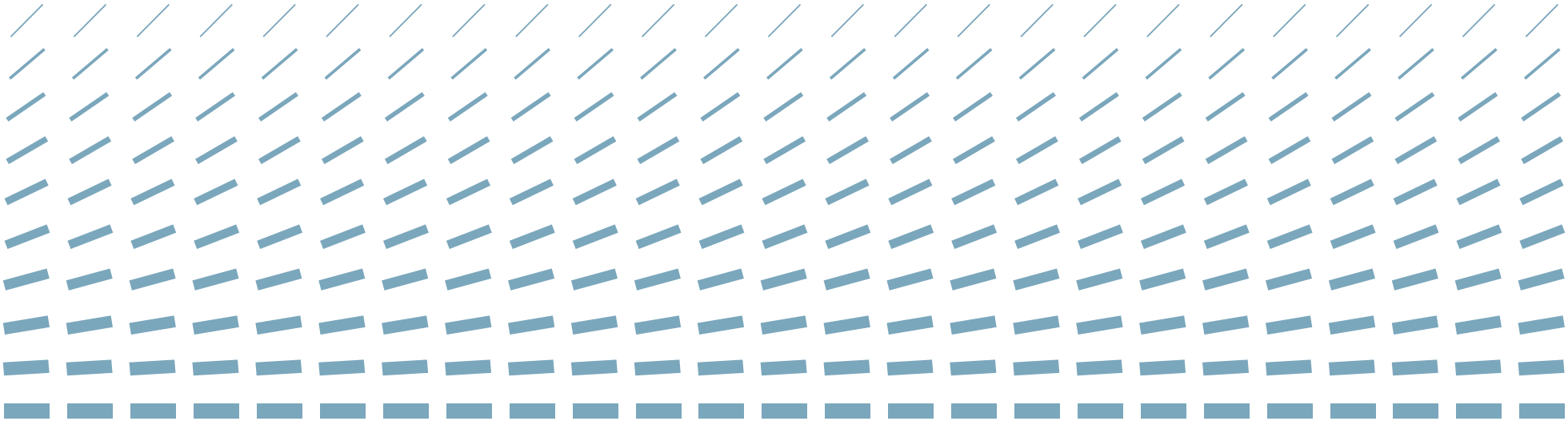
Expanding Collins Aerospace's Oven Portfolio Through Optimised Part Commonality

Master thesis

Emma Binnendijk



Master Thesis
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MSc Integrated Product Design
Faculty of Industrial Design Engineering
Delft University of Technology

Student
Emma Binnendijk
5043875

Chair TU Delft
Prof.ir. Daan van Eijk

Mentor TU Delft
Ir. André Valkenhoff

Company mentors Collins Aerospace
Ing. Michiel Blaauwhof
Ir. Marc Jaspers

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Preface

This thesis marks the end of my studies at IDE in Delft. From February till July 2025 I worked on this graduation project for my Masters degree Integrated Product Design. This project involves the design of a physical product within a context of strict technical requirements. This area of industrial design has increasingly fascinated me during my time in Delft. I appreciated the opportunity to explore this within a real industry context at Collins Aerospace.

I would like to thank my Collins Aerospace mentors, Marc and Michiel, for giving me the opportunity to work on this project. Their guidance and expertise were of great value to me throughout the process. I also appreciated the chance to work in the Collins Aerospace office in Houten and to visit the Aircraft Interiors Expo in Hamburg.

I would like to thank my mentor André and chair Daan for their wise design advice and the trust they placed in me during this project, as well as for helping to keep the ‘integrated’ in Integrated Product Design. Part of it being an integrated design is keeping the user in mind, I would therefore also like to thank all users and experts I got to interview at KLM and Transavia during the process.

I am lucky to have had the support of my friends from ‘KBP’ during my time in and around IDE. Throughout this and other projects, I could always turn to you for design advice , but also for some much-needed distraction along the way.

Lastly I want to thank Martin, Margreet, Anne Sophie, Juliët and Jasper for their support and motivation. With the family motto ‘opletten, je best doen en plezier maken’ in mind, a lot turns out to be possible, even obtaining a master’s degree.

