments along the side to fill the space between the fuselage and the seat. In addition, this deck is still equipped with overhead bins. These bins are primarily intended for smaller personal items (see figure 63) and are not easily accessible for both passengers during the flight.

Figure 62: Upstairs economy class in A380 Luftansa

Figure 63: Inside A380 bin (Tour of Airbus A380 Upper Deck, 2025)

Figure 64: Bins in A380 British Airways (Michele, 2021)

5.2 Existing solutions

5.2.2 Patent review

In addition to existing products, patents may also cover concepts that have not been physically realized. These ideas are legally protected and therefore cannot simply be adopted. This chapter analyzes relevant patents that relate to the console concept: the integration of luggage within the cabin & seats and the creation of a middle console. Similarities, differences and potential constraints for the further development of the design are identified.

Airbus A380 storage bin
The layout of the Airbus A380 is protected by a pantent, in which the storage bin is also included. Claim 5 of this patent states:
“The fuselage segment of claim 1, wherein the first passenger region is arranged in an upper region of the fuselage segment and comprises lateral stowage compartments for accommodating cabin luggage, which stowage compartments are arranged between the outer passenger seats and a fuselage inner wall.” (Erben et al., 2011).

Based on the wording of claim 5, the proposed concept does not appear to fall within the scope of this patent, as it is positioned between two seats instead of along the fuselage wall.

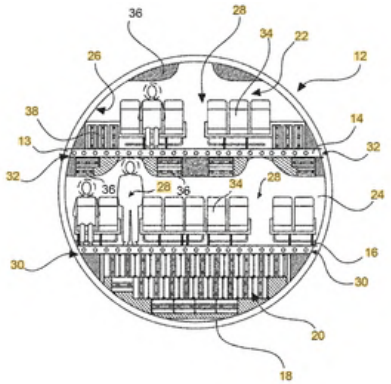


Figure 65: US20130306793A1 cross-section (Erben et al., 2011)

Aircraft luggage locker
This patent describes an aircraft seat with a pivoting seat cushion that mechanically closes an under-seat luggage locker. The proposed concept is considered to fall outside the scope of this patent.

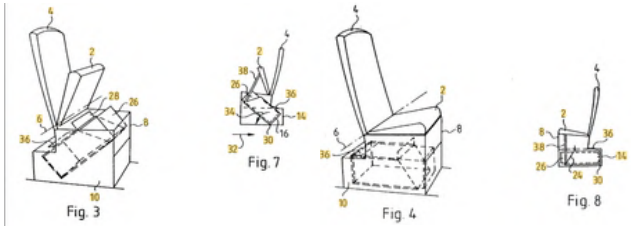


Figure 66: US20030222174A1 patent (Saint-Jalmes & Individual, 2002)

Passenger seat with a luggage receiving device
This patent describes a passenger seat with a foldable seat section that can lock luggage under the seat. The proposed concept is considered to fall outside the scope of this patent.

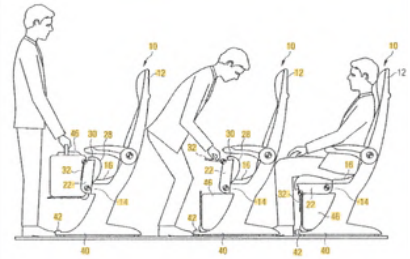


Figure 67: US8998313B2 patent side view (Reh et al., 2011)

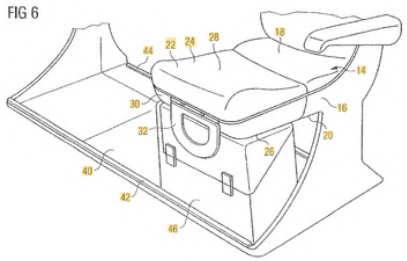


Figure 68: US8998313B2 patent close-up (Reh et al., 2011)

Aircraft seat cupholder console
If a seat in not in use, a seat cupholder can be installed in the middle seat. The proposed concept is considered to fall outside the scope of this patent.

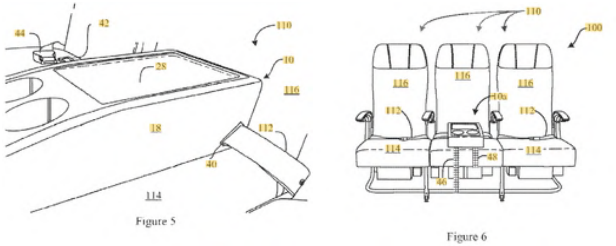


Figure 69: EP3259186B1 patent (Matthews et al., 2015)

Passenger seat with a luggage restraint
A passenger seat with a flexible under-seat luggage retention system that allows luggage to be inserted, secured, and flattened when not in use.

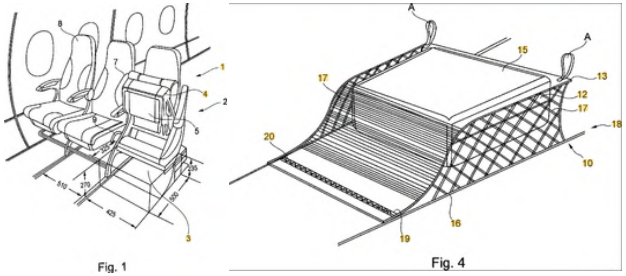


Figure 70: DE102006049002B4 patent (Schumacher et al., 2005)

Although products and concepts with similarities to the console concept were identified, **no solution was identified that replicates** the specific positioning, function, and integration of the proposed **console concept** between two passenger seats.

5.3 Functionality

5.3.1 Form of the luggage console

The arrangement of luggage between the seats requires further investigation in order to make a well-informed design decision. An overview of the considered options and their corresponding conclusion is presented below. Decisions were made based on low-key prototyping made of cardboard consolees.

▸ **The tests supporting the functionality conclusions can be found in Appendix H.**

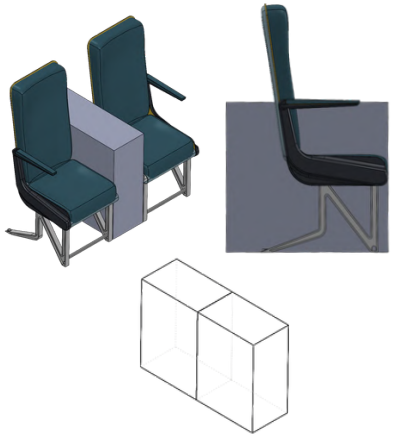
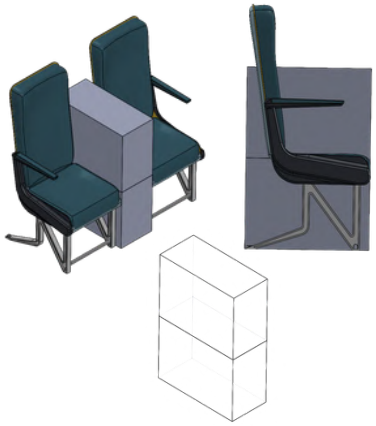
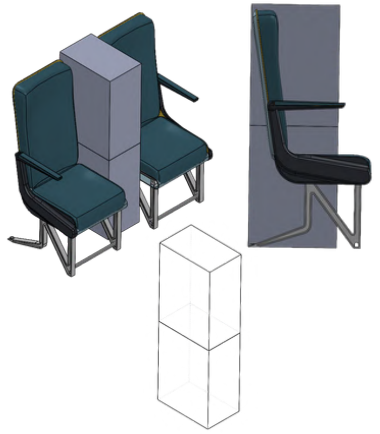
Name	T-Shape	In Line	Stacked	Closet
3D model with 2 x 25 x 40 x 55 cm suitcase				
Opportunities	• Protrudes less at the front or rear of the seat. • Appropriate dimensions relative to the armrest height.	• An additional 10 cm of space at the top allows for extra storage up to the armrest. • Allows for easy placement of the suitcase.	• Protrudes less at the front or rear of the seat	• Protrudes not at the front or rear of the seat • Allows for easy placement of the suitcase
Challenges	• Legroom is slightly reduced in width. • Placement of the lower suitcase is hard (especially with unfamilliar neighbour).	• Protudes beyond the seat length.	• Too high relative to the armrest, so additional centimeters in width are required to accomodate an armest. • Placement of the lower suitcase is hard.	• A barrier of this height between the seats is not desirable for a broad user group. • Additional centimeters in width are required to accomodate the armest.
Conclusion		Although multiple options were considered, the in-line arrangement of the luggage is selected for further development. This choice is based on its ergonomic advantages and dimensional compatibility with the aircraft seat. A remaining challenge is the impact on seat pitch.		

Figure 71: Overview decision making form of the luggage console

5.3 Functionality

5.3.2 Luggage loading access

It is important to analyse how luggage is placed inside the console, with consideration for ergonomics, logistics and dimensional requirements.

Name	Top	Back	Front
3D-model with 2 seats and console			
Opportunities	• The console closes automatically when pressure is applied to the armrest. • Improved access to luggage located at the back of the console.	• Ergonomically easy access to luggage.	• Ergonomically easy access to luggage.
Challenges	• Lifting the luggage is ergonomically less suitable.	• Additional space is required at the rear of the console to allow for a turning motion. • Closing the console is less intuitive. • One of the passengers has to wait for the other user of the console to acces the carry-on.	• Additional space is required at the rear of the console to allow for a turning motion. • Closing the console is less intuitive. • One of the passengers has to wait for the other user of the console to acces the carry-on.
Conclusion	To minimise space usage and related costs, top-loading access is chosen. While lifting the luggage is not ergonomically optimal, the reduced lifting height compared to overhead bins results in a clear ergonomic improvement.		

Figure 72: Overview decision making luggage loading access

5.3 Functionality

5.3.3 Luggage distribution

There are several ways in which passenger luggage can be distributed over the consoles. The allocation of luggage space influences usability, passenger interaction, and perceived ownership of the storage consoles.

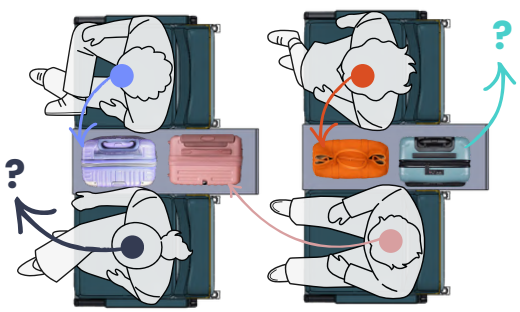
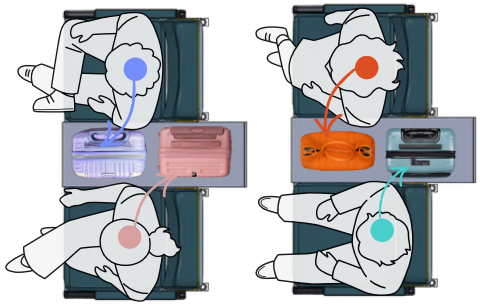
Name	Front & Back	Own row
Top view 2 seats & console, 35 inch seatpitch		
Opportunities	• Easy placement of luggage, with good visibility during loading.	• Clear and intuitive use for passengers.
Challenges	• The allocation logic is less intuitive and may be unclear to passengers. • A solution is required for passengers seated at the front and back of the aircraft, as no console place is available for these rows. • Accessing the console during the flight requires both passengers seated in front to be disturbed.	• The rear passenger needs to lean slightly over the seat in order to place the luggage inside the console.
Conclusion		To ensure the most intuitive use for passengers, the placement of luggage within the console of the passenger's own row is selected. This approach is easy to use, clear for all passengers and represents the least complex solution.

Figure 73: Overview decision making luggage distribution

5.3 Functionality

5.3.4 Opening the luggage console

The luggage console is filled with luggage from the top, within its own row; however, careful consideration must be given to how the luggage console is opened and closed.

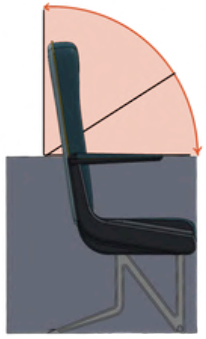
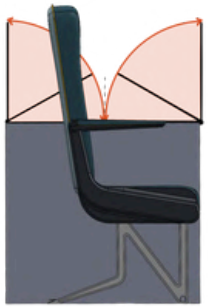
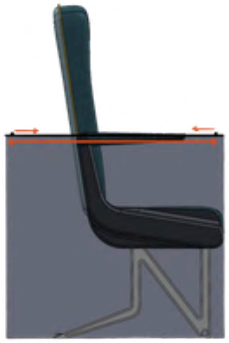
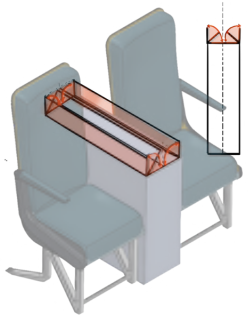
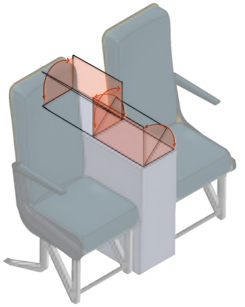
Name	Hinged Lid	¾ Hinged Lid	Split Lid	Sliding Lid	Toolconsole Lid	Personal Lid
Opening options for top loading						
Opportunities	• Automatic locking through load of resting arm, reducing the risk of the lid remaining open. • Requires only a single locking mechanism. • Intuitive use (car console)	• Automatic locking through load of resting arm, reducing the risk of the lid remaining open. • Requires only a single locking mechanism. • Space for extending the console towards the back • Intuitive use (car console)	• For each suitcase, one of the two lids can be opened.	• Creates a more premium feel • Less robust against misuse.	• Small radius of the lids.	• For each suitcase, one of the two lids can be opened. • Small radius of the lids.
Challenges	• The lid intrudes into the space of the passengers in the back row. • No available space for extending the console towards the back.	• Is it possible to place the second suitcase in the back without moving the one in front?	• One lid intrudes into the space of the passengers in the back row. • No available space for extending the console towards the back.	• Additional space is required to stor retracing components, reducing storage volume.	• Less intuitive use • Locking mechanism is harder.	• No available space for extending the console towards the back. • 2 locking mechanisms needed.
Conclusion		To ensure intuitive console use, the ¾ hinged lid is selected, as it enables backward console extension while minimising intrustion into the rear passenger space.				

Figure 74: Overview decision making for opening the luggage console

5.4 Dimensions

5.4.1 Ergonomics

In addition to luggage accommodation, it is essential that passengers are able to sit comfortably (see chapter 4.5)

Not all passengers have the same body dimensions. To ensure comfort for as many users as possible, the FAA Human Factors Design Standard provides guidelines for anthropometric considerations state:

“Anthropometric and biomechanics data shall be used in the design of systems, equipment (including personal protection equipment), clothing, workplaces, passageways, controls, access openings, and tools.” (Federal Aviation Administration, 2016)

“Using population extremes. Designers and human factors specialists shall draw upon the extremes of the larger male population distribution and the extremes of the smaller female population distributions to represent the upper and lower range values, respectively, to apply to anthropometric and biomechanics design problems.” (Federal Aviation Administration, 2016)

To visualise and apply these dimensions, the DINED anthropometric database is used. This database contains both global and Dutch anthropometric data. As the Dutch dataset is more extensive and represents larger body dimensions than the international average, the Dutch data is used as the design reference.

To comply with FAA guidelines, the design accounts for the P5-P95 user range, age: 20-60.

Legend:

International Dutch Estimation/ other source Measurement

? = data is not available in Dined

List of dimensions (all in mm)
7 = Head height
9 = Thigh clearance, sitting
14 = Popliteal height, sitting
15 = Shoulder sitting height
17 = Sitting height
21 = Breadth over the ellbow
22 = Shoulder breadth
23 = Head breadth
25 = Hip breadth, sitting
26 = Knee breadth
28 = Head depth
30 = Abdominal depth
32 = Popliteal depth
33 = Buttock-knee depth, sitting

P5 - measurements

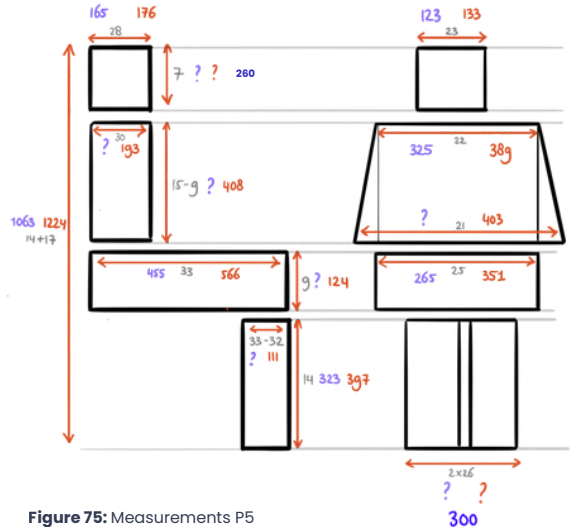


Figure 75: Measurements P5

P95 - measurements

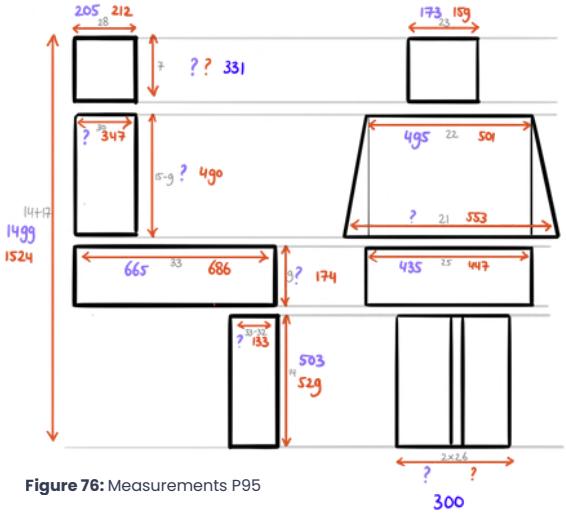


Figure 76: Measurements P95

3D-models of P5 & P95

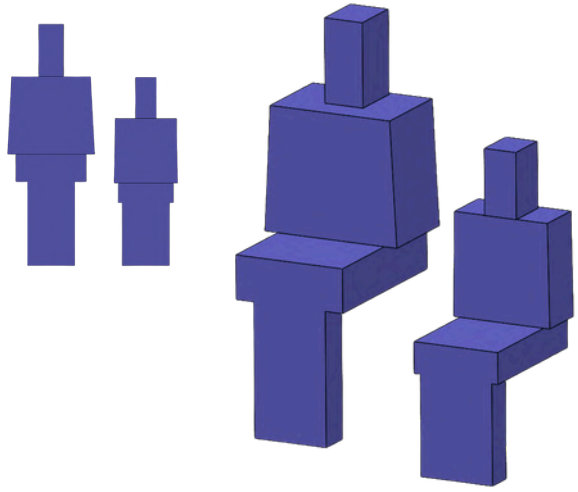


Figure 77: 3D-models P5 & P95

5.4 Dimensions

5.4.2 Aisle width

In C2-25.815 of EASA, regulations are defined regarding aircraft aisle width. Up to a height of 64 cm, the aisle width may not be less than 38 cm. Above the 64 cm, the minimum required aisle width increases to 51 cm.

Passenger seating capacity	Minimum passenger aisle width (cm (inches))	
	Less than 64 cm (25 inches) from floor	64 cm (25 inches) and more from floor
10 or less	30 (12)*	38 (15)
11 to 19	30 (12)	51 (20)
20 or more	38 (15)	51 (20)

Figure 78: Aisle width certification guidelines (EASA, 2023)

Confidential

Figure 79: Cross-section E9X with aisle restrictions

As a verification step and to ensure compatibility with the supply chain, the dimensions of the items required to roll through the aisle were assessed. This ensures that minimal adjustments are needed in other aspects of the system.

Figure 80: KLM airplane trolley (Driessen Aircraft Interior System - KLM Airplane Trolley, n.d.)

Figure 81: Wheelchair aisle aircraft (Wheelchair Aisle Aircraft, n.d.)

P95 measurements that are relevant (DINED):

- Hip breadth standing: 410 mm (international, 20-60) **› 64 cm, 510 mm**
- Elbow width: 553 mm **› 64 cm, 510 mm**
- Shoulder width: 501 mm **› 64 cm, 510 mm**
- Outside leg to outside leg: 300 mm **› 64 cm, 380 mm**

It can be concluded that the **cross-section dimensions are acceptable** (see figure 79, 80 and 81) for seating or walking and providing service in the aisle.

5.4 Dimensions

5.4.3 Seat design

To get an indication of the required dimensions of a comfortable seat, several seats are analyzed.

Market in 2025
Currently, there are various types of seats on the market, with Expliseat now offering one of the lightest versions.

Figure 82: Economy class seat Z85 (Safran, 2025)

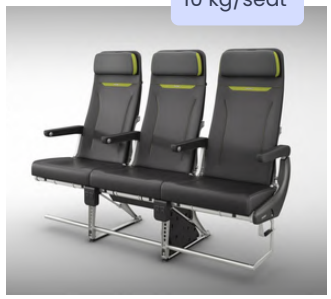
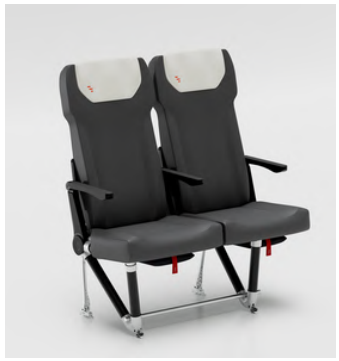


Figure 83: R2 economy class seat (R2 - RECARO Aircraft Seating, n.d.)

Lite
6 kg/seat
fixed recline

Prime
6.8 kg/seat
Recline 4.5" to 6"

Figure 84: Expliseat - TiSeat 2X (TiSeat 2X a – Expliseat, n.d.)



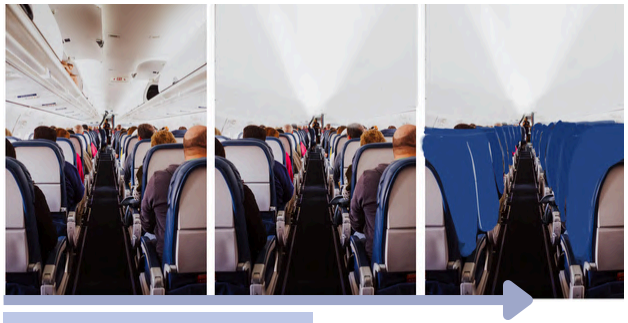
Lite
6kg/seat
Fixed recline

Prime
7.4 kg/seat
Recline 4.5" to 6"

Figure 85: Expliseat - TiSeat 2V (TiSeat 2V – Expliseat, n.d.)

A **fixed seat** is chosen to save weight. The survey showed that reclining the backrest is not a priority for passengers (chapter 3.4). For the rest of the seatback design, efforts are made to optimize comfort (see further in this chapter).