Emma Binnendijk
Delft, June 2025

Executive Summary

This thesis presents the proposed design for a modular concept for three oven products for Collins Aerospace, that answers the design assignment:

> **"Develop a concept for three modular aerospace galley oven products sharing a common chassis and have a minimum amount of unique parts to create a new business opportunity in the form of new products for Collins Aerospace."**

Collins Aerospace is a leading provider of aerospace solutions. Its galley inserts division specialises in designing in-flight galley equipment for commercial aircraft. These products are developed to meet strict aerospace industry standards and customer needs. Part of the galley inserts portfolio are convection and steam ovens, which heat up meals up to 170 °C, and bun warmers, which use static air to warm bread up to 80 °C. Currently, Collins Aerospace offers these products in standardised galley sizes, including Size 2 ovens and Size 4 bun warmers. There is a limited demand for the proposed new products for this project are a Size 4 oven, Size 4 bun warmer, and Size 5 bun warmer, making individual development not feasible, the modular approach could help to adress this gap in the portfolio. A Size 2 measures 563 × 287 × 570 mm, a Size 4 is half the height of a Size 2, and a Size 5 is half the depth of a Size 4.

To address the assignment, the Double Diamond design process is followed, consisting of the phases: Analyse, Define, Design, and Deliver. Throughout all phases, an integrated approach is applied by focusing on three key perspectives: the user, business, and technology.

In the Analyse phase the user, business, and technology context and needs are researched. The key insights from this phase lead to the main design drivers and list of requirements and wishes set in the Define phase. The main design drivers that are the basis of the following phases are:

Main design drivers

- The products must be usable for flight attendants when placed above worktop height.
- All three products share a common door design and fit product specific elements within a shared frame. Next to the door, shared components should be commonly designed wherever possible.
- The three products fit in the existing design language of the Essence and Modus collection of Collins Aerospace.
- The oven should have a capacity of at least 12 meals, with and extended goal of 16 meals.

In the Design phase, multiple design directions were explored. With criteria derived from the main design drivers and requirements the most suitable design direction was chosen. In the Deliver phase the layout of the elements, user interface, and integration in the Collins Aerospace design language was developed and validated.

This final design answers the assignment by proposing a modular design for three galley oven products, with a shared chassis, door, inner oven, user interface, and electronics between two or three of the products. Only a minimal amount of product specific element are required to define the individual product, primarily the heating elements. The design is user-centered, with an angled interface positioned on the side of the product to ensure ergonomic use for flight attendants. By combining these technical and user-focused aspects, the concept provides a business opportunity to expand the galley inserts portfolio for Collins Aerospace.

Recommendations include conducting further testing with a broader, international user group and validating the heating performance of the proposed products.

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1. Introduction



This chapter introduces the assignment, together with the context and approach of the project, as well as the structure of the report.

1.1 Context
1.2 Assignment
1.3 Approach and report set-up
1.4 Glossary

1.1 Context

The company

Collins Aerospace, an RTX Business, is a leading provider of aerospace and defense solutions. The company's galley inserts business is a division specialised in designing and manufacturing various products for aircraft galleys. These include a wide range of equipment and components that cater to the needs of both passengers and crew during flights.

Collins Aerospace's galley inserts business offers innovative and high-quality solutions to airlines and airframe manufacturers. These galley inserts are designed with a focus on efficiency, weight reduction, usability, and maximizing space utilisation to meet the strict requirements of the aviation industry. The company aims to enhance the in-flight experience for passengers while also streamlining operations for airlines and crew members.

Ovens and bun warmers

Part of Collins Aerospace's galley inserts product portfolio are ovens and bun warmers. Currently they offer multiple ovens and bun warmers (see Figure 1). The ovens are steam and/or convection ovens with airflow provided by a fan, bun warmers only have simple heating elements and operate with static air. This results in the ovens reaching temperatures of 170 °C and bun warmers only reaching 80 °C.

The ovens are common products purchased and used by airlines to heat up inflight meals for passengers and crew. The bun warmer is an extra option next to ovens, it is used to warm up buns and tableware. Per year 4000-5000 ovens and 150-200 bun warmers are sold by Collins Aerospace.