Dutch intercity direct train seat (backrest height)
Bringing calmness to the sightlines within concept 2 (see chapter 4.9.1 and figure 86) was highly appreciated by Elysian. Therefore, the seat height of the Dutch Intercity train is directly adopted as a reference.



More spacious & calm

Figure 86: Dimensions Dutch intercity direct seat NS

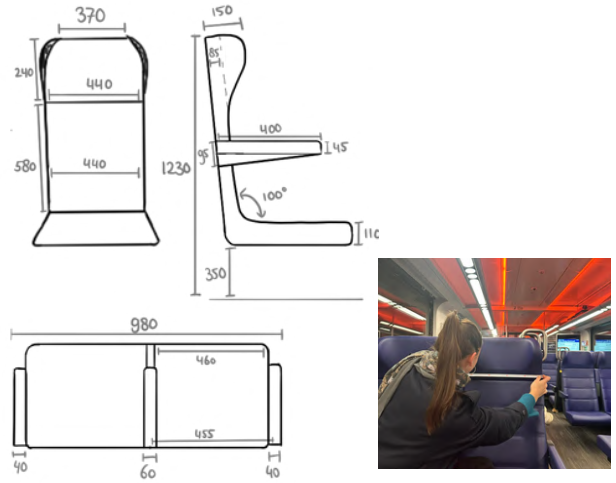


Figure 87: Dimensions Dutch intercity direct seat NS

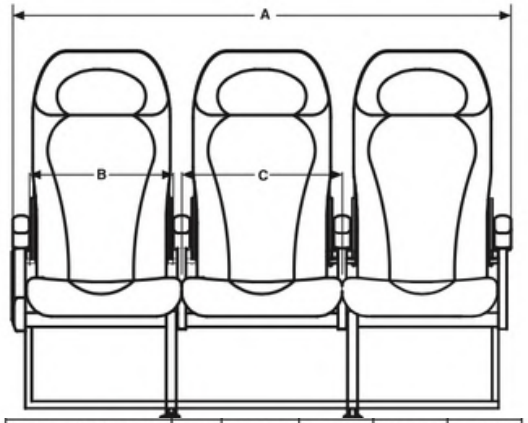
The upper edge of the seat **height** is therefore set at **1230 mm** in order to create a **spacious** feeling and **calm** sightline inside the cabin.

5.4 Dimensions

5.4.3 Seat design

Width
The width of the seat varies depending on the airline and aircraft type. In figure 88, it can be seen that the width of an individual seat can be measured in two different ways:
B = Space between the armrests → this one is used in this report.
C = Hip clearance

It is assumed that the armrest has a width between 4 and 6 cm (measured in a train and a Transavia aircraft).



PAX WIDTH	B	16.2"	17.2"	18.1"	19.0"
HIP CLEARANCE	C	18.2"	19.2"	20.1"	21.0"

Figure 88: Aircraft seat width dimensions (Those Confusing Aircraft Seat Measurements, Explained, 2015)

In figure 89, the seat widths of Transavia and KLM are shown. These measurements are based on Measurement B (space between the armrests).

KLM

On flights operated by KLM, the space in between armrests in Economy Class is as follows:

- Airbus A330: 46 cm
- Boeing 777: 43 cm
- Boeing 787-9: 43 cm
- Boeing 787-10: 41,5 cm
- Boeing 737: 43 cm
- Embraer 175 and 190: 45 cm

(KLM, n.d.)

transavia

Transavia: "The space between the armrests on our aircraft seats is 42 cm"
(Transavia, n.d.)

Figure 89: Airlines seat width (B)

Chapters 3.2.1, 3.3.1 and 3.4 demonstrated that a wider seat is preferred for several reasons, including improved comfort and increasing passenger body dimensions.

Ideally, **seat width** should be 18 inches, which equals **462.3 mm (B)**. **Minimum** seat width is **420 mm** (B).

Base for seat design - Rebel seat
A light, already certified seat will be used as the base for creating the seat for the E9X: the Rebel Airo aircraft seat, designed for the Flying-V (Liu et al., 2020). This seat is considered comfortable in terms of its dimensions but can be made even more comfortable with minor adjustments: (prevent touching neighbor's elbow & legs (console), hardness of the seat, backrest angle of the seat) (Liu et al., 2020).

▸ **Research about comfort of Rebel seat in Appendix I**

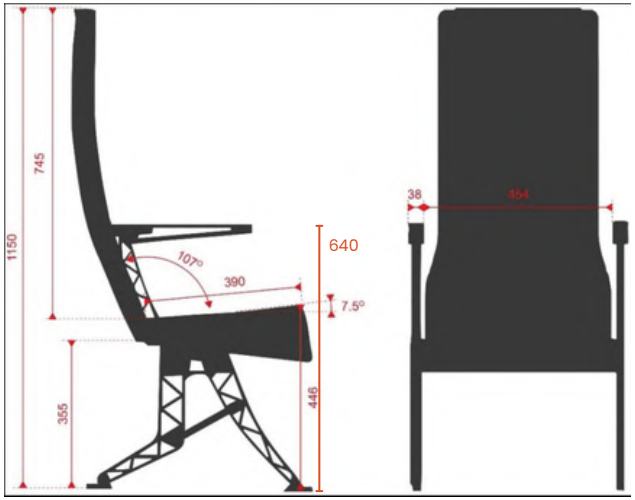


Figure 90: Dimensions of the Rebel Aero aircraft seat (Liu et al., 2020)

The dimensions of these aircraft seats are combined and checked against the ergonomic dimensions in chapter 5.4.5. Based on this, the height of the seat and the seat surface are determined.

5.4 Dimensions

5.4.3 Seat design

The seat surface height will be **446 mm** and the armrest height will be **650 mm.**

Back rest and seat

An option to create a lightweight seat is to make a seat contoured shell of composite which follows the human body closely, thereby reducing the need for thick foam (Hiemstra- Van Mastrigt, 2015).

The back contour from a study on developing comfortable passenger seats is used as a reference (see figure 91). This contour is traced and then forms the backrest of the seat (see figure 92).

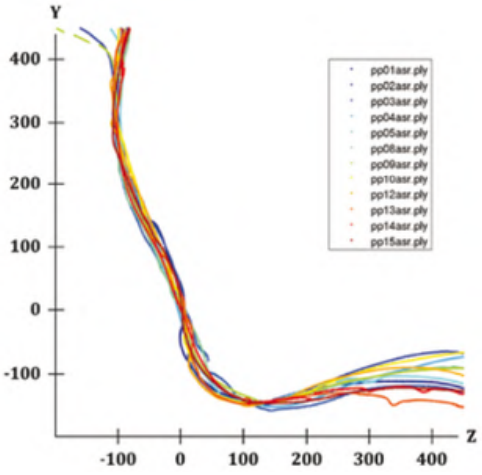


Figure 91: Research into the back contour in a seat (Hiemstra- Van Mastrigt, 2015)

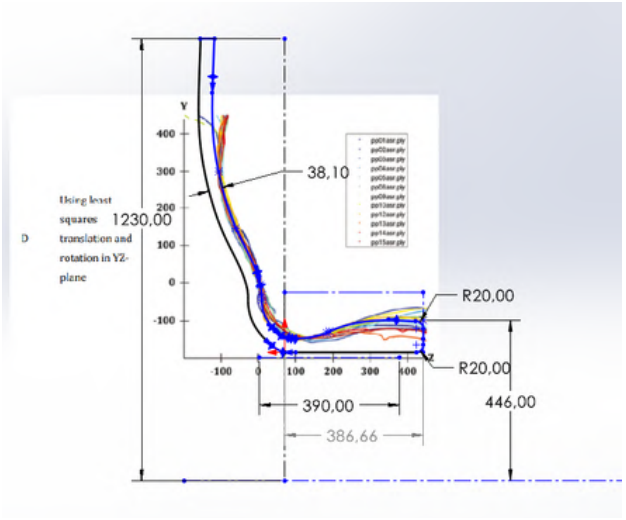


Figure 92: Back contour sketch in Solidworks

Ideal seat

All the desired dimensions have been combined to form how the seat would look most ideal with all the requirements (figure 93).

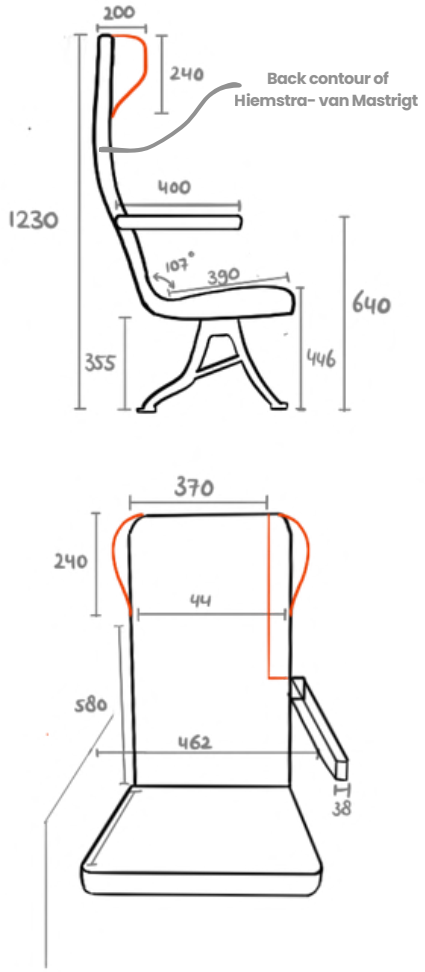


Figure 93: Ideal seat - combination of analysed seats

5.4 Dimensions

5.4.4 Luggage

Another important driver for the dimensions of the console concept is the size of the luggage it must accomodate.

Carry-on luggage dimensions - airlines
Airlines have defined limits for the carry-on luggage passengers are allowed to bring on board, as shown in figure 94. Since KLM and Transavia are currently involved in the Elysian project, their carry-on luggage dimensions are most important.

KLM	40 x 30 x 15 cm	€ 55 x 35 x 25 cm
transavia	40 x 30 x 20 cm	€ 55 x 40 x 25 cm
Lufthansa	40 x 30 x 15 cm	55 x 40 x 23 cm
RYANAIR	40 x 30 x 20 cm	€ 55 x 40 x 20 cm
TUI fly	40 x 30 x 20 cm	55 x 40 x 20 cm

€ = Pay extra for this piece of luggage on top of an economy ticket

Figure 94: Airlines carry-on luggage regulations

Ideally two 55 x 40 x 25 cm suitcases are stored inbetween the seats, but this has a huge impact on seat pitch & seat width.

It is important to create the right **balance** in the dimensions.

Dimensions in the future
As shown in figure 94, the dimensions for carry-on luggage are not globally standardized. The IATA (International Air Transport Association) aimed to make this clearer and easier for passengers with an initiative called “Cabin OK” (see chapter 3.2.2). This initiative introduced guidelines for carry-on bags to ensure that every passenger would be able to fit their luggage into the overhead bins (Ramakrishnan & MeenaR, 2015).

21.5 inches x 13.5 inches x 7.5 inches =
54.61 cm x 34.29 cm x 19.05 cm

Part of the initiative collaborating with luggage manufacturers to certify compliant luggage (see figure 95.

Figure 95: Cabin OK initiative (IATA ‘Cabin OK’ Bag Initiative Backfires, 2015)

The initiative was put on hold due to concerns (in particularly in North America) raised in the media and by key stakeholder (Aviation Week Network, 2025). However, given the intense interest in the Cabin OK program (Aviation Week Network, 2025) and given the fact that nearly 40 airlines intended to join, the introduction of an entirely new way of flying (the electric aircraft) presents the ideal opportunity to revive this initiative. Furthermore, according to Tom Windmuller, IATA Senior Vice President for Airport, Passenger, Cargo and Security (APCS), this initiative could lead to significant weight savings." (Aviation Week Network, 2025) Although it is clear that this is a concession, the decision to prioritize comfort leads to a smaller suitcase. Since Elysian expects many business travelers with shorter stays and fewer belongings, this concession is deemed acceptable, especially as it concerns shorter flights and fewer items passengers typically wish to bring (see chapter 3.4).

There is an interaction between suitcase dimensions and airline restrictions. The market is considered sufficiently large for initial implementation and is expected to adapt to the E9X restrictions. Collaboration with luggage manufacturers, similar to the Cabin OK initiative, is recommended (see Appendix J).

- **Research about available suitcases nowadays & influence of airline restrictions in Appendix J**

Including space for the construction, materials, extra function and to make it usable as an armrest, the console has the dimensions: **208 x 640 x 723 mm**

5.4 Dimensions

5.4.5 Combining console and seat

Fuselage cross-section and seat
The ideal seat, when combined with the console concept, does not fit into the fuselage of the E9X. Therefore, several adjustments are being made, while still considering comfort.

Confidential

Figure 96: Cross section original fuselage + ideal seats and console

Based on the fact that the minimum seat width is 454, the minimum enlargement of the fuselage is .

Confidential

Armrest & aisle
In figure 98, it can be seen that the seat does not fit in the given aisle constraints.

Confidential

Figure 98: Seat in aisle

This can be solved in an inventive way, as shown in figure 99. By cutting out the backrest, the seat fits entirely against the aisle. The seat base extends underneath for more hip clearance.

Confidential

Figure 99: Console seat set with aisle constraints (cut in backrest)

Space for shoulder & head
It can be seen that the P95 mannequin is positioned relatively close to the fuselage with its head and shoulders (see figure 100).

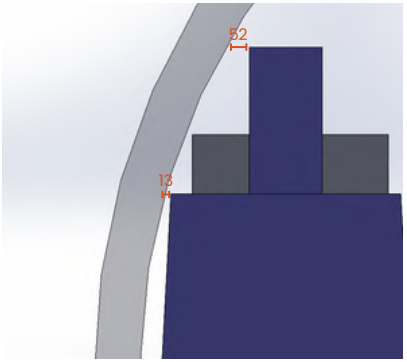


Figure 100: Dimensions seat to fuselage (without fillet in top) in mm, P95

Disclaimer: These are almost the widest and highest shoulders & head (P95). Any other shoulder and head that is narrower or lower will have more space due to the shape of the fuselage.

The placement of a seat in a medium-sized aircraft has been examined.

Figure 101: Dutch P76 in transavia Airbus A321neo (twin-jet) aircraft (in mm)

5.4 Dimensions

5.4.5 Combining console and seat

In the top section of a Dutch intercity train, there are also seats that are placed very close to the wall and ceiling (see figure 102).

Figure 102: Seat at the second floor a Dutch intercity train

In many aircrafts, the window provides more space in the fuselage wall.

Figure 103: Create more space by framing the windows (Hager, 2024b)

It can be concluded that the **distances** from the **fuselage** to the **seat** and the **P95 person** are **acceptable**.

Conclusion
By making trade-offs and implementing adjustments to the (not yet fully finalized) fuselage (see chapter 1.5), the design was optimized. The fuselage diameter will increase by The seat provides the same space between the armrests as the rebel seat and is close to the advise of airbus: 462.3 mm - 469.9 mm. The dimensions can be found in figure 104.

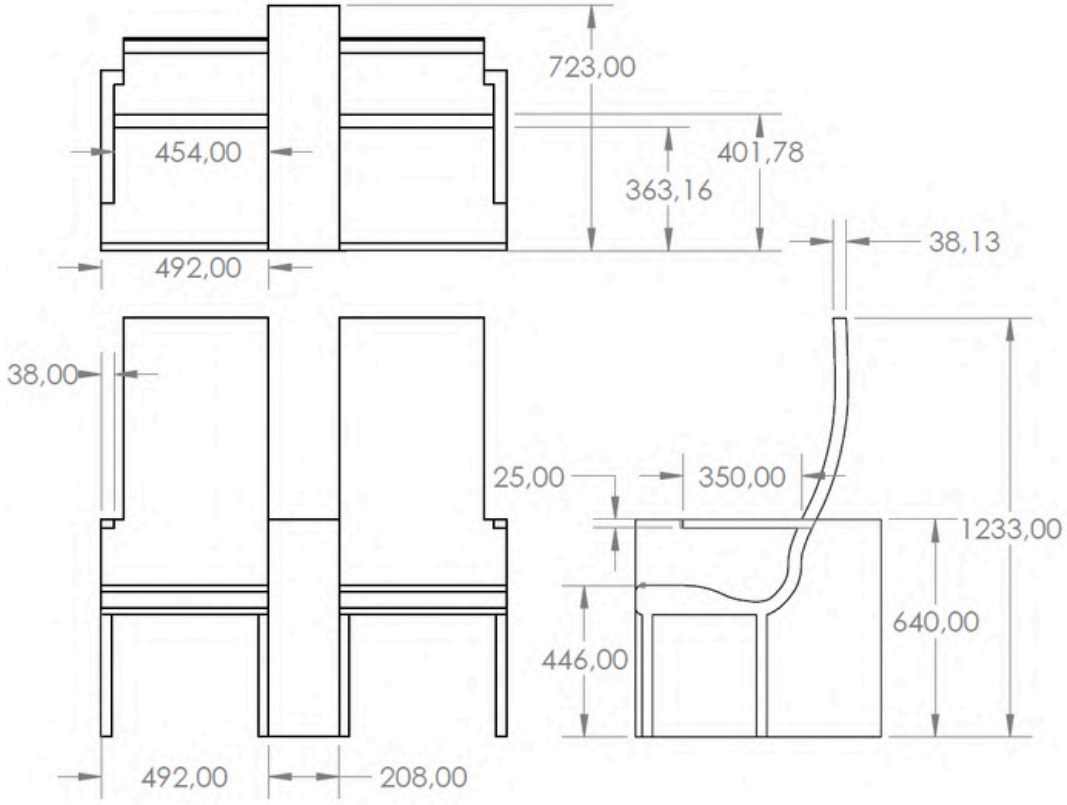


Figure 104: Conclusion dimensions seat & console

5.4 Dimensions

5.4.5 Combining console and seat

Figure 105 illustrates how two sets of seats and a console are positioned in a cross section of the fuselage, including the corresponding aisle constraints. Two mannequins, representing P95 and P5 percentiles, are placed in the configuration.

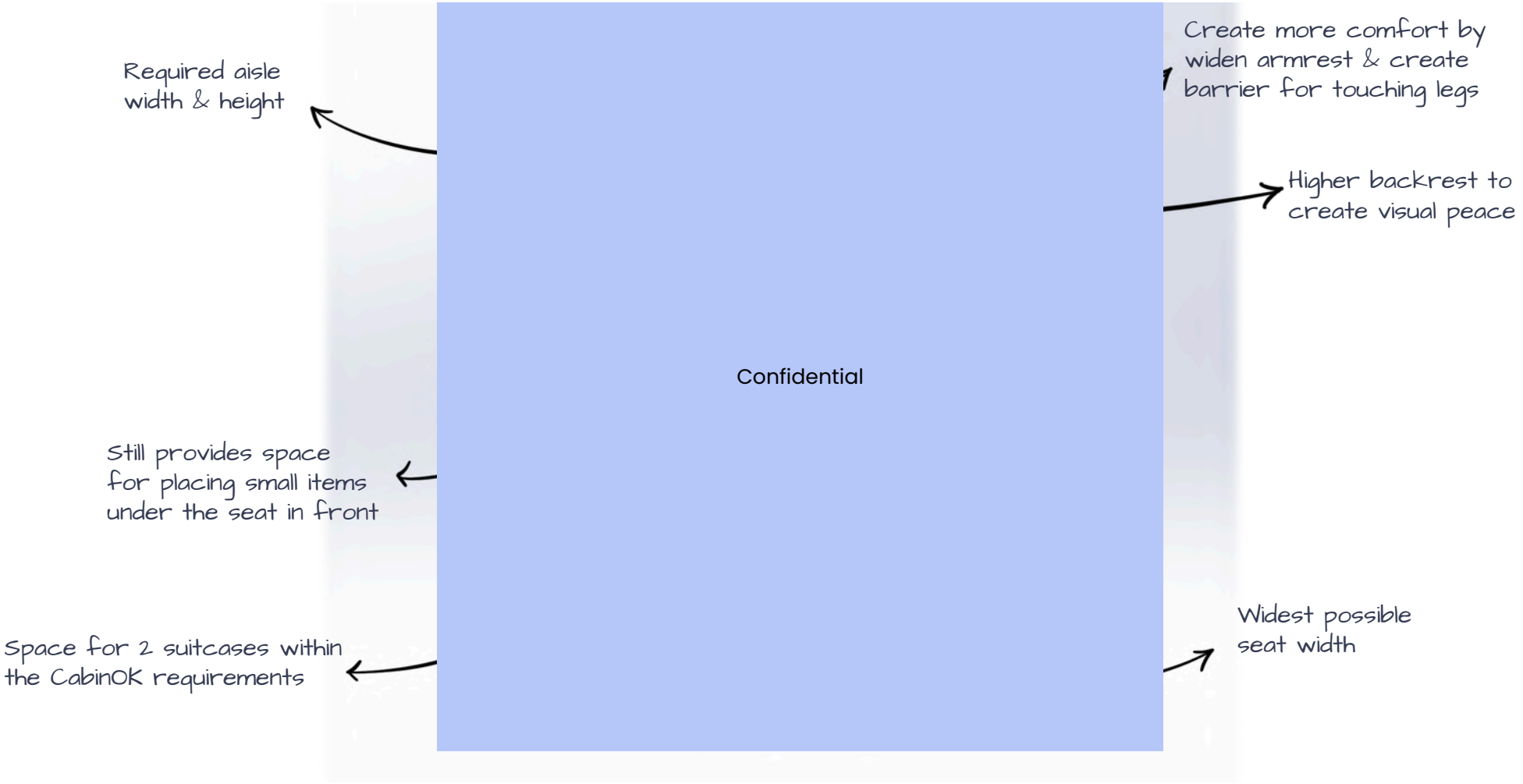


Figure 105: Cross-section of fuselage + with 4 seats and 2 consoles and two mannequins

5.4 Dimensions

5.4.6 Placement of console

Since the aircraft must be able to be evacuated within 90 seconds (see Chapter Certifications), it is important that each passenger can leave their seat during the flight. This is not only required for safety reasons, but also necessary for activities such as stretching legs or visiting the lavatory.

Due to the protruding part of the console, careful consideration must be given to the distance between the consoles in row.

Positioning of the console relative to the seats
The console can be positioned in several ways relative to the seat (see figure 106).

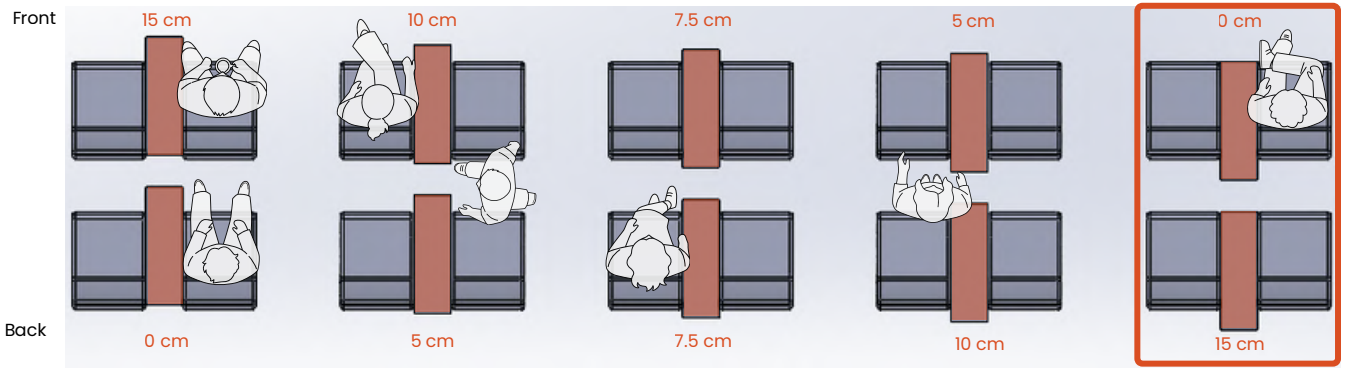


Figure 106: Distance from console to front or back of the seat, 35 inches seat pitch

Since entering and, in particular, exiting the seat is the most critical moment when making this decision, the results of the floor container concept test are analysed again.

When analysing the videos of the seven participants in the floor container concept study, it can be seen that each participant follows the line of the seat cushion with their lower legs when exiting the 'window seat' (see figure 107).

Figure 107: Test participants enter and exit the row of seats with their lower legs moving along the seat cushion.

Corners
It is important to round the corners as there is a high likelihood that passengers will pass by the console with clothing or body parts. This applies to both the front and back of the console.

To make getting out of the seat as natural as possible, the **front of the console** is **aligned with the line of the seat cushion**, allowing passengers to leave their seat by moving along the seat. It is important to add rounded corners to prevent injuries & damage.

5.4 Dimensions

5.4.7 Seat pitch

For entering and exiting the seat and taking into account that the aircraft must be evacuated within 90 seconds, seat pitch is an important factor within this concept. It must allow passengers to move from the window seat to the aisle between the consoles.

Guidelines
CS 25.813 states that "seat pitch must not obstruct evacuation" (EASA, 2023) but it does not specify exact dimensions for the space between seats.

CAP 747 does provide guidelines regarding the distance between seats: "The minimum distance between a seat and the seat or other fixed structure in front shall be 7 inches." (UK Civil Aviation Authority, n.d.) This equals **177.8 mm** (see figure 108).

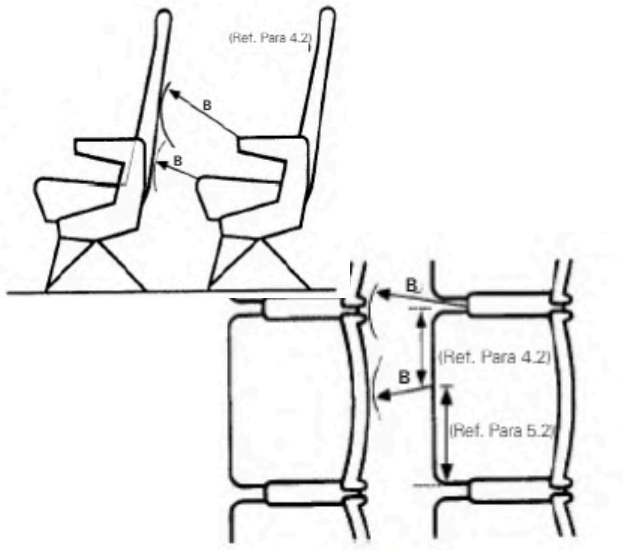


Figure 108: Guidelines for distance between a seat and the seat in front (UK Civil Aviation Authority, n.d.)

Test
To verify whether this distance is sufficient for exiting the seat (as a seat differs from a console), a test was conducted, in which cardboard mock-ups were used to represent the consoles.

Methods
This user research used direct observation, directed usability testing and a concluding survey and debriefing. This combination makes it possible to investigate subjective aspects of use.

The distance between the console was adjusted each time, and participants were asked to rank the comfort of entering and exiting the seat using the following scale:

1 = Impossible
2 = Difficult
3 = Manageable
4 = Easy
5 = Very comfortable

Participant demographics
The participants consisted of four participants, two men and two women, with heights ranging from 160-169 cm to 190-199 cm and shoe sizes differed from 37 to 45.

▸ **The user test form of this test is in Appendix X**

The test set-up can be found in figure 109.

Figure 109: Test passage between the consolees

The results showed that with a seat pitch of 34" and a corresponding clearance of 16.4 cm, all participants gave a score of 3 or higher. With a seat pitch of 35" and a corresponding clearance of 18.9 cm, half of the participants gave a 3 and the other half a 4.

Therefore, a minimum clearance of **164 mm is required**, but **189 mm is preferred** (also looking at the guidelines of CAP 747).

5.4 Dimensions

5.4.7 Seat pitch

Evacuation tests by Boeing
Although it is important that seat pitch does not negatively affect evacuation, Boeing tests indicate that seat pitch is not the limiting factor in evacuation performance (tests were conducted in a 3-3 configuration aircraft, but it can be assumed that a 2-2 configuration aircraft will always evacuate faster).

“Based on this extensive testing, it is the flow rate at the exits and not the seat pitch that is the principal factor that dictates the speed at which an airplane can be evacuated.” (Boeing, 2018)

This conclusion was based on tests conducted with a 28-inch seat pitch.

For a **32"** seatpitch the maximum allowance for the console length is **623.80 mm**.

For a **36"** seatpitch the maximum allowance for the console length is **725.00 mm**.

5.4.8 Different classes

As seen in chapter 3.2.2, it is a major trend that more and more airlines offer different types of classes, not just business and economy class. To adapt to this trend and offer passengers various options for luggage, seat pitch and privacy, four different classes have been designed, each with its own advantages:

- Stash class: 2 suitcases & normal seats
- Relax class: 2 suitcases & wide seats
- Nomad class: 2 smaller bags & normal seats
- CloudNest: 2 smaller bags &

Stash class, Relax class and Nomad class are all pretty similar, with a console in the middle and seats beside it. For the Cloudnest, it needs to be determined whether the console should be placed on the inside or outside. As can be seen in figure 110, it is not possible to place the console on the outside of the seat and still fit two suitcases. The curvature of the fuselage would cut into the console (as seen in the Airbus A320, see chapter existing solutions).

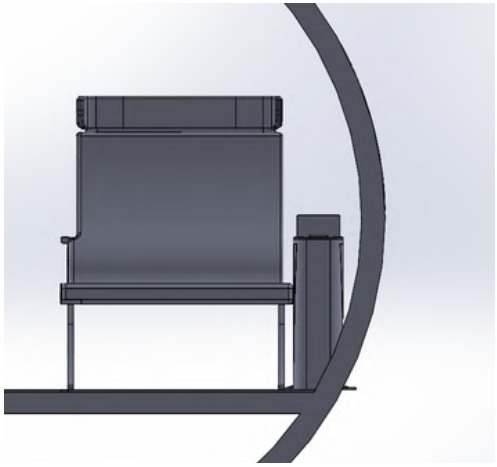


Figure 110: CloudNest, placing console on fuselage side of the bench

An overview of the classes can be found on the next page.

For the development of the concept, work will proceed with three of the four classes: the CloudNest, Nomad class, and Relax class, following Airbus' advice to opt for wider seats. The Stash class is included in this chapter to indicate that variations in seat width are possible, which creates opportunities for carrying luggage with different dimensions if an airline has this specific request.

5.4 Dimensions

5.4.8 Different classes

In all classes, in addition to the specified suitcase dimensions, a small piece of hand luggage mearuing 40 x 30 x 20 can also be carried and stored under the seat in front.

Stash class

Business class (more storage space)

- *36" seatpitch*
- *42 cm seat width*
- *25 x 35 x 55 cm suitcase per person*

Relax Class

Business class (more comfort - seat width)

- *36" seatpitch*
- *45.4 cm seat width*
- *20 x 35 x 55 cm suitcase per person*

Nomad class

Economy class

- *32" seatpitch*
- *45.4 cm seat width*
- *20 x 30 x 55 cm suitcase per person*

CloudNest

Family class

- *32" seatpitch*
- *90.8 cm seat width (for 2 passangers)*
- *40 x 60 x 55 cm storage space (for 2 passengers)*

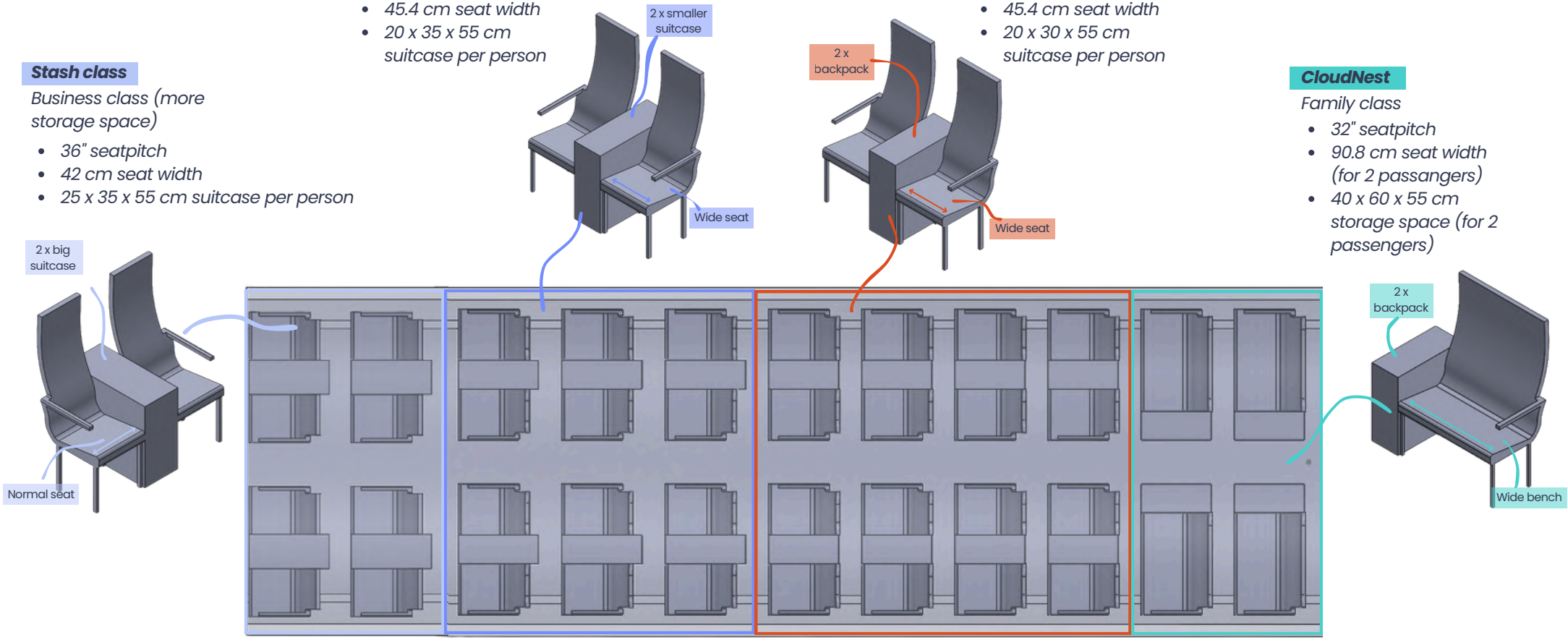


Figure 111: Different classes in the E9X

5.5 Certification

5.5.1 General

Before a newly developed aircraft type or change to this aircraft type may enter into operation, it must obtain a certificate or change approval from the responsible aviation regulatory authority (Aircraft Certification | EASA, n.d.).

Figure 112: European Aviation Safety Agency (EASA) (Daniel & Daniel, 2025)

Figure 113: Federal Aviation Administration (FAA) (Mayflower Communications, 2016)

The EU-USA Bilateral Agreement ensures mutual recognition of certification between the authorities. In addition, EASA has arrangements with (partial) acceptance of certifications with the aviation authorities of Japan (JCAB), Canada (TCCA), Brazil (ANAC) and China (CAAC).

'CS-25 large aeroplanes' is used for certifying aircraft with over 19 passenger seats, higher maximum take-off mass (12.500 lbs) and/or advanced multi-system architectures. Since the Elysian E9X exceeds 19 seats, it falls into this category and must therefore be certified according to EASA CS-25. (Consider the Differences in Design Philosophy Between FAR-CS-23 (Small Aircraft) and FAR-CS-25 (Transport Category Aircraft), 2025).

In this chapter, the 'Easy Access Rules for Large Aeroplanes (CS-25) book is reviewed and rules related to the console concept are highlighted, together with a certification expert at Elysian.

CS 25.803 Emergency evacuation
As mentioned earlier in chapter 5.4.11, an important rule is that the entire aircraft must be evacuated within 90 seconds.

"(c)For aeroplanes having a seating capacity of more than 44 passengers, it must be shown that the maximum seating capacity, including the number of crew members required by the operating rules for which certification is requested, can be evacuated from the aeroplane to the ground under simulated emergency conditions within 90 seconds."

The tests and research about guidelines in chapter dimensions - seat pitch show:

It can be assumed that the console concept **won't hinder evacuating** the entire aircraft within 90 seconds. However, **further testing is needed** to confirm this assumption and ensure that the evacuation time stays within the required limits.

CS 25.785 Seats berths, safety belts and harnesses

"(b) Each seat, berth, safety belt, harness, and adjacent part of the aeroplane at each station designated as occupiable during take-off and landing must be designed so that a person making proper use of these facilities will not suffer serious injury in an emergency landing as a result of the inertia forces specified in CS 25.561 and CS 25.562." (EASA, 2023)

This means that the seat and everything directly connected to it must be able to withstand a dynamic test of 16g of dynamic force without significant plastic deformation.

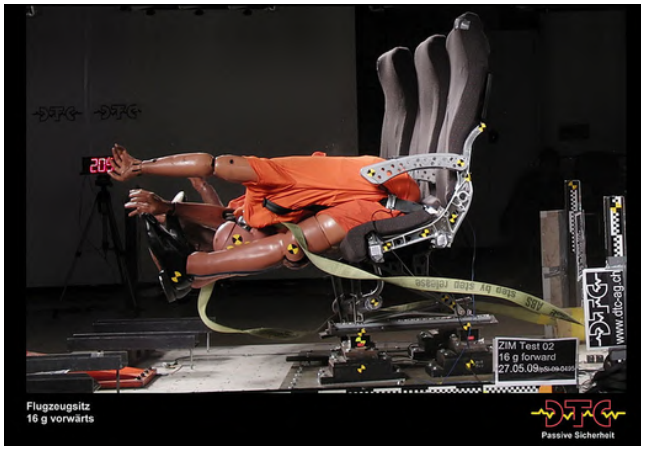


Figure 114: 16G dynamic testing (DTC Dynamic Test Center AG, n.d.)

CS 25.561 General
All other components must ensure that the evacuation of the aircraft remains safe and possible after deformation:

CS25.561 (b.3) *"The occupant experiences the following ultimate inertia forces acting separately relative to the surrounding structure:*
(i) Upward, 3·0g
(ii) Forward, 9·0g
(iii) Sideward, 3·0g on the airframe and 4·0g on the seats and their attachments
(iv) Downward, 6·0g
(v) Rearward, 1·5g" (EASA, 2023)

If the console is **connected** to the seats: a **16g** dynamic test is required; if it is **not connected**, the highest force is **9.0 g** forward (static).

5.5 Certification

5.5.1 General

Life vests
CS 25.1411 General
"The stowage provisions for life preservers described in CS 25.1415 must accommodate one life preserver for each occupant for which certification for ditching is requested. Each life preserver must be within easy reach of each seated occupant."

The **life vests** can remain in its usual position: **under the seat**.

5.5.2 Materials

CS 25.853 Compartment interiors
"For each compartment occupied by the crew or passengers, the following apply:
a. Materials (including finishes or decorative surfaces applied to the materials) must meet the applicable test criteria prescribed in Part I of Appendix F or other approved equivalent methods, regardless of the passenger capacity of the aeroplane." (EASA, 2023)

Use **certified materials**

CS 25.787 Stowage compartments
"AMC 25.787 (b) stowage compartments
(1) Passengers Areas are zones in which passenger seats designed for occupancy during taxiing, take-off, and landing are installed. In such cabin areas, if the means used to prevent the contents of the compartments from becoming a hazard by shifting is a latched door, the design should take into consideration the wear and deterioration expected in service.

(2) The following is provided as a clarification of the considerations to be followed when designing latching mechanisms, ..

- *Single latch: Consideration of wear and deterioration for single latches should be substantiated by test evidence (20.000 latch cycles may be used)*
- *Dual latch: where dual latches are installed there is no need to further demonstrate wear and tear.*

- *All latches, whether single or dual, should include a latch fail indication." (EASA, 2023)*

Figure 115: Single latch (Latch Assy – Paddle A20062 - Actron Manufacturing, n.d.)

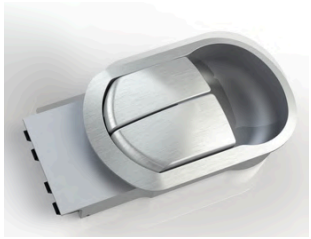


Figure 116: Dual latch (Latch Assy - Double Paddle, Double Bolt A23182 - Actron Manufacturing, n.d.)

- Latches must account for wear and deterioration
- **Single** latches require **test** evidence (20.000 cycles)
- **Dual** latches **don't** require wear **tests**
- Both should include a **latch fail indication** ((visual) indictation of latch malfunction or failure)

5.5 Certification

5.5.3 Passenger Service Unit

The console concept eliminates overhead bins. A growing problem is where to store items that normally go in overhead bins, such as oxygen masks, seatbelt lights and ventilation.

Passenger Service Unit
In current aircraft, these functions are located in the so-called PSU (Passenger service unit) that can be placed inside the overhead bins.

Figure 117: PSU (Passenger Service Unit | Astronics PECO Inc., n.d.)

For the console concept, PSU's functions must be moved to a different location, if still applicable in the E9X. The PSU houses:

- Oxygen masks
- Non-smoking sign
- Seat-belt sign
- Service button
- Light
- Ventilation

Non-smoking & seat belt sign:

CS 25.791 Passenger information signs and placards
"(a) if smoking is to be prohibited, there must be at least one placard so stating that is legible to each person seated in the cabin." (EASA, 2023)

"(b) Signs that notify when seat belts should be fastened and that are installed to comply with the Operating Rules must be installed so as to be operable from either pilot's seat and, when illuminated, must be legible under all probable conditions of cabin illumination to each person seated in the cabin." (EASA, 2023)

"(e) Symbols that clearly express the intent of the sign or placard may be used in lieu of letters." (EASA, 2023)

- **Required**
- There must be a **visible** no smoking sign **for everyone** in the cabin
- Belt signs must be visible to everyone
- This may be in letters or symbols

Figure 118: Signs in aircraft nowadays (Ghazanchyan, 2018)

Oxygen masks

The E9X will fly at an altitude where oxygen masks are required.

CS 25.1447 Equipment standards for oxygen dispensing units
If oxygen-dispensing units are installed, the following apply:
(a) There must be an individual dispensing unt for each occupant for whom supplemental oxygen is to be supplied.

(c)If certification for operation above 7620 m (25 000 ft) is requested, there must be oxygen dispensing equipment meeting the following requirements:

(1) There must be an oxygen-dispansing unit connected to oxygen supply tereminals immediately available to each occupant, wherever seated.

- **Required**
- An oxygen mask must be available for **each passenger** and should be **readily available** (immediately available)

Figure 119: Oxygen masks in aircraft nowadays (Chrisontour84, 2018)

5.5 Certification

5.5.3 Passenger Service Unit

Service button
EASA has not set specific regulations for having a service button. However, it is an industry standard to have one near each seat, and many airlines will want this feature in their interior. To keep the design as close as possible to the already functional 'journey' and to offer extra comfort, it has been decided to integrate this feature into the E9X. There are still guidelines for designing within an aircraft:

CS 25.1301 Function and installation
"(a) Each item of installed equipment must –
(1) Be of a kind and design appropriate to its intended function;
(2) Be labelled as to its identification, function, or operating limitations, or any applicable combination of these factors."

- **Desired**
- **Clearly identifiable** function
- Appropriate to intended function

Figure 120: Service button (Knuth, 2023)

Ventilation
Although personal ventilation is appreciated by many passengers, as noted by cabin crew in the interview chapter, newer aircrafts, such as the Boeing 787, are increasingly adopting more efficient and generalized climate control systems (McDonald, 2025). These systems are designed to maintain a comfortable environment for all passengers without the need for individual controls.

Redirecting the ventilation system to the console is not only complicated but also takes up a significant amount of space.

Figure 121: PSU lights, seats & ventilation(Knuth, 2023)

The decision was made to implement a more streamlined, **general climate control** system in the E9X. However, **further testing** will be necessary to evaluate what kind of impact this has on passenger comfort.

Seat numbering
As can be seen in figure 121, some PSU's include seat letter designations. Other airlines may place the seat numbering on the overhead bins. There are no
specific rules regarding seat numbering in the CS-25, but it is important to keep in mind that passengers need to be able to find their seat easily.

Seat numbering **is not required**, but passenger must be able to find their seats easily).

Light
The option to turn personal lights on or off can offer extra comfort to the passengers, allowing them to decide whether they want to read or sleep during an evening or night flight. The light will be a nice addition, but is by no means essential.

While personal lighting can **enhance passenger comfort**, it may **not** be **necessary** as screens are becoming the primary tool for reading and working.

5.5 Certification

5.5.4 Conclusion

According to the EASA CS-25 regulations, several factors were considered to enable the certifiction of the console concept. These have been incorporated into the design.