Figure 1: *Collins Aerospace ovens and bun warmer.*

1.2 Assignment

Problem definition

A limited demand for small sized ovens and bun warmers from Collins Aerospace customers cannot be met due to high development costs of these individual products. To address this gap in the portfolio, a modular approach with common parts between the products is seen as an opportunity. By doing this, less individual development (design and qualification) costs are needed, since similar or shared parts are used, as well as a shared appearance and way of use. It can also serve as an inspiration for further modular approached design in future galley inserts.

Three oven configurations are requested:
1. Bun warmer, ARINC Size 4
2. Bun warmer, ARINC Size 5
3. Half size oven, ARINC Size 4

ARINC standard sizes are used (see Figure 2), the standard size of an oven is Size 2 (563 × 287 × 570 mm), the proposed small oven is a Size 4, which is half a Size 2 in height. The existing bun warmer is Size 4, an extra proposed bun warmer should be Size 5, which is half a Size 4 in depth.

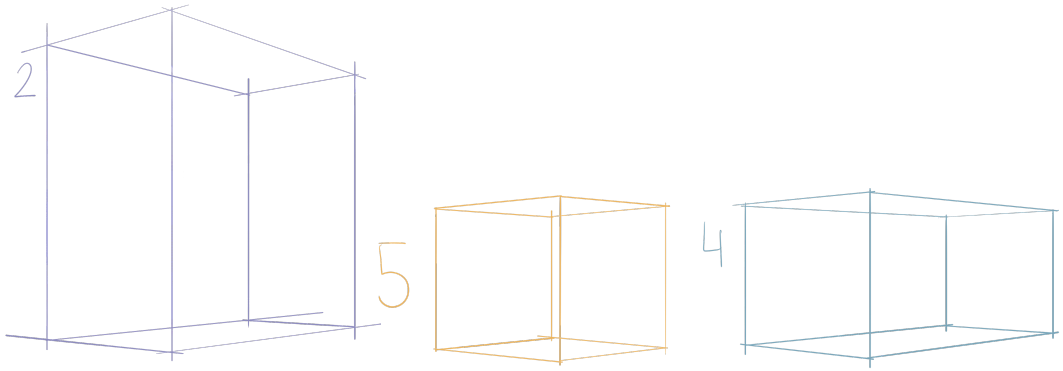
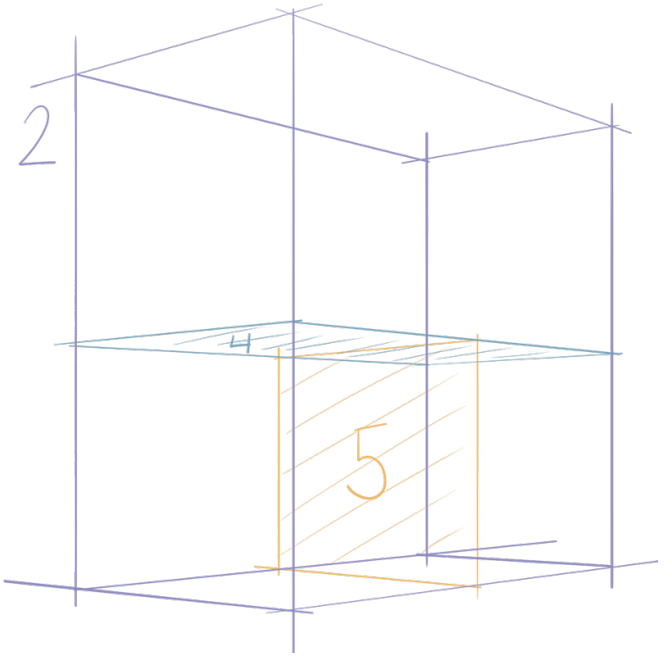


Figure 2: *ARINC sizes ovens and bun warmers.*

Assignment

The assignment for this project based on the problem and foreseen opportunity is:

> **"Develop a concept for three modular aerospace galley oven products sharing a common chassis and have a minimum amount of unique parts to create a new business opportunity in the form of new products for Collins Aerospace."**