- **Construction of an aircraft can be found in Appendix L**
- **Determining the angle of the screen can be found in Appendix L**

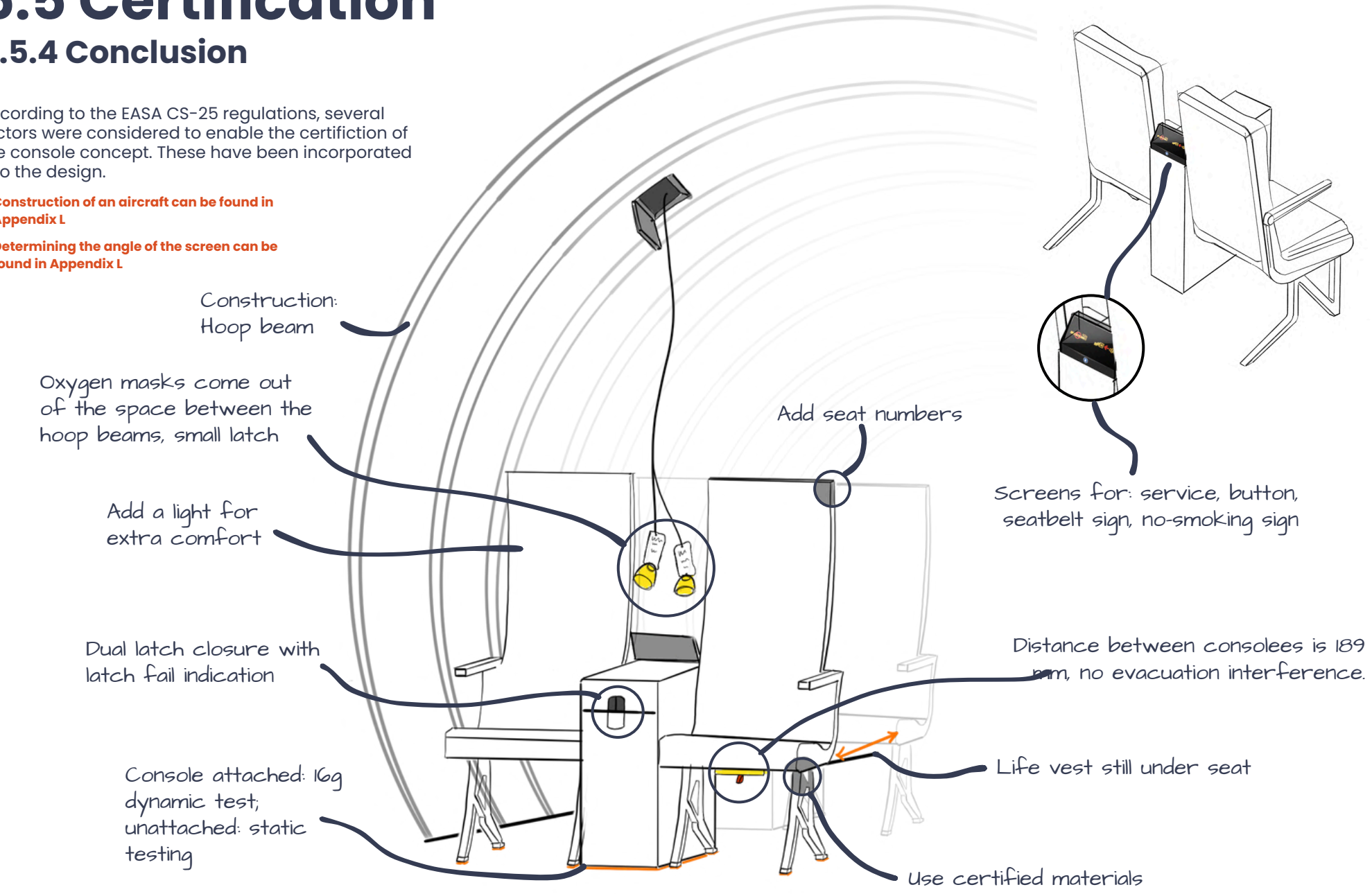


Figure 122: Conclusion of certification

5.6 Stakeholders

5.6.1 Passengers

To ensure that the user is not overlooked, the personas of 2035-2065 are placed in the console concept aircraft

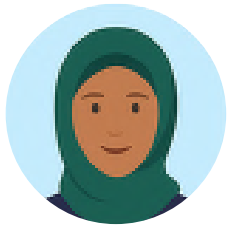
	 **Millie** The Business traveller	 **Grace** The Independent senior	 **Kai** The family-centric parent	 **Amira** The Sustainability-Minded Explorer	 **Elias** The space & comfort seaker
Class	Relax Class	Stash Class	CloudNest Class	Nomad Class	CloudNest class
Bagg-age	1 small item + small suitcase	1 small item + walking stick 1 checked-in suitcase	2 children's backpacks 1 checked-in suitcase	1 backpack (little oversized)	1 cabin suitcase 1 small item
Trip type	Short business trip	Visit to children living abroad	Family holiday	Solo trip	Weekend trip with girlfriend
Reason	"I wanted to bring my prototypes for my investor presentation and ensure I was well-rested."	" I had a short stay, only needed a pair of clothes and my toothbrush."	"I wanted to have my child close by, he sleeps better on my lap."	"I wanted the cheapest option, it must be an electric aircraft & I like to have my own space."	"Me and my girlfriend like to sit next to each other and then we can share the width of the seat."
Person in seat					

Figure 123: Personas of 2035-2065 in different classes

5.6 Stakeholders

5.6.1 Passengers

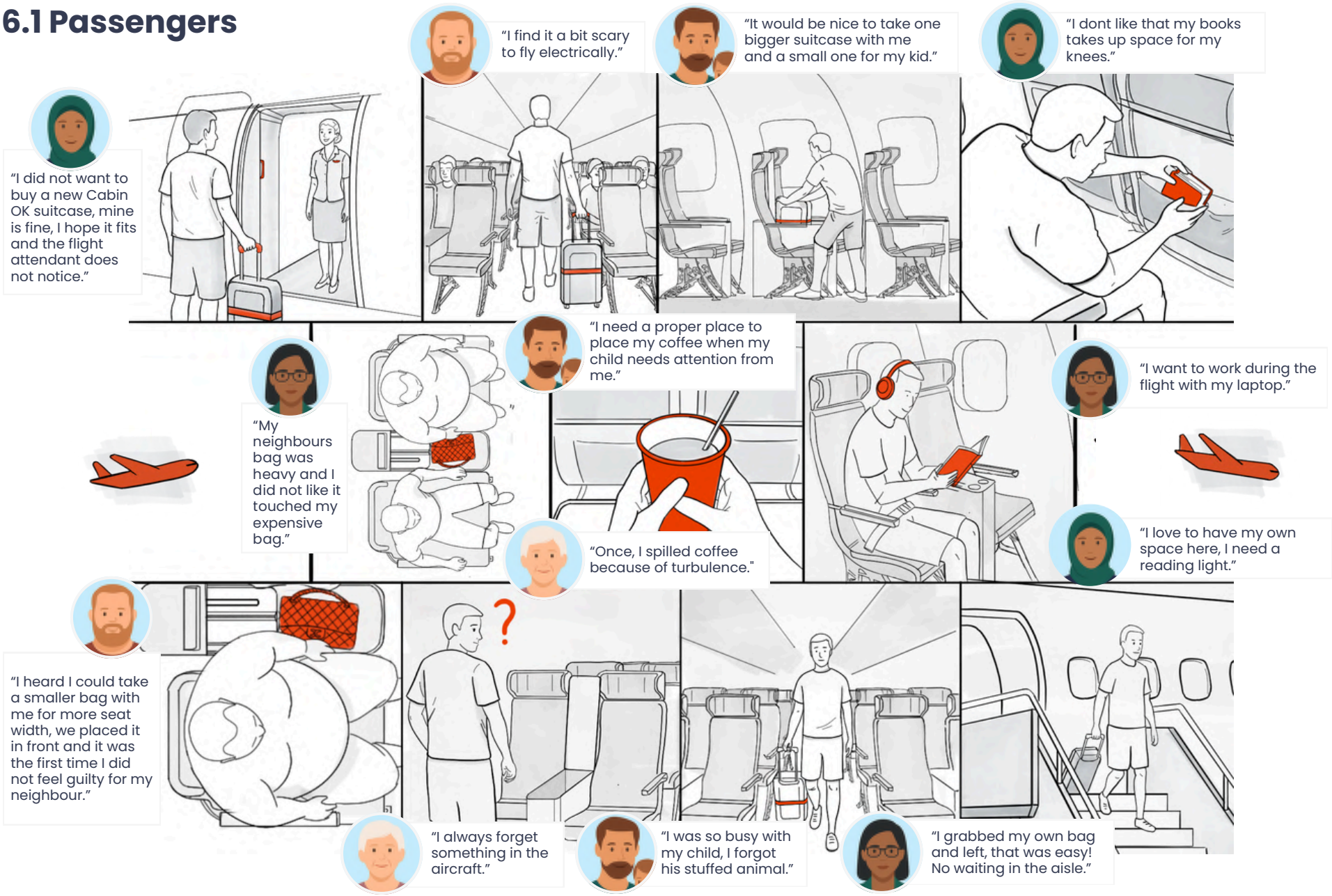


Figure 124: Personas of 2035-2065 - passenger journey in SkyConsole concept

5.6 Stakeholders

5.6.1 Passengers

The concept can be improved in several areas for passenger comfort:

- Checking the **size** of the **carry-on luggage**
- **Layout** of the console (luggage compartments or separate)
- Space for **personal belongings** that don't affect seating comfort
- Space for placing **drinks**
- **Workstation** possibilities
- **Reading light**
- **Forgetting items** in the console

5.6.2 Airlines & Aircraft leasing companies

As outlined in chapter 3.1, the ability to easily reconfigure aircraft interiors is important for both aircraft leasing companies and airlines. Leasing companies benefit from reduced time and cost when adapting aircraft for different operators, while airlines require flexibility when configuring newly acquired aircraft according to their specific requirements.

In current practice, reconfiguration involves the removal and replacement of major interior components such as carpets, seats, and overhead bins. Overhead bins, in particular, often need to be replaced due to their dependence on seat pitch, which varies between airlines.

The console concept creates an opportunity for solvig this. Removing the overhead bins eliminates the need to adapt these components to different seat pitches. Instead, each console–seat combination can be repositioned independently, allowing for increased flexibility in cabin layout adjustments. Further details and a solution are provided in chapter 5.9.5: Design Language – Ease of Adaptation.

Further development of the **ease of adaptation** is desirable in order to increase interest from airlines and aircraft leasing companies.

5.6 Stakeholders

5.6.3 Cabin Crew

To evaluate how the console concept interacts with the cabin crew, the operational cycle described in the interview chapter is used as a reference framework.

All orange exclamation marks are placed next to actions that could potentially be affected by the console concept (see figure 125).

- **Cabin inspection**

It should still be possible to check if the consoles contain any dangerous objects. This can be a bit harder with a lot of seperated places where luggage is stored.

- **Passenger welcome**

It becomes more important that the carry-on luggage does not exceed the measurement limits.

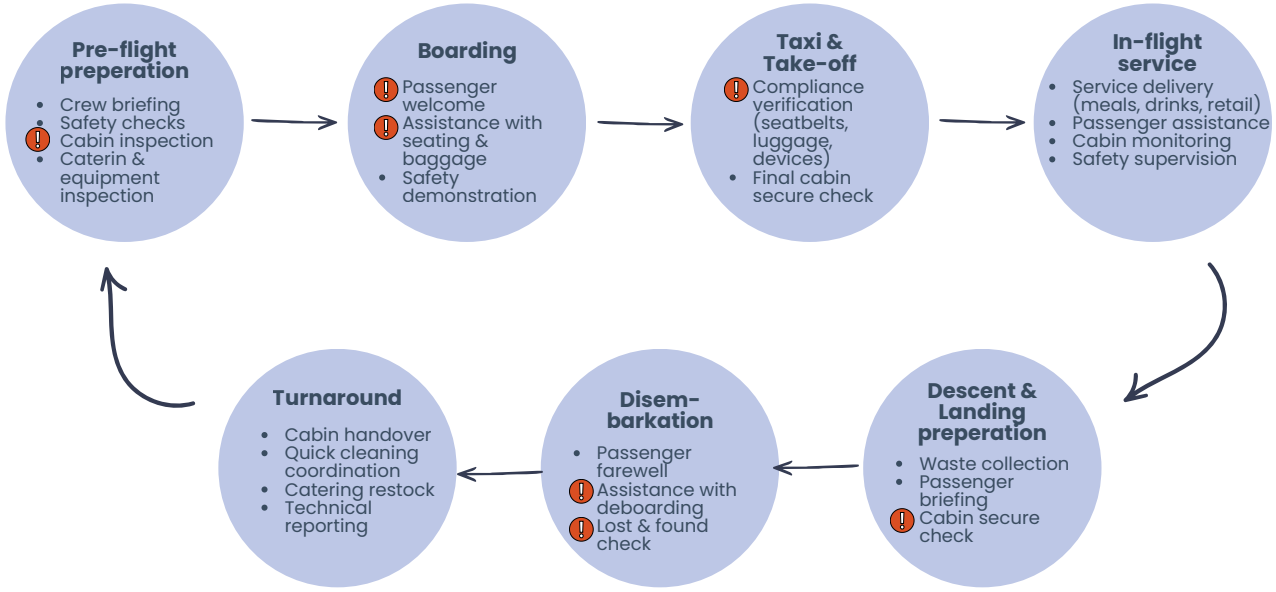


Figure 125: Operational cycle cabin crew with console concept.

- **Assistance with seating & baggage**

This is something thath might be harder with this concept.

- **Compliance verification**

It is still easy to see, but it would be nice if it could be automated.

- **Cabin secure check:**

It is important that all the consoles are closed again, that is a bit of extra work to check the seatbelts, tray tables and the consoles.

- **Assistance with deboarding:**

This is something thath might be harder with this concept.

- **Lost & found check:**

This is more work for the cabin crew with all the different consoles.

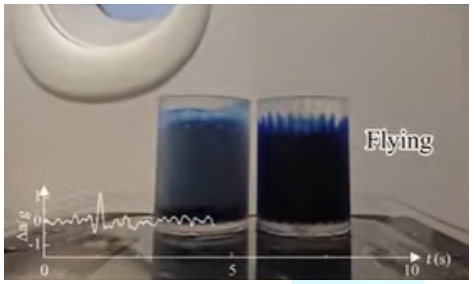
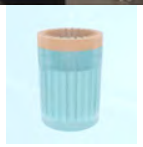
There is potential for improvement by making adjustments to the concept to better align it with the operational tasks of the cabin crew. This mainly includes:

- Checking **carry-on luggage** for the correct **dimensions**
- Checking the **consoles** for **items left behind**
- Checking **seatbelts** and **locking** the consoles

5.6 Stakeholders

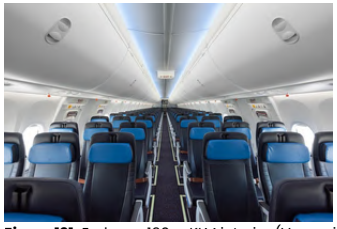
5.6.4 Conslusion- extra functionalities

Looking at the stakeholders, the console concept can be improved by adding extra functionalities.

Name	IR Reflection Sensor in console for lost items	Seatbelt fastened & console lock sensors	Cup holders	Special cups for spill prevention
Examples	 **Figure 126:** IR Reflection sensor (Optical Reflection Sensor Infrared IR 950Nm TCRT5000, n.d.)  	 **Figure 127:** Aircraft seatbelt (Wecklein, 2026) 	 **Figure 128:** Cupholder in car (Cup Holders Paved Way for Interior Car Design, 2009)	 **Figure 129:** Notch cup that is designed to prevent spilling water (Ma et al., 2025) 
Opportunities	• Facilitate safety and lost item checks for cabin crew & passengers • Small and inexpensive • Allow visibility of available console space	• Facilitate seatbelt checks for the cabin crew. • Facilitate console lock checks for the cabin crew.	• Usable without unfolding the table • Luxurious feeling	• Less dirt on the interior • Reduced risk of hazardous situations with hot beverages
Challenges	• Make it vandal-proof	• Make it vandal-proof	• Make inside easily changable/cleanable, because dirt gets in	• These can be reusable (or maybe single-use in the future), but how to implement logistics around cleaning the cups
Conclusion	Implement	Implement	Implement	Out of scope for this project, but recommended

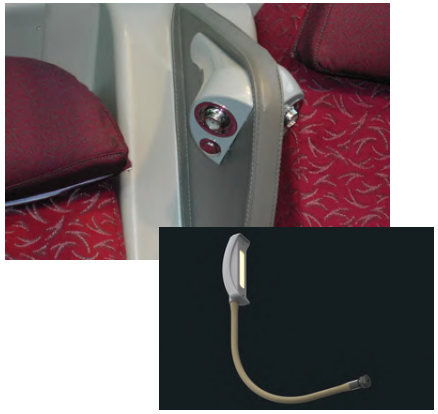
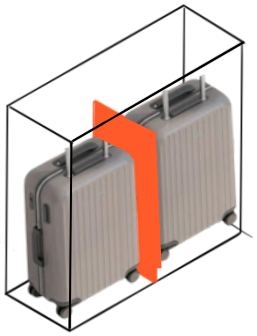
5.6 Stakeholders

5.6.4 Conslusion- extra functionalities

Name	Suitcase dimension check	Easy changable interior	Table	Phone holder
Examples	 **Figure 130:** Handbgaggage scanner from Malaysia Airlines (Malaysia Airlines - Facebook, 2020)	 **Figure 131:** Embraer 190 - KLM interior (Vernooij, 2019)  **Figure 132:** Embraer 190 - Scoot interior (Falconer, 2024)	 **Figure 133:** Traytable in aircraft	 **Figure 134:** Tiny tray table for phone (Makazu, 2025)
Opportunities	• No check at the gate - time saving • No odd-sized baggage on board if not indicated	• Interior refurbishment for leasing companies is faster • Less material waste	• Nice for business passengers • People are used to it	• Comfort
Challenges		• Airlines have less options to choose from in terms of seat form and lay-out	• Adds extra weight	
Conclusion	Out of scope for this project, but recommended	Implement	Implement	Implement

5.6 Stakeholders

5.6.4 Conslusion- extra functionalities

Name	Compartment for stowing small personal items	Light	Console devider
Examples	 **Figure 135:** Small items storage in Volvo XC90 console	 **Figure 136:** Aircraft seat lighting (Seat Lights - SELA LIGHT, 2022)	 **Figure 137:** Divider in console
Opportunities	• Easy storage of small items • Luxurious feature	• Expands activity possibilities for passengers •	• No discussion between passengers, each has their own part • No damage problems
Challenges	• The IR sensor has to work for this part as well	• Adds extra weight	• The dimension restrictions are even stricter • The divider has to be thin and light
Conclusion	Out of scope for this project, but recommended	Implement	Implement in all classes, exept for the CloudNest, so that people have more options for packing the console when they travel together.

5.7 Construction

5.7.1 Standard aircraft seats

Frame
For certification & operation purposes, aircraft seats must be both strong and lightweight. The seat structure is therefore typically made from hollow aluminium or composite tubes designed to withstand high forces while keeping weight to a minimum.

Seats are usually mounted as a connected row onto floor seat tracks, which allow them to be securely fastened to the aircraft structure. These tracks enable easy replacement of seats and make it possible to adjust the seat pitch when airlines change their cabin layout.

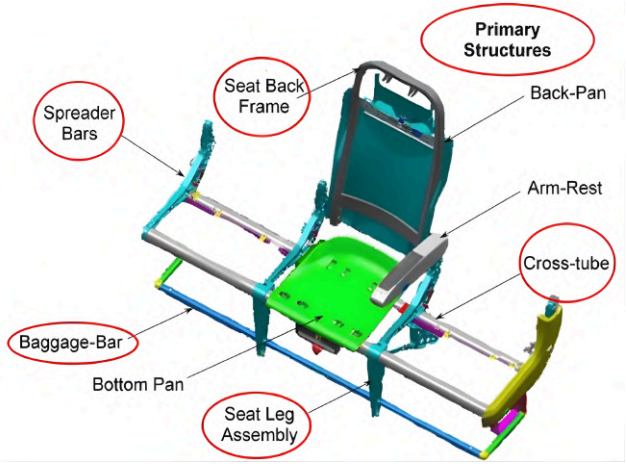


Figure 138: Schematic illustration of major structural seat components (Kurzynowski et al., 2020)

2 & 3 - seats configuration
In many larger aircraft, rows of three seats are installed. As can be seen in figure 139, these seats have a construction in which the legs are attached to the ground in the middle.

In a row of two, the legs are at the ends. This is all to optimize weight and strength.

Figure 139: 3 aircraft seats(Recaro, 2022)

Figure 140: 2 aircraft seats (Aircraft Seats for Sale | Airline Seats | Pilot Seat | Skyart, n.d.)

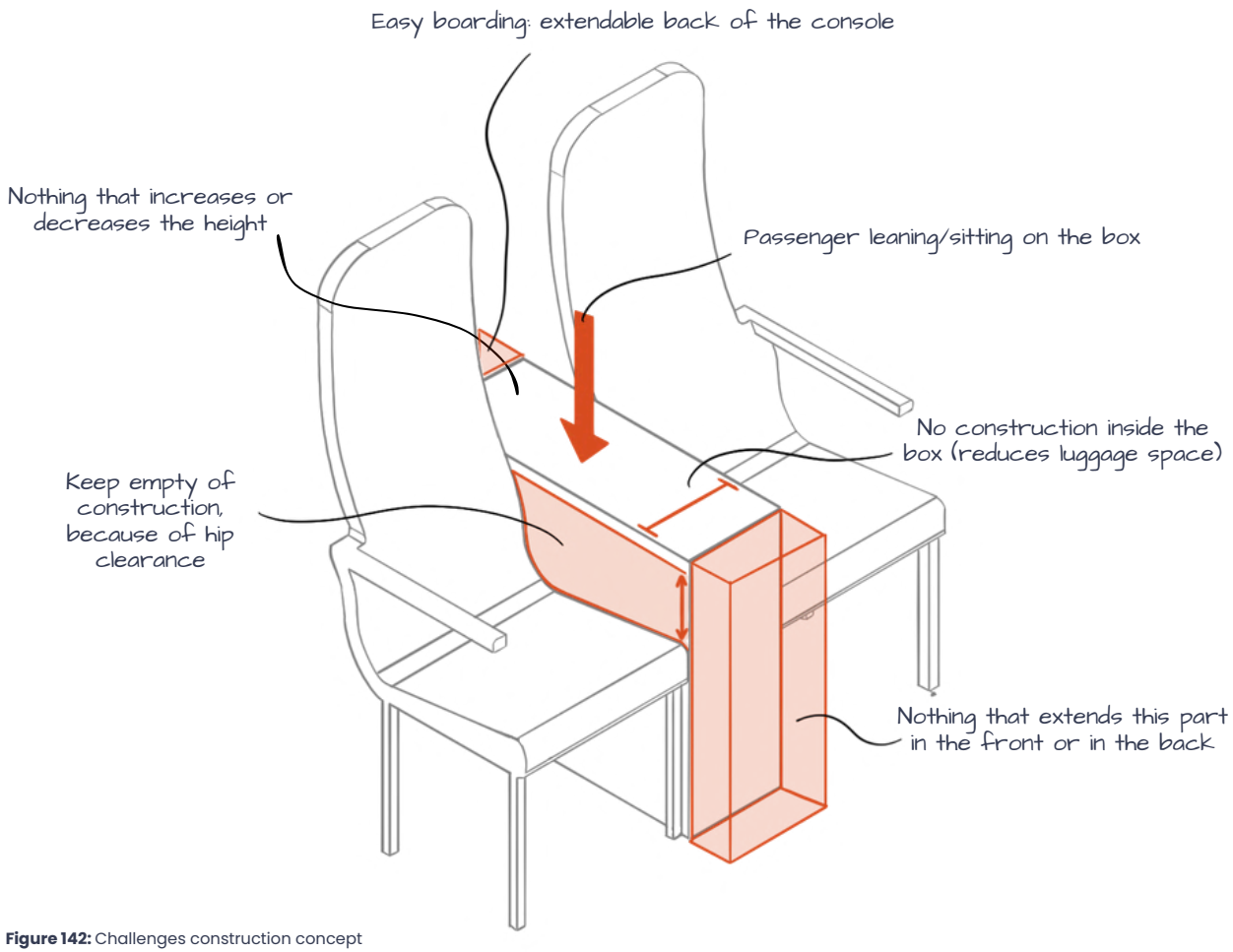
Difference between console concept and 'normal' aircraft seat
No tubes can run through the console. So this requires a different solution.

Figure 141: 2 aircraft seats frame (Custom Precision Machining for Aircraft Seat Frames, n.d.)

5.7 Construction

5.7.2 The challenge

The challenge
Figure 142 shows that there are several important factors for the construction of the concept (see chapter 5.4).



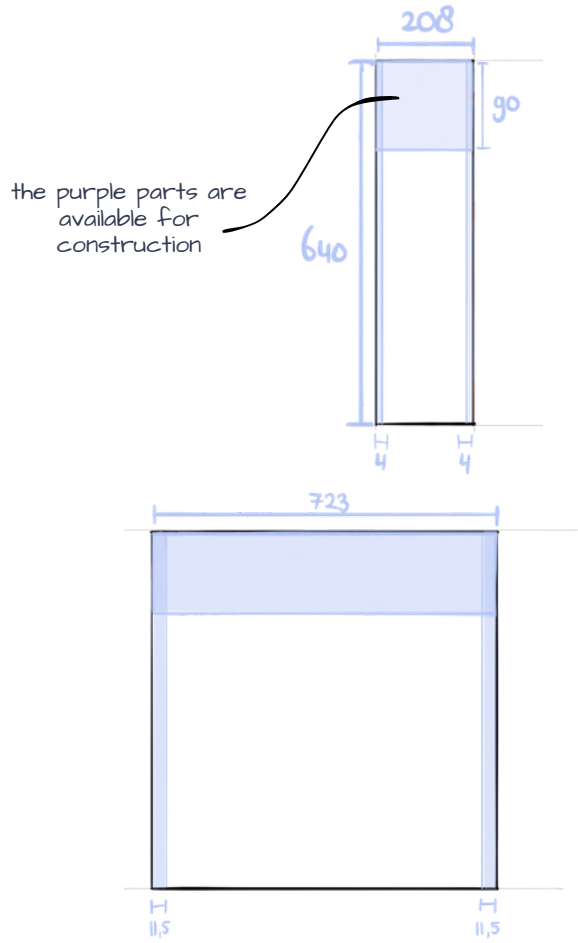


Figure 142: Challenges construction concept

5.7 Construction

5.7.3 Comparable solutions

There are business class seats that also have a compartment/wider armrest between the seats. This can provide inspiration for how to solve the construction problem.

Businessclass seat with compartment
In figure 143 you can see that the beam of the structure runs through the front and the back of the box, this will result in less space being able to fit into the box.

Figure 143: Business class seat with compartment (Acro Series 7 | 1210 Business Class Seats - Aviationgate.com, n.d.)

Rebel seat
Some seats, like the Rebel seat in figure 144, are certified with individual legs for each unit. Unlike seats on a support beam, the Rebel seat used in the dimensions chapter has no main frame and can be placed individually.

Figure 144: Rebel seat with legs per seat

Smaller aircraft - curve of fuselage
In aircraft with similar fuselage dimensions to the E9X, there isn't always space to place the seat fully with the legs on the ground (see orange circle in figure 145). Solutions for this exist (see figures 146 and 147).

Confidential

Figure 145: Cross-sectional view of the fuselage with a four-legged seat

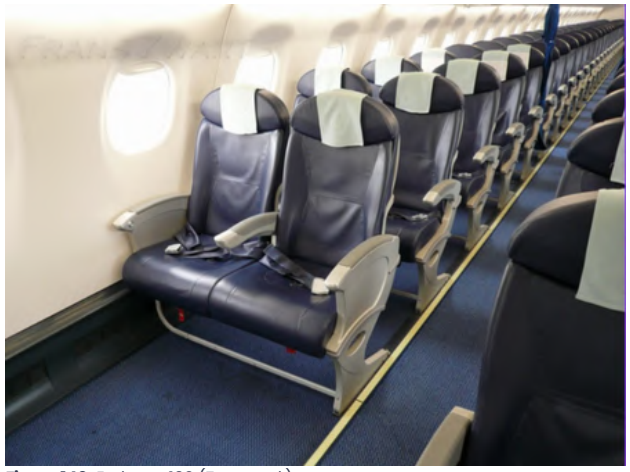


Figure 146: Embraer 190 (Zwart, n.d.)

Figure 147: Small fuselage solution (Doy, 2025)

5.7 Construction

5.7.4 Possible solutions

For the box and the seat, several construction methods are possible. In the morphological chart (Van Boeijen Annemiek et al., 2013) below, the different options have been explored.

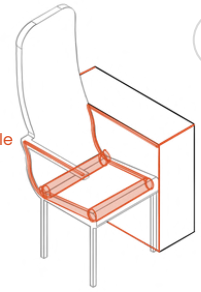
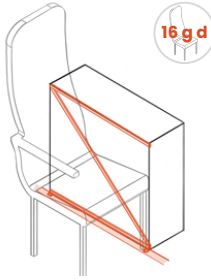
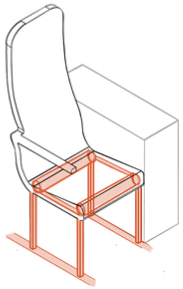
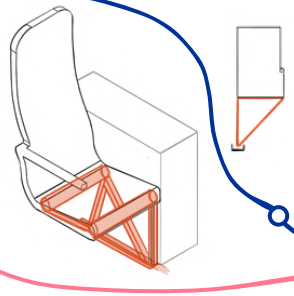
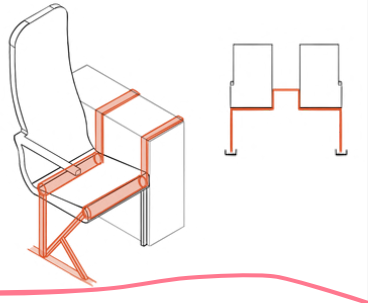
Construction of console	Combined seat & console construction (armrest connection) 	Individual console construction 		
Construction of seat	Seat with 4 legs 	Seat with 2 legs 	Seat 'hanging' on box 	
Combination	Individual console construction with Seat with 4 legs	Combined seat & console construction with Seat with 4 legs	Combined seat & console construction with Seat with 2 legs	Combined seat & console construction with Seat 'hanging' on box
Opportunities	• Lightweight • Static testing on console	• Lightweight	• 2 rails (like in aircrafts nowadays)	• 2 rails (like in aircrafts nowadays)
Challenges	• 4 rails instead of 2	• Negatively influences the legroom • 4 rails • 16 g dynamic testing on both box & seat	• Negatively influences the legroom • 16 g dynamic testing on both box & seat	• Box opening becomes more restricted /narrower • Heavier • 16 g dynamic testing on both box & seat
Conclusion	Most lighweight options, the rebel seat can be used (easy to implement) and test requirements are most favorable			

Figure148: Morphological card for the seat and console construction

5.7 Construction

5.7.5 Proposal

Lightweight and in the right places
It is important to make the box as lightweight as possible (see chapter 5.10). The construction must also be positioned in the right places to avoid hindering comfort and usability. Figure 149 shows a sketch of a way to achieve is.

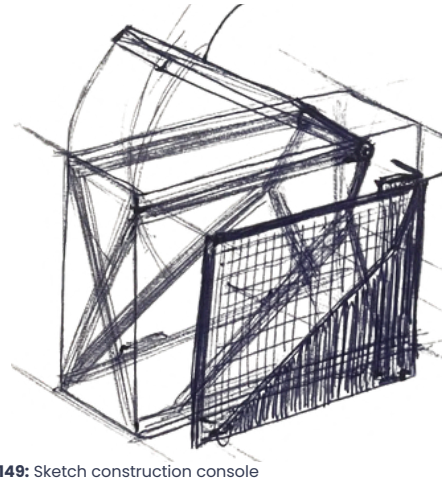


Figure 149: Sketch construction console

Extending back
The box can be extended at the back for easier boarding. This is done by adding springs to the sides of the inside of the console that are attached to an inner shell. This shell is pushed outward by the suitcase(s) placed inside. The springs pull the inner shell back when the suitcase is removed from the box.

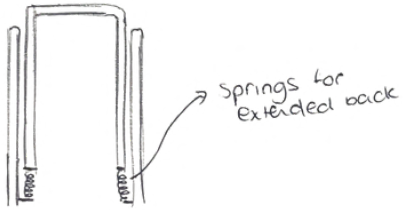


Figure 150: Sketch extending console

Conclusion - proposal for construction
in figure 151, a 3D model op a proposal for the construction can be seen. In the sides is 2mm left for housing and in the front and back (combined) 21 mm.

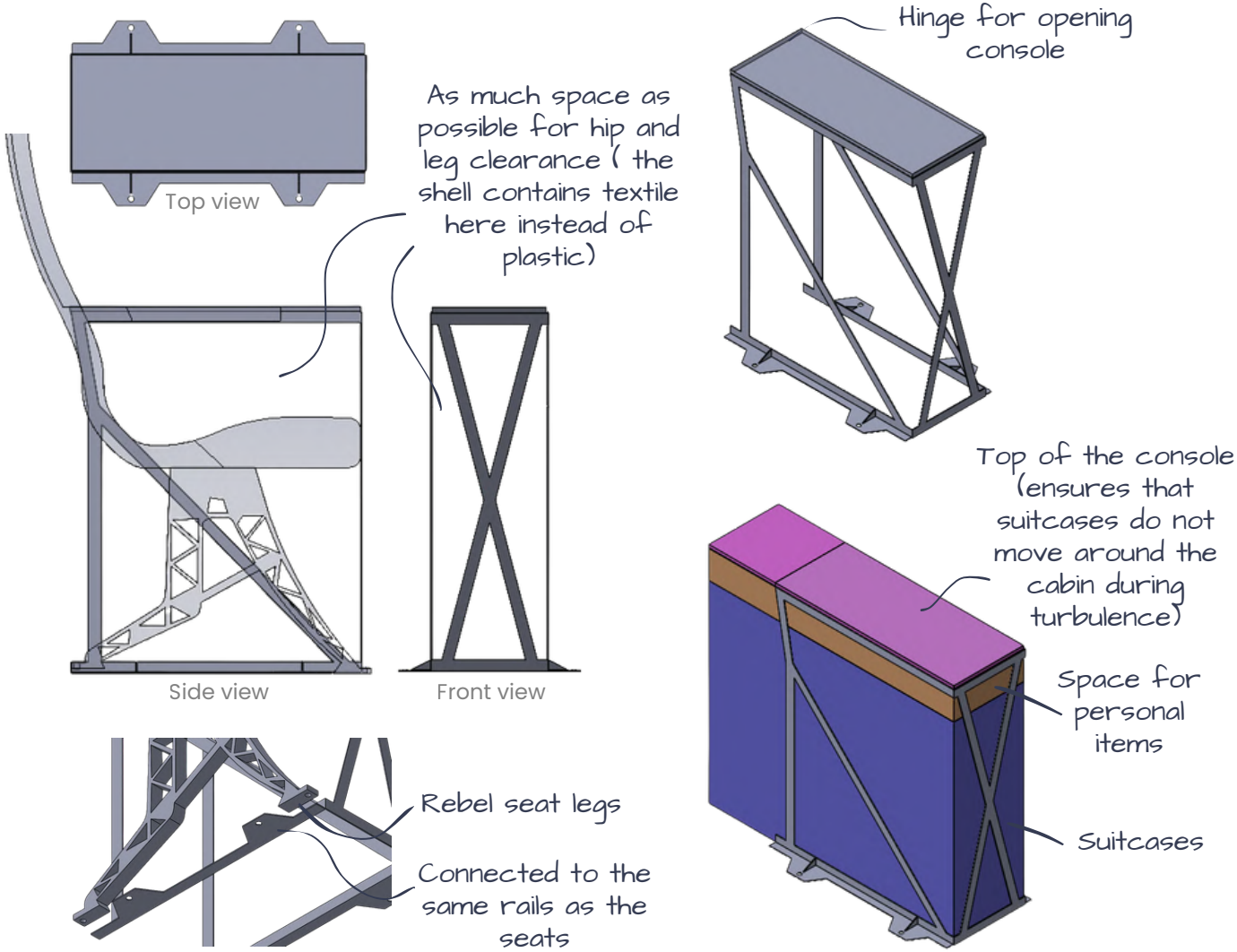


Figure 151: Proposal for construction

5.8 Materials

5.8.1 Exploration

As mentioned in the certification chapter, only certified materials may be used in aircraft interiors. Material selection should also support a clean and well-maintained appearance, as this has a strong influence on perceived comfort. As noted by Vink and Brauer (2011), "The correlation between hygiene and the comfort score is often high when a clean or fresh looking airplane is mentioned. It seems worthwhile to have clean-looking planes, which means paying attention to cleaning and to buying products that retain their looks for a long time."

In addition, the interior must be resistant to intensive use, making durability an important consideration. Sustainability should also be taken into account, alongside the weight of materials, as minimizing weight remains essential in aircraft design.

- **Certified materials**
- **Water resistand, easy to clean**
- **Robust material** (as less wear as possible overtime)
- **Sustainable**
- **Lightweight**

Aluminium
Aluminium is widely used in the aircraft industry, due to the well-balanced combination of weight, strength, corrosion resistance, and workability (AMSpec, 2025). Aluminum is highly recyclable and it is expected that the per-unit greenhouse gas emissions for aluminum will decrease in the future due to greener electricity and higher recycling rates (Harpprecht et al., 2024).

Therefore aluminum is used as the main material for construction of the console.

Foamlab
Foamlab makes bio-nanocellulose foam, which is also suitable for the aviation industry. It can be produced in various levels of softness and compressibility, offering a sustainable solution for the plastic foams currently used.

Bio-nanocellulose foam may therefore be a promising option for filling the seats. At the same time, it is worthwhile to explore other possibilities, as described in the thesis by Klerken (2026). This opens up opportunities for developing a more sustainable aircraft seat.

Figure 152: Foam of foamlab (Foamlab | High-performance Bio-based Foams | Delft, NL, n.d.)

For now, it is assumed that the seat cushions are made from sustainable foam.

Bio-leather
To maintain a clean appearance and ensure the seats are easy to clean, inspiration is drawn from the Intercity Direct trains, which were referenced by Elysian. These trains use a leather-like upholstery material, which is therefore also applied in the console concept.

In addition, developments in bio-based leather alternatives within biotechnology are increasing (X. Liu et al., 2021), ranging from materials derived from plants (such as pineapple and mushrooms) to bacteria and fish by-products. Further research is required to determine the most suitable material choice.

Recycled plastics
For the shell of the seats and the console, it is important to select a lightweight material. Plastic could be a suitable solution for this purpose. Krüger Aviation has created the first 100% recycled polycarbonate materials for the aviation industry, which result in 50% lower CO_2 emissions compared to virgin materials and can be recycled at least five times (Krüger Aviation GmbH, 2025).

For the console and the seat, materials such as **aluminium**, **bio-based leather**, **sustainable foam**, and **recycled polycarbonate** are proposed. **Further research** is required to validate these material choices.

5.9 Design language

5.9.1 Guidance

Elysian has not yet defined a clear interior vision or specific focus for the passenger experience. Research indicates that first impressions play a significant role in the overall comfort perception (see chapter 3.3.1). Therefore, it is essential to carefully consider the design language of the interior, as visual coherence and aesthetic consistency directly contribute to how passengers experience comfort.

As a first step towards establishing this direction, a design language is developed to further elaborate and structure the console concept. Elysian already has a graphic design language as can be seen in the logo: dynamic & premium.

ELYSIAN

Figure 153: Logo Elysian (Vraka, n.d.)

It is important to note that the E9X will ultimately be operated by different airlines, each with its own established design language and brand identity. Therefore, the proposed interior concept must allow sufficient flexibility for airlines to apply their own visual and experiential signature within the framework provided by Elysian. This aspect will be further addressed in the conclusion.

The method
To establish a design language, several structured steps were undertaken (partly based on the Visual Quality scan to create a design from the TU Delft):

- Define six key qualities with Elysian
- Group into three directions
- Determine balance on scales
- Fill in the visual quality scan framework
- Create moodboards
- Select preferred design direction

Key qualities
To determine the key qualities, a Personality Adjective Words card set was used as a supporting tool. The circled adjectives (figure 154) were selected in collaboration with Elysian and represent the core characteristics that the interior and passenger experience should communicate.

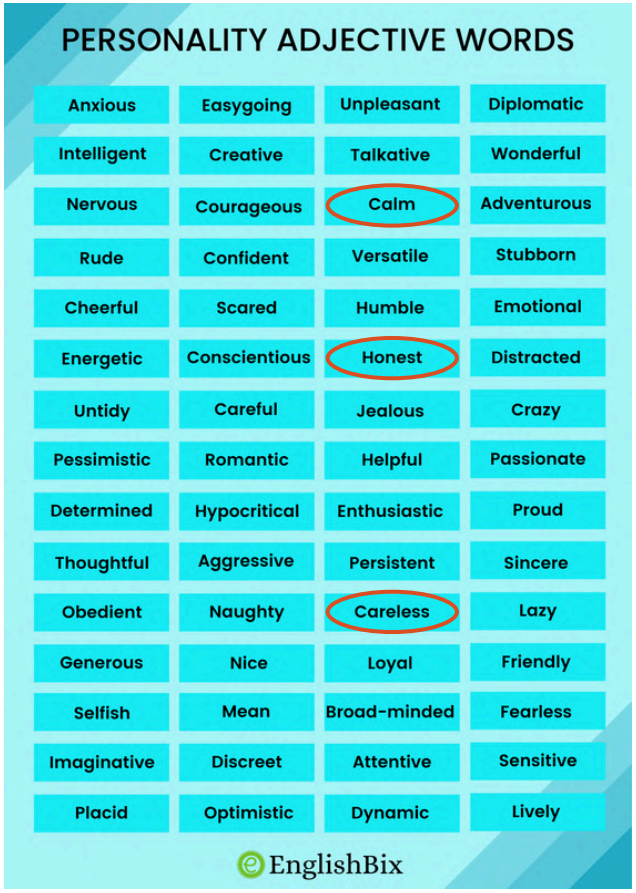


Figure 154: Personality adjective words (EnglishBlix, 2023)

Combining
The six selected adjectives were grouped, in collaboration with Elysian, into three distinct design directions:

1. Calm & Careless
2. Adventurous & Fearless
3. Honest & Friendly

Oppositional adjective scale
To further define and clarify these directions, they were positioned on an oppositional adjective scale together with Elysian. By placing each direction between contrasting characteristics, a more precise understanding was established of how each design direction should express itself within the interior.

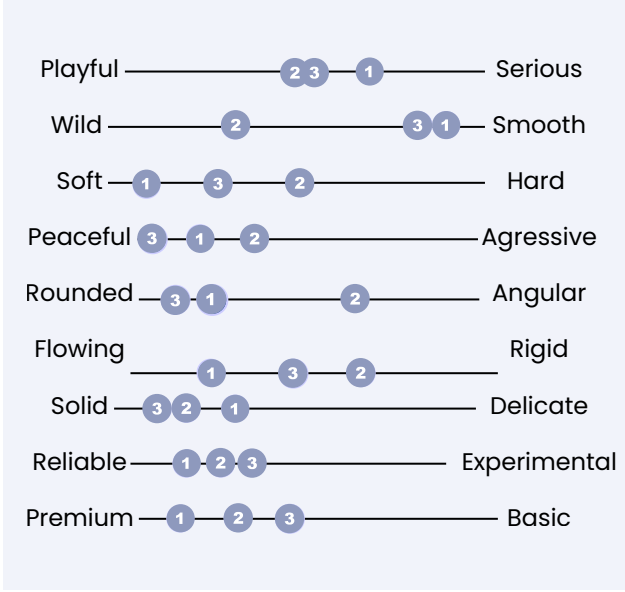


Figure 155: Opposition adjective scale for 3 directions

5.9 Design language

5.9.2 Moodboards

Creating moodboards

The six components of a design language, as described in the Visual Quality Scan, are defined based on the outcomes of the oppositional adjective scale and discussed with Elysian. Based on the defined components of the design language. Each design direction is expressed through its own dedicated mood board, reflecting its specific characteristics and atmosphere.

▸ **The outcomes of the visual quality scan can be found in Appendix M.**

Figure 156: Moodboard per design language

5.9 Design language

5.9.3 Selection

Preference study
To further develop the concept within a specific style, a small study was conducted to explore which design language people associate most with an electric aircraft.

After a brief explanation of the project, participants were asked the following:

- Look at the 3 moodboards
- Choose the design language you feel best fits:
  - The E9X aircraft
  - A possible Elysian airline
  - The future: 2035-2065
- Vote for your choice
- (Optional) Can you explain why you believe this design direction fits best?
- (Optional) Does the design language you personally find most appealing correspond with the one you consider most suitable? If not, please explain the difference.
- (Optional) Is there anything you would like to add?

This was conducted online among individuals without a specific professional background and among employess of Elysian, in total 31 respondents.

Results
The majority of participants selected design language 1 (48.4%, see figure 157). However, a notable difference emerged between the responses of online participants and those provided by employees at Elysian's office (see figures 158 and 159).