1.3 Approach and report structure

The primary approach of this project is based on the Double Diamond model, following the four stages of 'Analyse', 'Define', 'Design', and 'Deliver'. Within these stages different design methods from the Delft Design Guide (van Boeijen et al., 2013) and Roozenburg en Eekels (1998) are used. The design approach with main activities per stage in visualised in Figure 4. Throughout the phases a contiuous focus on three key perspectives for an integrated design are considered: the user, business, and technology (see Figure 3)

The chapters in this report follow the same structure as the design approach. Chapter 2 presents the Analyse phase of the project. In this phase the technical, business, human, and trend aspects are analysed. This leads to the understanding of the products, their use, and opportunities. Chapter 3 presents the Define phase, in which the findings of the Analyse phase are used to set the main design drivers and list of requirements and wishes. The Define phase sets the focus of the Design phase, in which ideation leads to design directions. Based on the main design drivers and list of requirements and wishes a concept is chosen and developed. After this development, the final product is presented and validated in Chapter 5 Deliver. Chapter 6 and 7 finishes the report with the conclusion and recommendations.

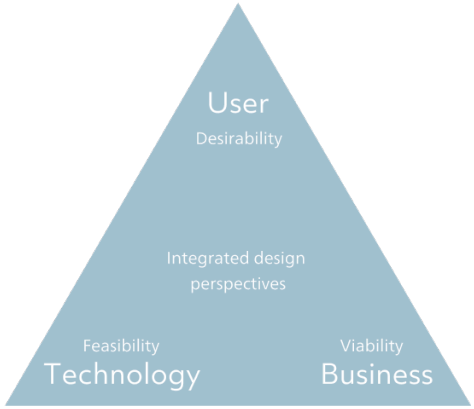


Figure 3: *Integrated design approach.*

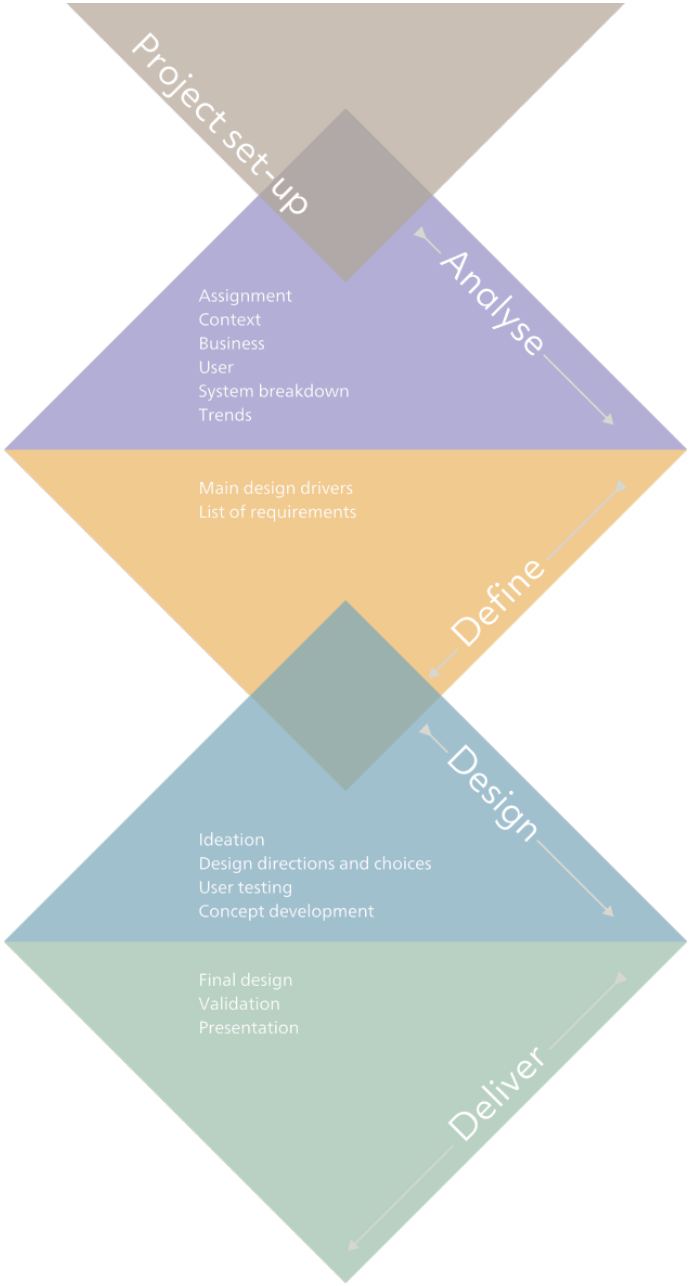


Figure 4: *Double Diamond project approach.*

1.4 Glossary

AIX	Aircraft Interiors Expo
ARINC	Aeronautical Radio Incorporated; describes the form, fit, function and interfaces of avionics, cabin systems and aircraft networks.
Basket	Insert voor bun warmer
EASA	European Union Aviation Safety Agency
FAA	Federal Aviation Administration
FA	Flight attendant
Galley	Kitchen in aircraft
HMI	Human machine interface
Insert	Removable container placed in galley insert
Meal carrier	Insert for oven
OEM	Original Equipment Manufacturer
Retainer / Double retainer	Lock / Two independent locks
Skit	Tray that is inserted in, and part of meal carrier
ULTEM/PEI	ULTEM is a trade name for the material PEI (polyetherimide), an advanced plastic.

2. Analyse



This chapter presents the analysis of the business, human, technical, and trend aspects of the oven and bun warmer. The analysis is done by desk research, taking apart ovens and bun warmers, interviews, consulting experts at Collins Aerospace, and visiting the Aircraft Interiors Expo in Hamburg.

The key insights per topic are highlighted in blue boxes throughout this chapter. These insights serve as input for the Define phase discussed in Chapter 3.

2.1 Business
2.2 User
2.3 System breakdown
2.4 Trends

2.1 Business

The proposed products should expand the galley inserts portfolio of Collins Aerospace. To get insight on why and how these new products could do this, the portfolios of Collins Aerospace and competitors are researched.