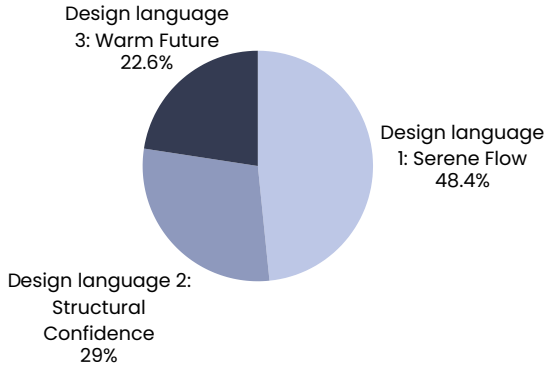


Figure 157: Overall results best design language for electric aircraft (31 respondents)

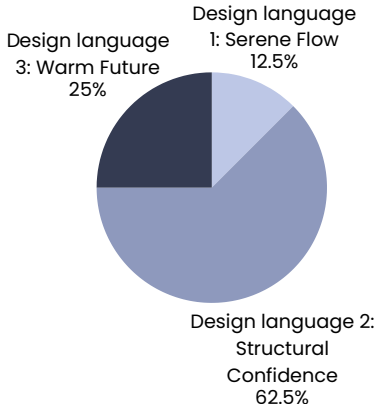


Figure 158: Results Elysian best design language for electric aircraft (8 respondents)

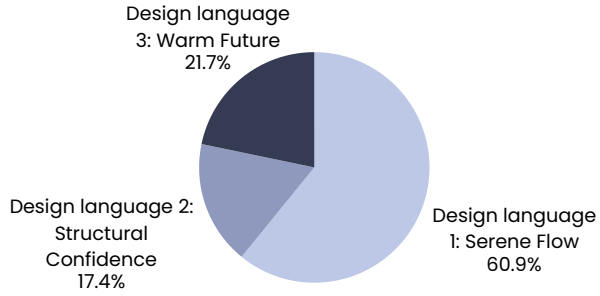


Figure 159: Online results best design language for electric aircraft (23 respondents

Among the Elysian team, design language 2 is clearly the preferred option, whereas among the online participants, design language 1 is by far the most favored.

The reasoning behind their choices may provide further insight:

Design language 1:

- "It aligns with what I already know from aircrafts."
- "It gives the calmest appearance; I think that is very pleasant, especially if people find flying nerve-wracking."
- "It gives me a calm, clean look. It's nice that the colours are light, that makes it feel fresh."
- "I find this one a bit too cold and distant."

Design language 2:

- "This aligns most with the electric cars I already know."
- "It feels a bit heavy for an aircraft."
- "Warm yet calm!"
- "Premium, high-tech."

5.9 Design language

5.9.3 Selection

- “Spot on, resembles innovation.”
- “I love the seat in DL 2.”

Design language 3:

- “I like this one the most. A bit funky, but I wouldn’t immediately associate it with electric.”
- “Clearly distinct from other aircraft interiors.”
- “No one design fits all formula can be found, this one works best for budget airlines.”

General comments:

- “I would like to experience that electric flying is different from a ‘regular aircraft’.”
- “I think people might find it exciting or nerve-wracking at first to fly electric, and that it therefore helps if the interior looks reassuring.”
- “I think I find Serene Flow just as beautiful as Warm Future, but the ‘vibe’ is probably more important right now. The second option feels a bit like a midlife crisis car (still beautiful though).”

Discussion

Drawing a clear conclusion is challenging, particularly because participants with prior knowledge (the Elysian team) expressed a substantially different preference compared to respondents from the online survey.

Based on both the results and the accompanying comments, a combination of elements from the different design languages appears to be the most suitable approach:

- The foundation is based on design language 2, due to the strong preference expressed by the Elysian team and its clear association with electric vehicles.
- Key characteristics linked to electric vehicles are incorporated (see Chapter 3.6).
- The overall appearance should feel lighter, similar to design language 1.
- Subtle warm accents are introduced to reduce tension and create a more welcoming atmosphere, inspired by design languages 1 and 3.

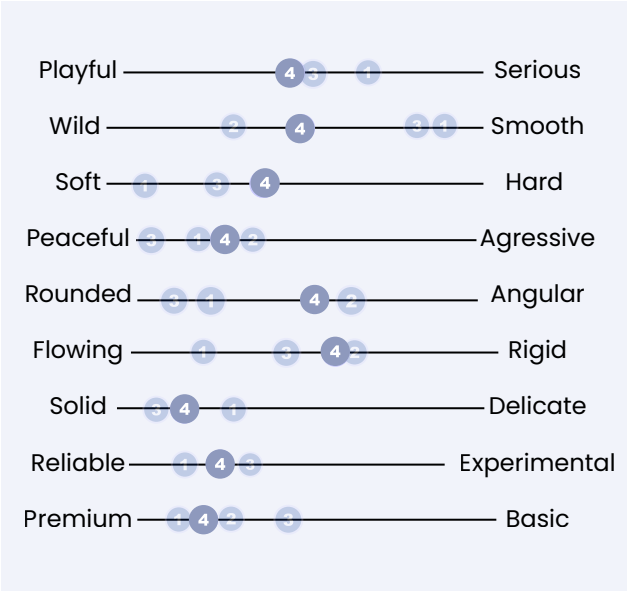


Figure 160: Opposition adjective scale for the new design language

Based on this, a revised visual quality framework was completed, followed by the development of visual quality scan framework and a a corresponding moodboard (see figure 161).

▸ **Visual quality scan fframework of design language 4 can be found in Appendix M**

▸ **A bigger version of this moodboard can be found in Appendix M**

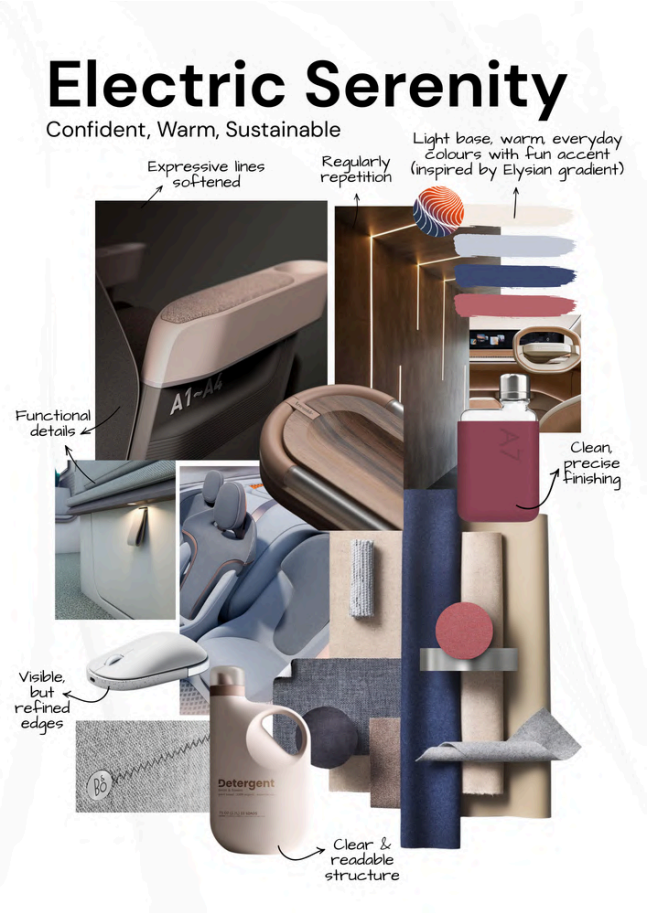


Figure 161: Moodboard final design language: Electric Serenity

By integrading feedback from multiple respondents across three proposed design languages, a singular design direction was formulated (see figure 161).

5.9 Design language

5.9.4 Implementation

Name & logo concept
Based on the selected design language and Elysian logo, a name & logo for the console concept is created for Elysian.

The term console is used to emphasize that the concept is not only a storage unit for baggage, but a multifunctional element within the cabin. In addition to providing storage, it contributes to privacy, enhances the perception of luxury, functions as an armrest and integrated additional features.

Several criteria were defined for the naming of the concept:

- The name should convey a sense of luxury.
- It should reflect innovation.
- The name should give an indication of its function or association.
- It should remain relatively simple and easy to understand & remember.

This resulted in the name: SkyConsole

SkyConsole
by ELYSIAN

SkyConsole in Elysian style
Sketches have been made to determine the shape and look of the seat. The outcome can be seen in figure 162.

- **Inspiration moodboard can be seen in Appendix M**
- **Sketches can be seen in Appendix M**

Figure 162: Skyconsole for Elysian

5.9 Design language

5.9.5 Ease of adapting

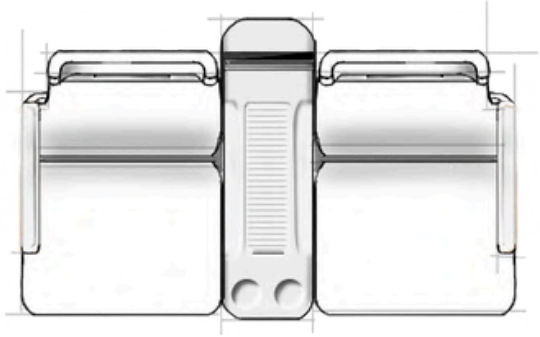
Adapting to different airlines
On the previous page can be seen what the SkyConsole concpet would look like in Elysian's design language, but it is also important to make it comparable with other design languages.

One of the stakeholders: leasing companies, but also other stakeholders such as airlines, benefit form the fact that the interior can be easily adapted. This is advantageous for both maintenance and airlines (see chapter 5.6.1).

The seat is designed so that it can be easily and quickly converted to another airline's design. Besides that, the components can easily be taken out of the aircraft for cleaning or repairing: resulting in less time on the ground for the aircraft, leading to reduced financial loss.

The idea is that the construction/shell of the seat and the console remain the same and are relatively neutral in shape and color, blending with the style of the airline (see figure 163).

The SkyConsoles can be slid along the rails to adjust to the desired seat pitch of the airline.



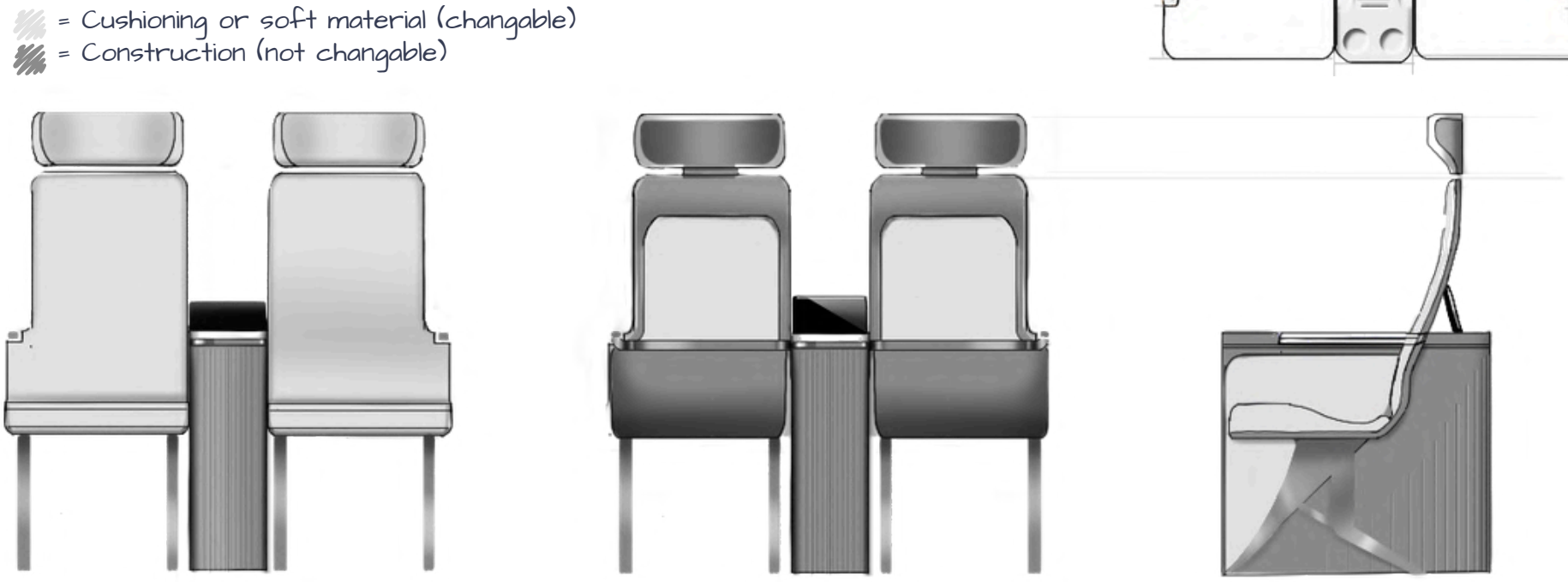


Figure 163: Neutral SkyConsole

5.9 Design language

5.9.5 Ease of adapting

Examples for Transavia & KLM

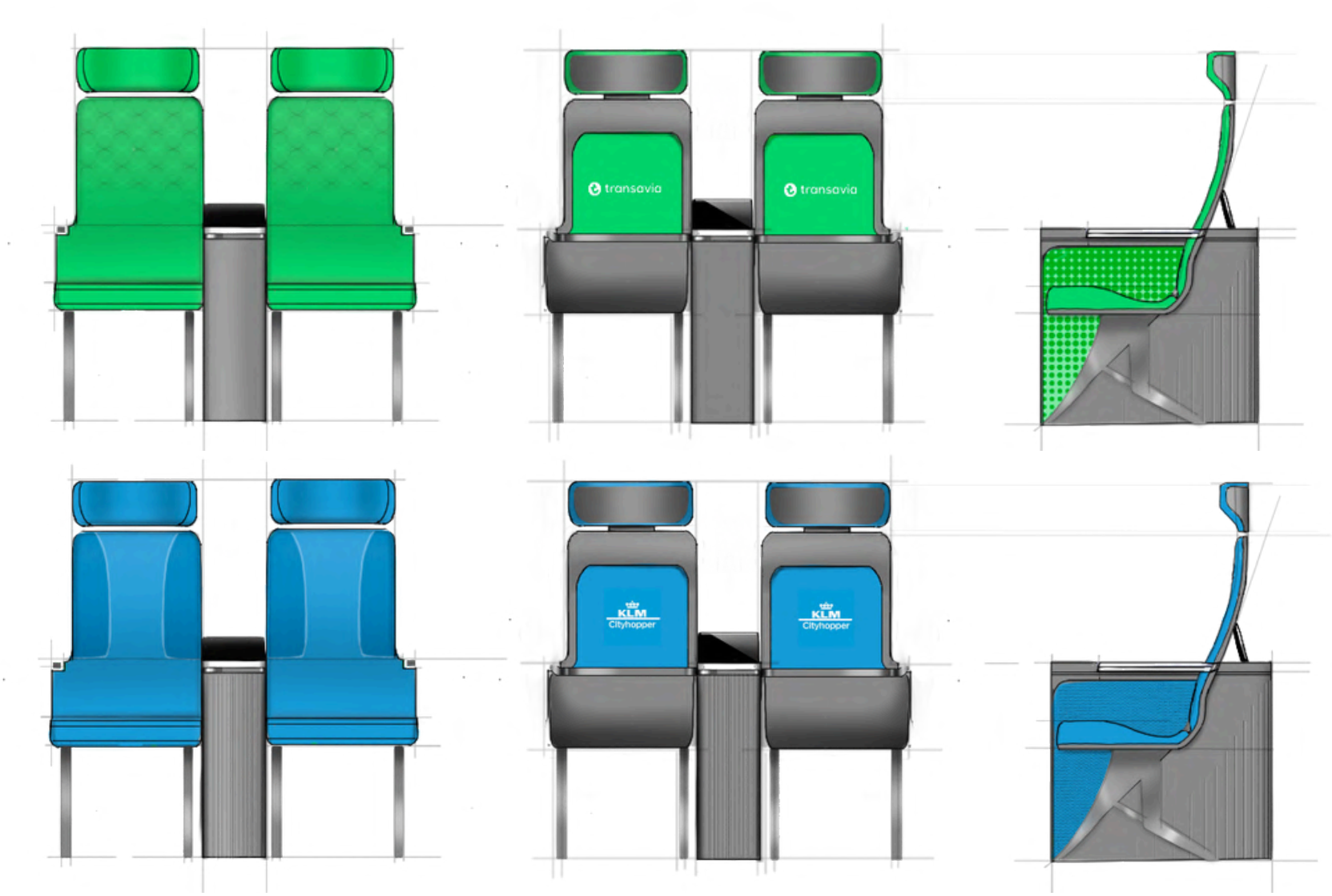


Figure 164: Examples of SkyConsole for Transavia & KLM

Chapter 6

Deliver

6.1 Final design

6.1.1 The Refined E9X cabin

A storage, dividing, and armrest console has been designed for the E9X in three different variants to offer future passengers an optimal experience. The design process took into account the needs of stakeholders such as cabin crew, airlines, and aircraft manufacturers, as well as the technical challenges involved in designing for an aircraft environment (including lightweight materials, dimensional and weight constraints, and certification requirements). Resulting in: the SkyConsole.

SkyConsole
by ELYSIAN


Front view - cabin


Side view - cabin


Back view - cabin

6.1 Final design

6.1.2 SkyConsole in short

6.1 Final design

6.1.3 Placement of luggage

6.1 Final design

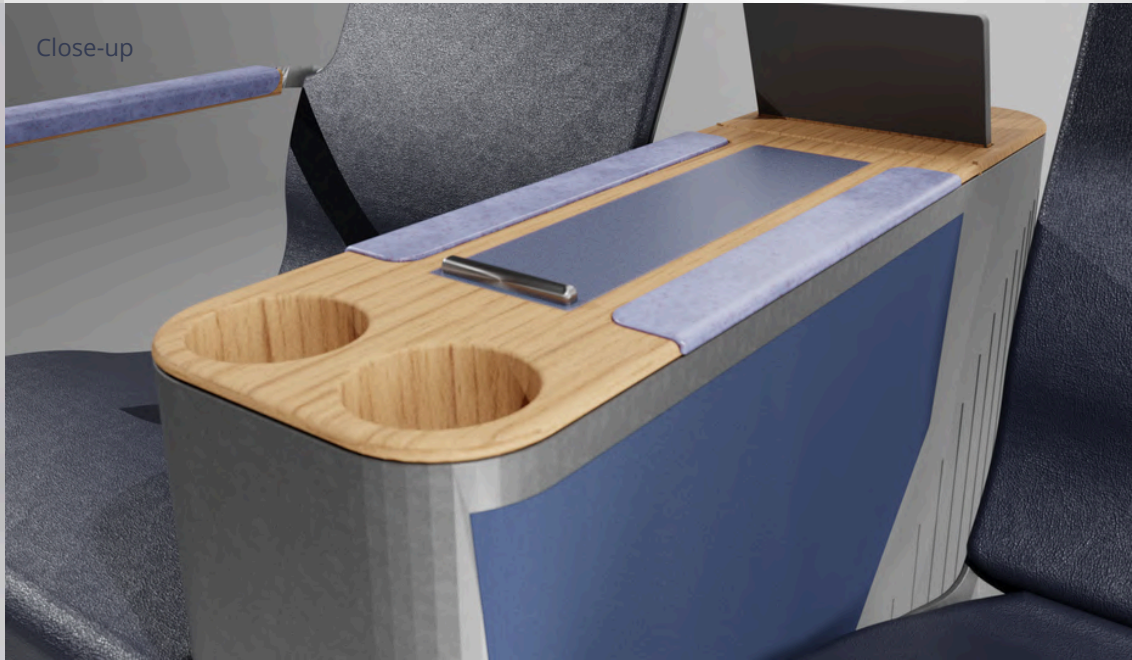
6.1.4 The SkyConsole

Front view

Side view

Back view

Close-up



6.1 Final design

6.1.5 Different classes

Relax Class

Business class (more comfort - seat width)

- *36" seatpitch*
- *45.4 cm seat width*
- *20 x 35 x 55 cm suitcase per person*

Nomad class

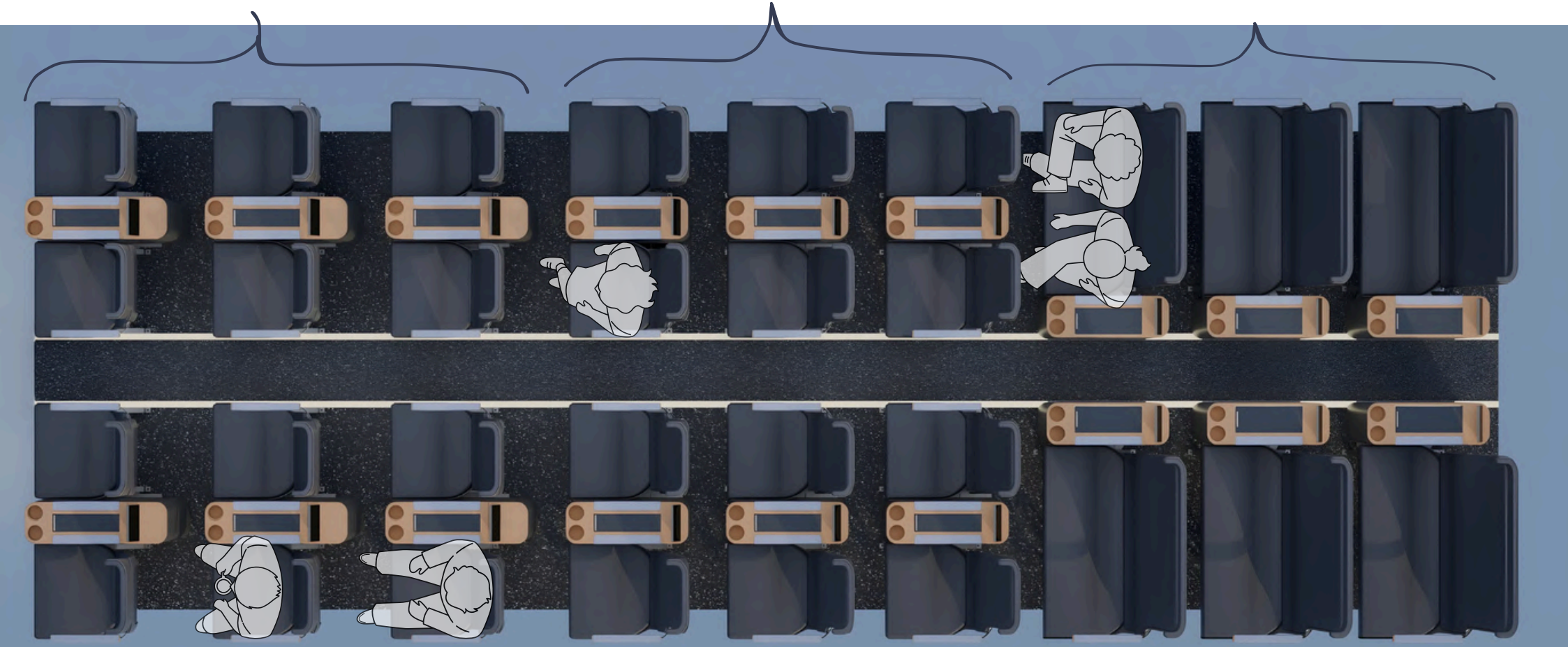
Economy class

- *32" seatpitch*
- *45.4 cm seat width*
- *20 x 30 x 55 cm suitcase per person*

CloudNest

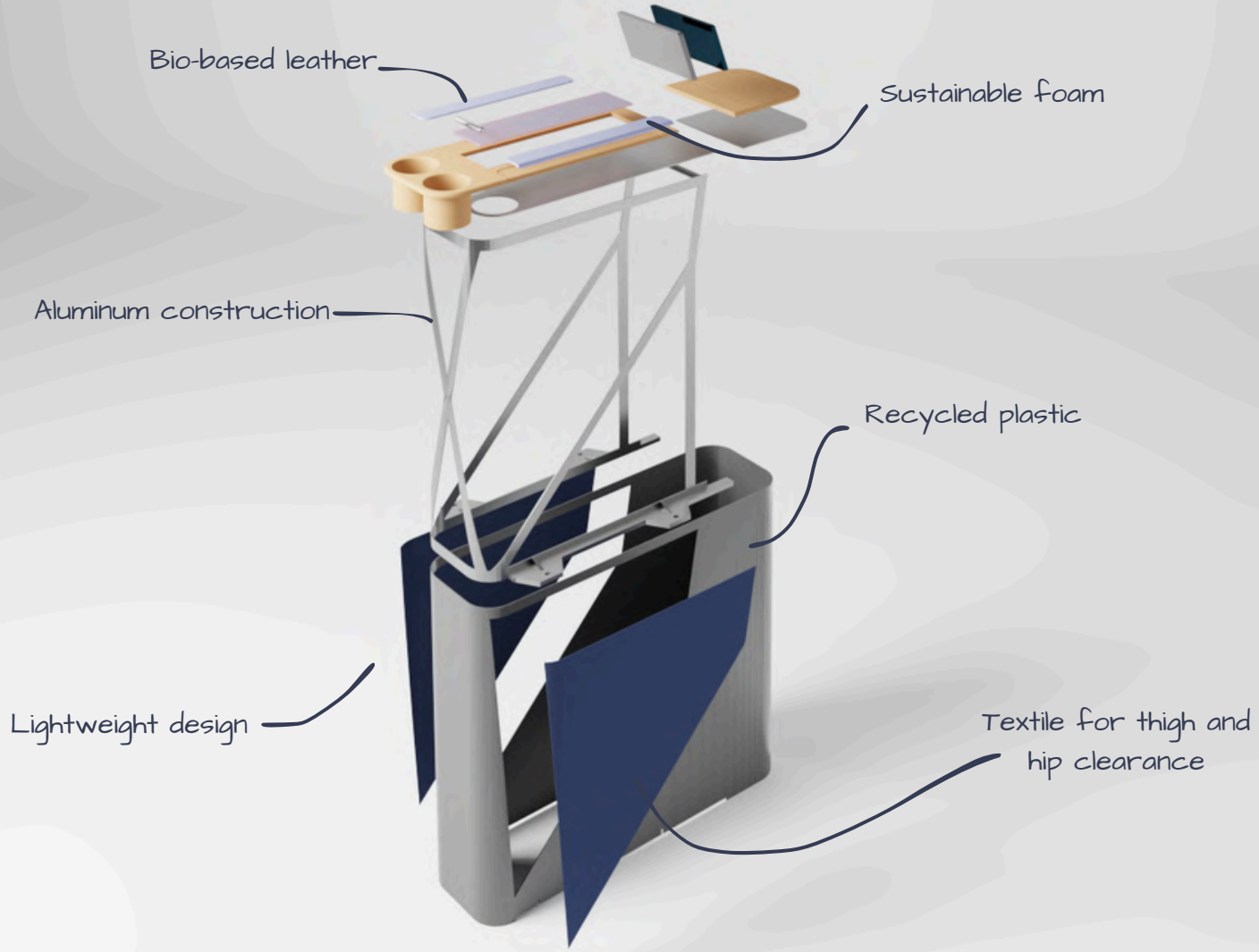
Family class

- *32" seatpitch*
- *90.8 cm seat width (for 2 passangers)*
- *40 x 60 x 55 cm storage space (for 2 passengers)*



6.1 Final design

6.1.6 Exploded view

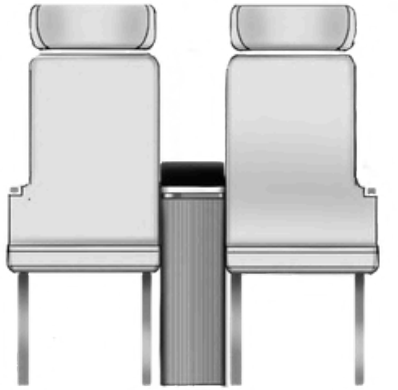


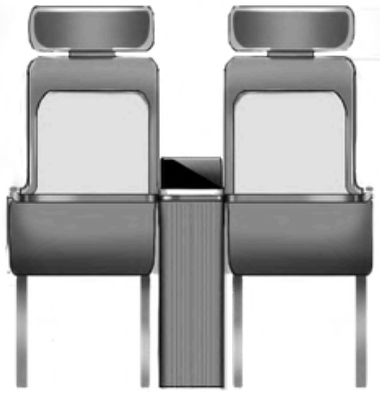
6.1 Final design

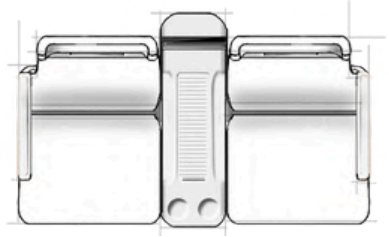
6.1.7 Ease of adapting

To accommodate the needs of airlines and aircraft companies, the skyConsole is easily adaptable to various airline configurations. This design also allows for quick maintenance and cleaning in case of dirt or damage, minimizing aircraft downtime. As a result, the core interior structure can be utilized for a longer period, reducing material waste and promoting sustainability.

= Cushioning or soft material (changable)
= Construction (not changable)







6.1 Final design

6.1.8 Extra functionalities

Sensors for preventing items being left behind and for facilitating cabin crew workflow.

Cup holders

Small personal items storage space

6.1 Final design

6.1.9 Cabin in use

Chapter 7

Evaluate

7.1 Evaluation Stakeholders

7.1.1 User testing

To properly evaluate the concept, mainly in terms of user-friendliness and comfort, user tests were conducted with 11 participants. The test involved placing a suitcase or backpack in the SkyConsole and then sitting on one of the seats and after that, leaving the aircraft with luggage. First, they were asked to do it intuitively (non-directed), and if they did not do it 'correctly', an explanation was given, and the participant was allowed to do it again.

▸ **The document that was used during the tests can be found in Appendix N**

Participant demographics
The participants consisted of four men and seven women, with heights ranging from 160-169 cm to 180-189 cm. Their frequency of exercise varied from never to five times a week. 10 of the 11 participants had experience using overhead bins on airplanes. The ages ranged from 18-24 years old to 55-64 years old.

Methods
This user research used a mixed-methods approach (like the floorcontainer test) consisting of direct observation, non-directed usability testing with a think-aloud protocol and a concluding survey and debriefing. This combination makes it possible to investigate both behavioral and subjective aspects of use. Participants were allowed to do the test alone or with someone else together.

Set-up
As shown in figure 165, a prototype of the SkyConsole concept was created for testing purposes. Next to the SkyConsole, two RebelSeats were placed. It was explicitly stated that the focus was not on the comfort of the seats, as this was not the main focus of the test and the seats used were a little different from the ones designed for the concept.

Figure 165: Protoype of SkyConsole for testing

The console was placed 18.9 cm from the front row to simulate boarding and disembarking, similar to what would occur in the SkyConsole concept (though there would be a console instead of seats). The row in front of the seats was important for the non-directed test, as this is a typical area where many people are accustomed to placing their belongings.

The suitcases (see figure 166) weighed 7 kg in total, as airlines typically set a maximum weight between 7 and 10 kg (Seo, 2025), and it was important the suitcase weight not to distract too much from the rest of the usage. It would be interesting to conduct further tests with heavier luggage.

Figure 166: Suitcase used in final test

Figure 167: Backpack used in final test

The first 10 participants were assigned the suitcase, and finally, three tests were conducted with a backpack (see figure 167) to compare the difference. The backpack weighed 5 kg to make the simulation as realistic as possible (Zweers, 2025).

Results
Intuitive use
Eight out of the 11 participants used the console correctly on the first try to place the carry-on luggage. The vast majority of the test subjects found it clear how to use.

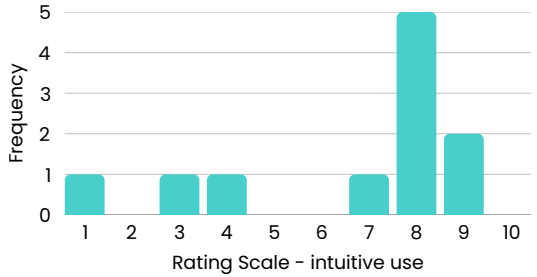


Figure 168: Rating of how intuitive the product was to use

The participants who did not understand it right away placed the luggage under the seat in front of them (see figure 169). Two participants who conducted the test together placed the suitcases horizontally in the console (see figure 170).

Figure 169: Bag placed in front

Figure 170: Horizontal placement of luggage in console

7.1 Evaluation Stakeholders

7.1.1 User testing

Participants indicated that there were no specific cues available, but it made sense to them because the layout was different from usual, and they assumed that the luggage should go there. Interestingly, no one placed the suitcase under the seat in front of them, this only happened with the backpack.

"There was some confusion on my part because it wasn't visually obvious that such a large suitcase would fit inside.

"It is clear that it has a lid, and a lid means it can open."

"Out of habit, I placed the bag under the seat in front of me, but if I had received a small hint or if I did this more often, it would actually be very easy and clear."

"I was hesitating whether the front part should be able to open in order to roll it in."

Comfort of luggage placement
After each participant had placed the luggage in the SkyConsole correctly at least once, they were asked how comfortable they found this way of storing their luggage on a scale from 1 to 10, with 5 representing the overhead bins.

The results are shown in figure 171. All participants found storing luggage in the SkyConsole more comfortable than in the overhead bins. One participant, who had no experience with the overhead bins, rated it on a scale of 1 to 10 without using it as a reference.

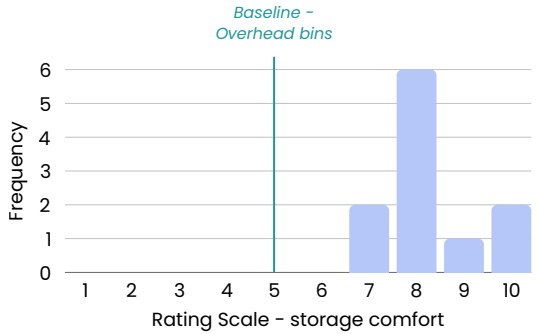


Figure 171: Rating of how comfortable it was to store the luggage

"It is easier to lift than over your head, but it is a bit more awkward at the window seat than at the aisle seat."

"You almost do not have to lift it."

"You do not have to lean over someone, which is nice. You can easily help the other person if you are already sitting, and it is a good conversation starter!"

"It is still a bit of a puzzle figuring out where I should stand when placing the suitcase."

Overall comfort of SkyConsole concept
The participants were then asked to rate the overall comfort on a scale from 1 to 10 (see figure 172). The **average** score on **overall comfort** was a **8.2**.

Two participants indicated that it was more difficult to reach the window seat due to the console.

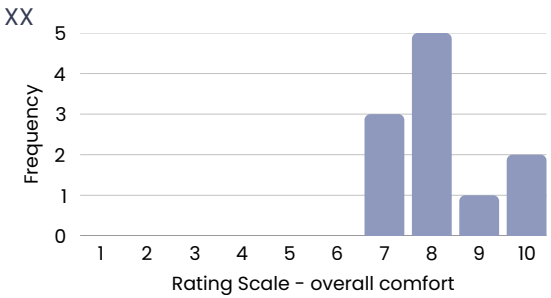


Figure 172: Rating of the overall comfort of the SkyConsole concept

"I did not have to lift, it fit well and sitting was more comfortable due ot the extra space."

"I think it is more comfortable if you know the passenger next to you."

"Clear, simple and covenient."

"I am curious how this works if you also have a phone and jacket in your hands."

Hygiene
The participants were asked to rate the hygiene on a scale from 1 to 10 (see figure 173).

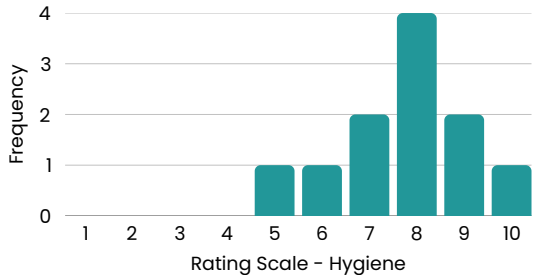


Figure 173: Rating of the overall comfort of the SkyConsole concept

7.1 Evaluation Stakeholders

7.1.1 User testing

Overall, participant indicated that they did not think about it being dirty.

> "Never thought that could be an issue."

> "I think it could be a bit dirtier because people might place their bag on the seat first."

> "I do not think it is any dirtier or cleaner than the current system."

> "Things could fall in and it might look like a trash bin for some people."

Other observations
It was noted that people with a backpack first sat down and then placed their bag in the console (see figure 174), while people with a suitcase placed it either from the aisle or standing in front of the seat. This could have a slightly positive impact on boarding time, as not every passenger stores their baggage from the aisle and fewer people need to wait for each other, but this requires further research.

Figure 174: Participant taking backpack with him to window seat

Figure 175: Participant standing in front of aisle seat while placing luggage

Figure 176: Participant placing a suitcase in the SkyConsole from the aisle

Conclusion
It seems that the SkyConsole is perceived as positive and comfortable. There is still room for improvement by adding use cues or explaining how the system works in another way. The method of storing luggage is clearly more comfortable than in the overhead bins. However, boarding to the window seat negatively impacts overall comfort. Hygiene could also be improved, as bags are placed on seats and things may fall into the console.

The SkyConsole offers **improved comfort** for luggage storage, but there are **areas** to **improve**, particularly in terms of **boarding** and **hygiene**.

7.1 Evaluation Stakeholders

7.1.2 Cabin Crew

To evaluate if the SkyConsole concept is also comfortable an operationeel wenselijk voor cabin crew an interview with a flight attendant was conducted (een van de flight attendants die in de analyse fase ook gebruikt was voor een interview).

Methods
This interview followed a semi-structured format, which is effective for gathering in-depth information. First, the SkyConsole was presented in broad terms, without additional details about its functionalities, certification, or dimensions. This was done to potentially verify these ideas and uncover interesting topics that may not have been considered yet. If a concern was raised, any potential solution that had already been considered was presented and evaluated.

► **The interview set-up can be found in Appendix O**

Introduction of the concept
The first reaction of her was very positive.

> "It looks very chic, with a nice appearance. The design and colors are beautiful. I think this would be very ergonomic for the cabin crew. No overhead bins would be so great."

But after asking about negative points, several concerns raised:

- Boarding to the window seat seems more difficult.
- What happens if someone needs their suitcase but there are drinks on the console?

Workflow of the system
After further questioning and going through the operational cycle, almost all additional functionalities had already been presented.

- ***IR sensor & sensors for closing console and seatbelt***

> "No more lost & found checks would be really nice."

> "The seatbelt and console sensors would save us so much time."

- ***Suitcase dimension check***

> "It would be perfect for checking suitcases, but I am worried people might work around it and sneak larger suitcases into the cabin.

- ***Easy changable interior***

> "This is also very nice for the cabin crew, if stuff gets dirty, but you have to store the spare parts somewhere."

- ***Tray Table***

According to her, the tray table is a must-have

> "I wouldn't recommend transparent tables, they get dirty quickly. It needs to be sturdy because kids jump on them and people lean on them."

- ***Phone Holder***

> "A phone holder is amazing.People are now building entire pyramids just to look at their phones."

An important point to consider is that there is currently no designated space for items that do not fit in the console, such as guitars, hats, or crutches. The flight attendant suggested storing these items in a central location. According to her, this would not be an issue for the cabin crew, as they can store and retrieve them when needed, while larger items (such as strollers) can be placed in the hold.

Operational feasability
Something that was not yet clear in the stakeholder analysis:

- ***Assistance with seating & luggage and Assistance with deboarding:***

> "This will be different, but certainly not more difficult than it is now."

The flight attendant indicated that the concept fits well within the operational cycle and saw few differences that would be significantly negative for the cabin crew.

Workload and ergonomics

> "This will definitely make a difference for me and many of my colleagues. I think KLM will also be happy that fewer people will drop out due to back injuries caused by the overhead bins."

Additional functionalities
The additional functionalities that had not yet been discussed were then presented:

- ***Special cups for spil prevention***

> "For business class, the glasses could be a solution. It might be more difficult to clean, though."

7.1 Evaluation Stakeholders

7.1.2 Cabin Crew

- ***Compartment for stowing small personal items***

She mentioned that she can imagine people might not always feel comfortable with this being a shared space.

> "Perhaps you could divide it into two separate sections; people might prefer that."

- ***Light***

This was clear: add this to the concept.

- ***Console divider***

> "As long as checking the baggage is easy, this is very convenient."

Comparison with the current situation
Overall, she was very positive about the difference between the overhead bins and the SkyConsole concept. Removing the overhead bins created a greater sense of space and had a positive impact on the way of working.

Other insights
She strongly recommended assigning the compartments in the console to specific seats in advance, to minimize confusion and potential conflicts.

Cleaning was also discussed. According to her, it would be somewhat different from the current situation and there is room for improvement in making the console easier to clean, but this was not considered a deal breaker.

She also pointed out that the acoustics might change without overhead bins. There is a possibility that more noise could travel through the cabin or that conversations between passengers might be reflected differently. This led to a discussion about enew opportunities created by the absence of overhead bins, ranging from innovative lighting to projecting the flight safety video on the ceiling.

Conclusion
It can be concluded that no major cabin crew related aspects were overlooked during the design process. The concept supports efficient working and, according to the flight attendant, may even offer benefits in terms of passenger behavior, cabin crew ergonomics, and reduced sick leave for KLM.

This quote summarized her thoughts on the concept:

> "It really comes down to feeling, flying is all about soft skills. The console can create a sense of safety, like a small personal space, almost like a living room. It changes how you experience space; it feels more luxurious and more spacious. People may feel less cramped and therefore less irritated, especially with the added sense of separation, like having your own space, but still an open and comfortable one."

The SkyConsole **fits well** within the **cabin crew's operational cycle**, and the interview provided valuable ideas for further development in the next phase.

7.2 Weight

7.2.1 Estimation

To validate the SkyConsole concept, it is important to estimate its weight, as the weight of the fuselage is crucial for efficiency. The power required from the aircraft's battery is linked to its weight, lift-to-drag ratio, and flight speed (Hepperle, n.d.). This shows that reducing weight is key, as any increase in weight directly affects power requirements and, therefore, the range.

The difference between the SkyConsole concept and a conventional aircraft lies in the furnishings and the fuselage weight, which is increased by [redacted] These changes are analyzed.

Furnishing:
It can be assumed that the rest of the weight will be comparable to the components currently used in an aircraft, with only the parts marked with an orange exclamation mark being sifnificantly different. Components like passenger service units, ceiling panels, and lighting systems may undergo some changes, but these changes are expected to have a minimal impact on the overall weight, which is why they are not being studied in detail at this stage.

- Furnishing (max. 2,098 kg (De Vries et al., 2024))
  - Cabin seats
  - Overhead bins
  - Cabin walls/panels
  - Lighting systems
  - Ceiling panels
  - Lavatories
  - Galley(s)
  - Passenger service units
  - IFE systems (inflight entertainments)
  - Safety features

Overhead bins
The traditional overhead bins will be removed and replaced by individual sky consoles. In order to make a proper comparison, the weights will be converted into weight per passenger.

The traditional overhead bins weigh as follows:
- Boeing 737-300, for 2 rows (6 passengers): 29 kg = **4.8 kg per passenger** (Cabin Units Interiors | SkyArt, n.d.)
- Airbus A320, for 2 rows (6 passengers): 40 kg = **6.67 kg per passenger** (Cabin Crew Safety, n.d.)

As shown in figure 177, the Relax Class SkyConsole weighs 3.3 kg per passenger, and the Nomad Class console weighs 2.8 kg per passenger, meaning both consoles **save** at least **one kilogram per passenger**. Which is at least **88 kg** in an aircraft designed for 88 passengers.

However, it is important to conduct further research into the static tests and the durability of the construction and material thickness to verify whether the SkyConsole can be certified with this composition.

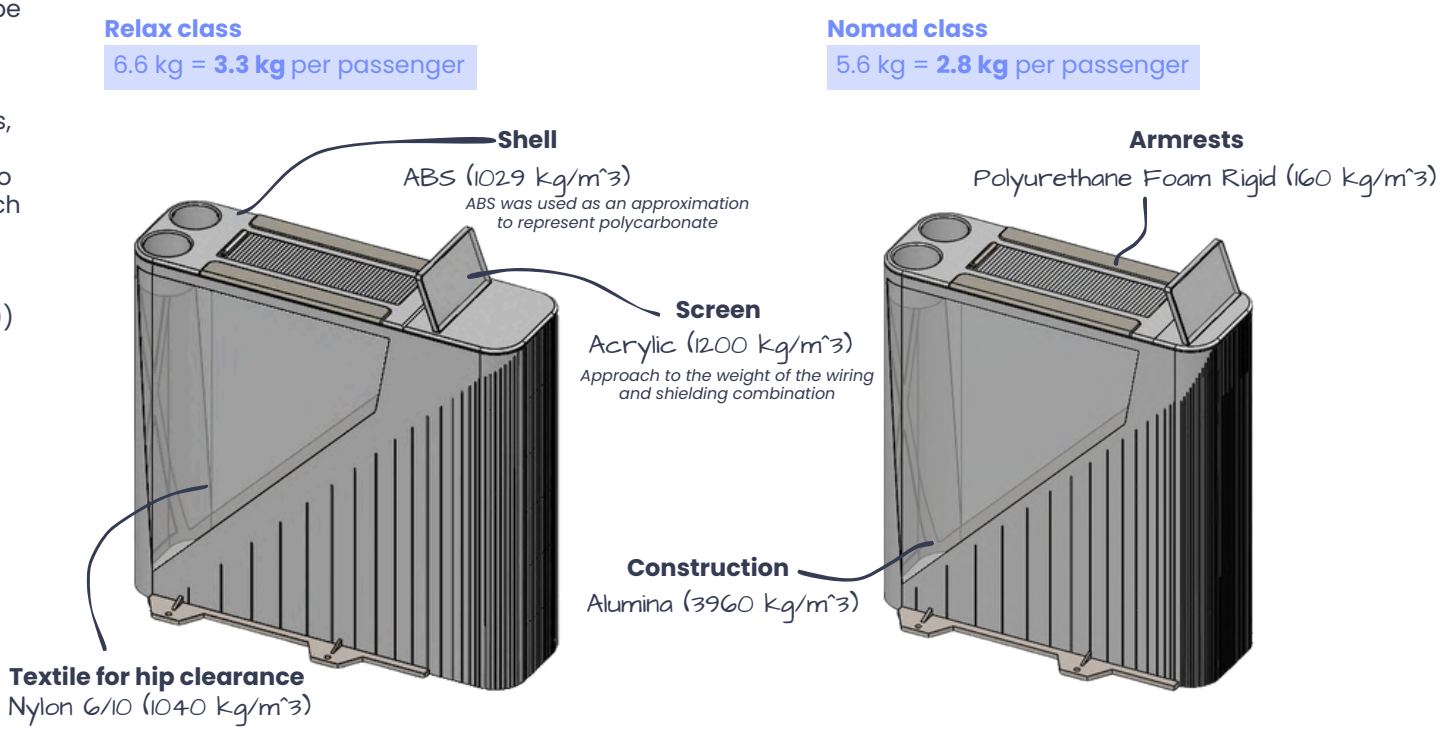


Figure 177: Weight estimation of Relax class - and Nomad class console

7.2 Weight

7.2.1 Estimation

Rebel seat
The seats in the SkyConsole concept are based on the Rebel seat, which was designed for the Flying V.

This is a lightweight seat and will therefore offer the potential to reduce overall weight.

An average aircraft seat weighs **10 kg** per passenger (see chapter 5.4.7).
The **Rebel seat** weighs **7.2 kg** (incl. two armrests per seat, one of which would be redundant for the Sky console). This would result in a weight saving of almost 3 kg per passenger.

For an aircraft with 88 passengers, this would result in a weight saving of **246 kg**.

Fuselage
Another significant difference in weight will be caused by the fact that the fuselage has been enlarged by 10 cm. The components that contribute to the weight of the fuselage include:

- Fuselage (max. 4,342 kg (De Vries et al., 2024))
  - Skin
  - Frames
  - Stringers
  - Bulkheads
  - Floor structure
  - Longerons
  - Windows and door frames
  - Doors and emergency exits

The enlargement of the fuselage has an effect on each of these components. To get an approximation of what that effect is, the relationship between volume and weight of the fuselage is considered (Ardema et al., 1996):

$$\rho_B = \frac{W_B}{V_B}$$

ρ_B	gross fuselage density
V_B	fuselage volume
W_B	weight of fuselage structure and attached components

Figure 178: Fomula for estimation of the aircraft's fuselage (Ardema et al., 1996)

The formula in figure 178 shows that the weight of the fuselage is directly proportional to the volume, assuming the density remains constant (unless there's a change in the material).

The fuselage originally had a diameter of [redacted] has been added. According to the formula in figure 178, this will result in a [redacted] increase in volume.

$$V = \pi \cdot h \cdot (D^2 - d^2) / 4$$

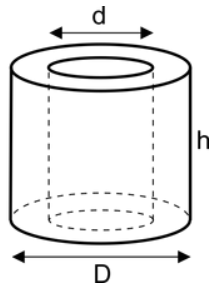


Figure 179: Fomula for volume of a cylinder (Hoyos, 2022)

The **weight** of the **fuselage** will therefore **increase** by approximately [redacted] what would result in a weight **increase of** [redacted]

Although a total of [redacted] kg will be added, there has been a weight saving of 246 kg through the reduction in seat and overhead bin weight, meaning the fuselage would weigh approximately the same or even less than before. In addition, not only will the weight increase due to the enlargement of the fuselage, but the aerodynamic drag will also change (see recommendations).

It is possible to reduce the seat width from 46 cm to 43 cm. This would eliminate the need to enlarge the fuselage, but it contradicts Airbus' recommendation to widen the seats (Experience, 2016).

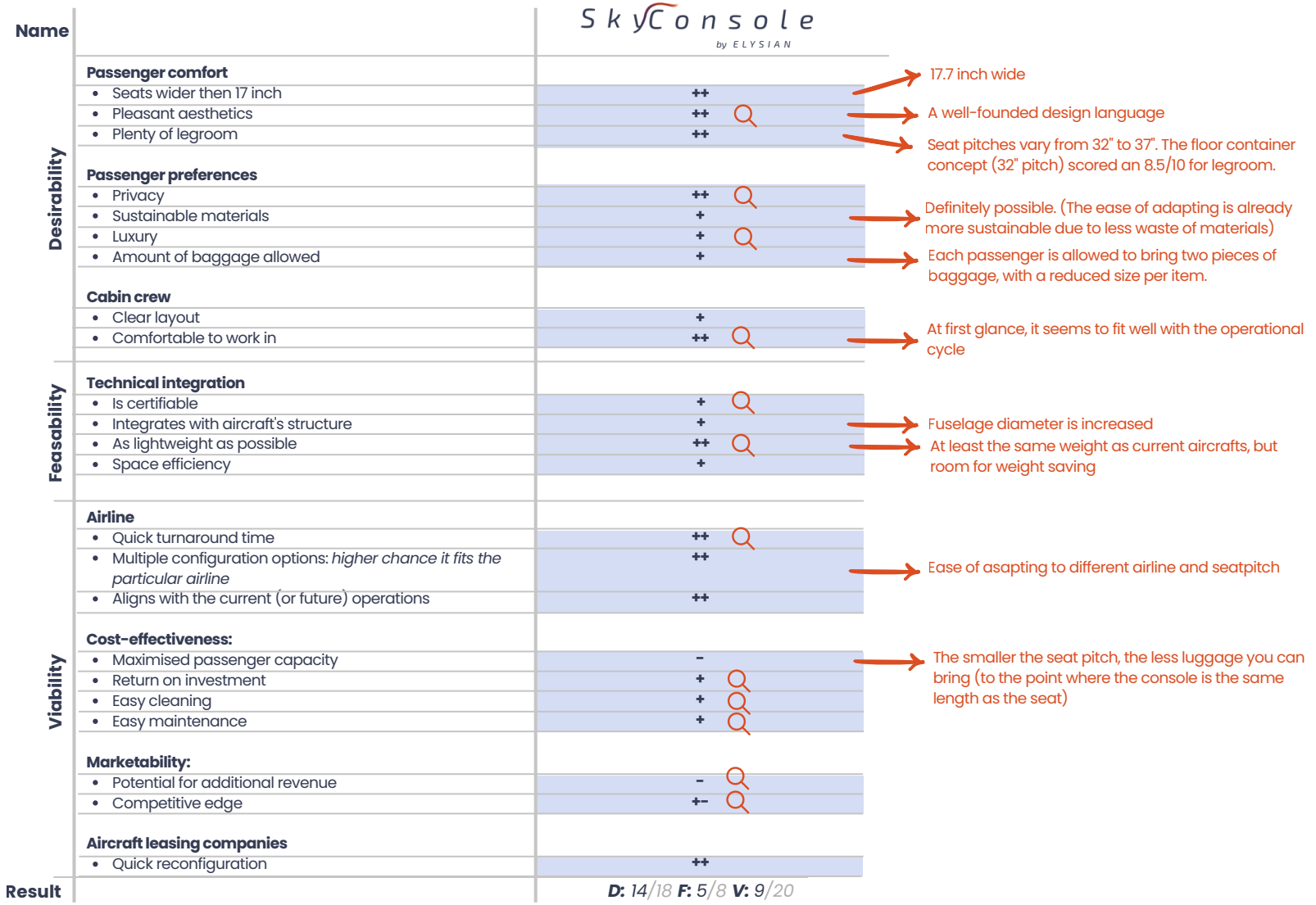
This is a trade-off that must be carefully considered (see recommendations).

The SkyConsoles concept offers a **promising opportunity** for **weight reduction**; however, the enlargement of the fuselage has a significant impact on the overall weight, meaning that the **final weight** will be **approximately** the **same (or slightly less than** before. By reconsidering the seat width, there may be potential for further weight savings. **Testing** is required to ensure **certification** and to confirm the **accuracy** of the calculated **weight**.

7.3 Evaluation

7.3.1 Desirability, Feasability, Viability

TFigure 180 presents the desirability, feasibility, and viability requirements and wishes. These have been reassessed based on the key takeaways from the previous chapters in the develop & evaluation parts.



Explanation:
In this concept evaluation matrix, the SkyConsole concept is evaluated per requirement using the following scores and corresponding values: ++ (2), + (1), +- (0), - (-1), and -- (-2). These values are ultimately summed up per categorie to determine which concept best aligns with the specified requirements in case of Desirability, Feasability and Viability

= needs more research to draw clear conclusion. This review is a reasonable assumption.

Figure 180: Evaluating Desirability, Feasability and Viability of SkyConsole

7.3 Evaluation

7.3.2 Conclusion

As shown on the previous page, the SkyConsole concept was evaluated across three categories: Desirability, Feasibility, and Viability. Figure 181 illustrates where the SkyConsole concept stands in relation to these three categories.

Desirability was 14/18 = 78%
Feasability had 5/8 = 63%
Viability had: 9/20 = 45%

It can be concluded that the SkyConsole concept performs well in terms of desirability and feasibility. However, there is still room for improvement in terms of viability. This will be especially important for convincing airlines.

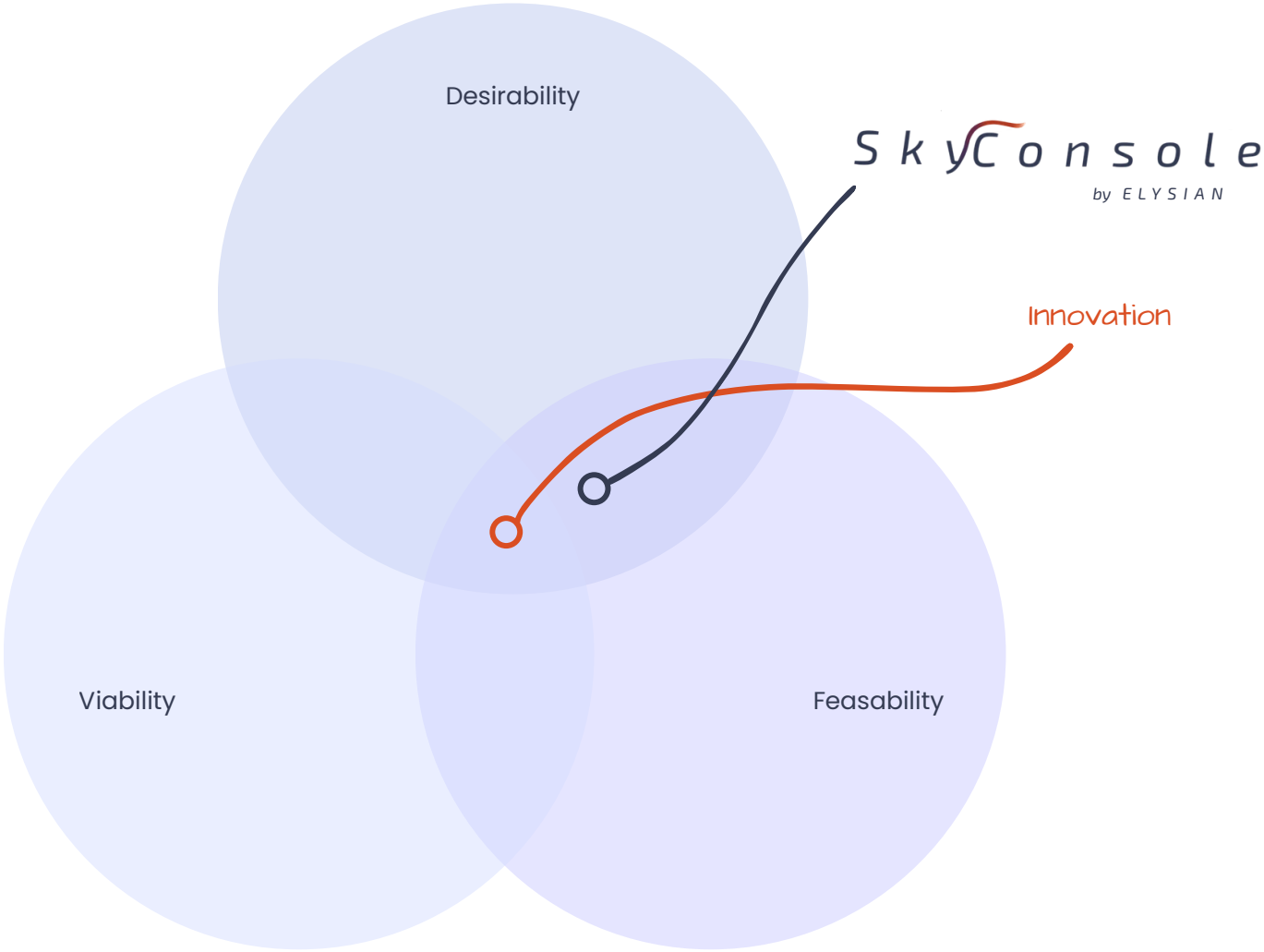


Figure 181: Design thinking Desirability, Feasability and Viability innovation diagram

Chapter 8

Conclusion

8.1 Limitations

There are several limitations to this project that should be noted and taken into account. These range from limitations related to the final design of the SkyConsole, to challenges faced during the research phase and scope due to the limited project timeline.

SkyConsole Concept:

Balance between seat width and fuselage diameter

A key challenge was finding the right balance between seat width and maintaining the original fuselage diameter. Increasing the seat width to 18 inches requires a larger fuselage diameter, which impacts the aircraft's weight and drag. Retaining the 'standard' seat width of 17 inches has, according to research, a less favorable impact on the passenger experience, but it keeps the concept feasible within the original fuselage diameter.

Access to the window seat

During testing of the floorcontainer concept, it became clear that participants were uncomfortable moving to the window seat. The placement of the console may make this even more difficult. Increasing the seat pitch could resolve this issue, but this is not cost-effective for airlines. Reducing the console size would also solve the problem, but it negatively impacts passenger satisfaction as they would be able to carry less luggage.

Usability and cleaning

The ability to easily clean the design is a major consideration. The idea of opening the console from the bottom for easy vacuuming is a potential solution, but this could create issues from a certification standpoint. More research is needed to determine how the design can remain both functional and easy to maintain.

Lid placement and accessibility

Placing the lid at ¾ of the console allows for placing the screen on the back of the console and the rear of the console to slide out for easier boarding (not fully developed, see scope limitations). However, this design makes it impossible to retrieve the rear luggage without first removing the front one. This issue requires further investigation.

Research:

Small user tests, not in a real environment

Many decisions in this project were based on short user tests with a limited number of participants. Due to limited resources and time, these tests were conducted on mock-ups rather than in a real environment. While the tests provided valuable insights into the design direction, the small sample size and use of mock-ups mean that the results may not fully reflect how the design would perform in real-world conditions. This is especially relevant for the floorcontainer concept, access to the window seat, and the seat pitch of the skyConsole. The same applies to the user test conducted during the evaluation phase.

Scope:

FEM Analysis for structural validation

The structural validity of the console is currently based on assumptions, but FEM (Finite Element Method) analysis needs to be conducted to confirm that the design meets the forces required by EASA for such systems.

Weight

Minimizing weight is a significant challenge. The choice of materials and the final design can influence the final weight limitations of the SkyConsole. A proposal for materials and construction has been made for this project, but this was not the main focus and requires further investigation to draw definitive conclusions.

Implementation of certification requirements, construction, and additional functionalities

Due to the limited time for this project, not all the requirements and functionalities based on certification regulations, stakeholder analysis and construction have been fully implemented into the final design. This aspect needs further investigation and integration into the design.

Sustainability

There is still room for improvement by conducting more research on sustainable materials. Additionally, further investigation is needed into how the ease of adapting this design compared to a standard aircraft impacts its sustainability, particularly in terms of the lifespan and environmental footprint of the overall design.

Airlines and Aircraft Leasing Companies

No in-depth research has been done regarding how airlines and aircraft leasing companies evaluate this concept. Assumptions were made based on conversations with Elysian, but further research is necessary to understand how these stakeholders would actually receive and implement the concept.

Luggage storage in the console

During user tests, it was observed that passengers often placed their luggage on the seats before placing in inside the console. This raises concerns about hygiene and whether passengers would exhibit the same behavior in a more controlled test environment. The impact of this behavior on the functionality of the design needs to be further explored.

Costs

There has not been done any research on the costs of the SkyConsole. This could be important to provide more insight into the viability of this design.

8.2 Overall conclusion

During this project, research was conducted to improve the passenger experience on the E9X aircraft by Elysian. After identifying opportunities for enhancing the passenger experience in the future, a design goal was established:

"Create a compact, **intuitive**, and **inclusive** aircraft interior that enhances **passenger comfort** and **crew efficiency** on short-haul flights by rethinking how **personal space**, **luggage**, and **interaction** coexist within **limited cabin dimensions**."

The SkyConsole concept successfully aligns with this design goal:

- **Intuitive**: The final user test showed that the design was intuitive, as 8 out of 11 participants successfully used the system without instructions. However, there is still room for improvement by adding more use cues to guide users.
- **Inclusive**: By widening the seats, not only has more comfort been provided, but the design also anticipates a future where more passengers may be overweight. The inclusivity aspect could still be further developed to accommodate those who typically face challenges in aircraft seating.
- **Passenger Comfort & Personal Space:** The wider seats, higher seat backs creating visual peace, and the separation between passengers provide high comfort. The evaluation resulted in a rating of 8.2 out of 10 for comfort and personal space.
- **Crew Efficiency**: Regular evaluations with cabin crew ensured that the concept effectively meets their operational needs.
- **Luggage**: The concept creates a dedicated space for each passenger's carry-on luggage, enhancing convenience and organization.
- **Interaction:** By introducing a barrier between seats, the potential for passenger irritation is minimized. Additionally, the console could serve as an interesting conversation starter between passengers.
- **Limited Cabin Dimensions:** Thoughtful decisions were made regarding the dimensions to ensure the design fits seamlessly within the existing E9X cabin layout.

In addition to the design goal, feasibility, desirability, and viability factors were addressed. Through testing, research, and design iterations, user testing confirmed that these aspects were improved compared to the initial concept.

8.3 Recommendations

The following recommendations are based on the limitations previously mentioned in this project. They aim to identify potential improvements for the future, both regarding the design of the SkyConsole and the execution of further research.

SkyConsole:
Balance between seat width and fuselage diameter
- Investigate the actual impact of increasing the fuselage diameter on power and range.
- Find the optimal balance between seat width, the volume of luggage that can be placed and the fuselage diameter.
- Explore alternative seat configurations that can increase seat width without enlarging the fuselage diameter.

Access to the window seat:
- Conduct more research on the access to the window seat.
- Optimize the console size to make access to the window seat easier without negatively affecting the passenger experience.
- Investigate alternative seat configurations that can maintain or increase the console length while still allowing easier access to the window seat.

Usability and cleaning:
- Explore innovative solutions for designing modular components that facilitate console maintenance without compromising functionality or certification requirements.

Research
Small user tests, not in a real environment
- *E*nsure that tests of the floor container concept, window seat access, and seat pitch are conducted in a real-world environment to validate the findings.

Scope:
FEM Analysis for structural validation and weight optimization:
- Conduct FEM analysis to confirm the structural integrity of the design and ensure that it meets the EASA requirements for such systems.
- Research lighter and more durable materials that maintain structural integrity while minimizing weight.
- Evaluate the impact of different materials on the weight of the design and their effect on the overall durability of the console.

Sustainability and adaptation to standard aircraft:
- Investigate how the adaptability of the design compares to the sustainability of a standard aircraft interior.
- Evaluate the impact on the lifespan and ecological footprint of the design when compared to traditional aircraft systems.

Airlines and Aircraft Leasing Companies:
- Evaluate the concept with airlines and aircraft leasing companies to gain insight into their willingness to implement the concept and define possible improvements.

Luggage storage and hygiene concerns:
- Investigate ways to optimize luggage storage for both hygiene and user convenience.
- Develop guidelines or a user education plan to ensure passengers use the system correctly, which would enhance hygiene and efficiency.

Combining with overhead bins:
- If there is increased demand for luggage space from airlines, leasing companies, or passengers, it could be beneficial to develop a smaller version of the SkyConsole that fits between seats to create more privacy and a sense of luxury. This should be explored further.

Chapter 9

Personal Reflection

10.1 Personal reflection

At the start of this project, I defined a set of goals, divided into professional and personal goals. To monitor my progress, I created a weekly template to track development and ensure these goals remained in focus (see figure 182). After the midterm evaluation, I added additional focus points. This structure made it easier to stay aligned with my goals and maintain a clear overview throughout the project.

Figure 182: Weekly form

Professional

Interdisciplinary integration

Early on, I realized that aircraft interior design is far more than an aesthetic challenge. It involves many complex aspects beyond my expertise, such as certification, structures, and operational cycles. I had an insightful conversation about certification with Floris from Elysian and maintained close contact with cabin crew to better understand operational workflows. These discussions were both enjoyable and highly valuable. Overall, I am satisfied with how I integrated different disciplines, although I would have liked to consult a construction expert to further validate and develop the concept if I had more time.

Calm in ambiguity & accept the unknown

From the beginning, I anticipated that the early stages of the project would be uncertain due to the lack of a clearly defined research question. While this offered freedom, it also introduced doubt. There were moments, particularly around the midterm, where I was not satisfied with my ideas, which caused some stress. This improved after developing the console concept, although I occasionally questioned whether it was truly the right direction. This goal required continuous attention and was something I actively had to remind myself of throughout the project.

Because of the broad starting point, my analysis ended up being quite scattered, and I sometimes found it difficult to summarize in my report. The second part of the process and the report (the development of the concept) is really where my interest shines the most. I'm generally satisfied with this part (although the concept still has many flaws and challenges).

Show structured professionalism

I aimed to approach every meeting with clear preparation and defined objectives. Overall, I am satisfied with how this went. However, during busy periods leading up to deadlines, this was often the first aspect to suffer, indicating room for improvement in the future.

Work efficiently

I am pleased with how efficiently I worked and how much I was able to explore within the concept. I noticed that I can make decisions quickly, which is a strength, but I need to remain critical of which decisions require deeper consideration. Additionally, I should ensure enough time is reserved for finalizing and refining work, as this stage cannot be rushed.

Deep dive into the airplane industry

At the start of the project, an aerospace engineering student helped me understand the fundamentals of aircraft design, which provided a strong foundation. The aviation industry fascinates me, and I feel that I have learned a significant amount over the past months.

Key Insights

- Collaborating with other disciplines was very educational and interesting, and it benefited the project.
- Starting a project with a broad approach has both positive and negative aspects. Next time, I will personally aim for a more defined goal from the beginning.
- Using the weekly form was helpful and ensured that the goals were evaluated and not forgotten.

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