Galley inserts portfolio Collins Aerospace

Collins Aerospace has a long history with designing galley inserts. Before the current galley insert collections started, the product portfolio existed of individual products, developed by different companies that were later acquired by Collins Aerospace. Nowadays, there are three Collins Aerospace galley insert collections: Endura, Essence, and Modus.

The collection with the oldest products is the Endura collection (see Figure 5), consisting of steam and/or convection ovens, a bun warmer, a coffee maker , a water boiler, and a tri-mode chiller (beverage chiller/refrigerator/freezer).



Figure 5: *Collins Aerospace Endura galley inserts.*

The Endura products were introduced as individual products in 2004 and 2005 and were grouped as Endura only after the introduction of the Essence galley inserts collection in 2012. With this the more technical numbered products, like the DS3000 oven, were given the branded Endura name.

Since the Endura products were developed individually, there is no design consistency in this collection. However, Collins Aerospace made the first variable frequency oven and had the patent for a closed steam system in ovens, gaining a huge advantage to competitors. This innovative design paid off, the Endura oven is Collins Aerospace's most sold product with over 40.000 ovens manufactured.

The next step for Collins Aerospace was taken in the Essence collection (see Figure 6). With the help of design consulting agency Teague, they developed a common design language for all inserts, creating a family of galley inserts, something that was new at the time (Teague, 2023). The Essence collection is wide, with steam and convection ovens, a bun warmer, microwave oven, coffee maker, espresso and cappuccino maker, Nespresso maker, water boiler (tank with spout), beverage cup (hot water jug), and tri-mode chiller. The Essence galley inserts collection won a Crystal Cabin Award, an important award in the aerospace business, in 2012.



Figure 6: *Collins Aerospace Essence galley inserts.*

The Essence collection inspired two other introductions. First the Modus collection (see Figure 7) was introduced. The Modus collection consists of steam and/or convection ovens, a coffee maker, and a water heater. With Modus Collins Aerospace offers entry level products with a similar, but more simple looking, design as the Essence collection. For example, in the Modus oven, the premium retainer systems of the Essence oven are replaced by a traditional quarter turn retainer (see Figure 8 and 9). Next to an entry level collection, premium ovens were introduced. The Essence Premier oven (see Figure 10) is a premium oven complimentary to the Essence collection. The Essence Premier distinguishes itself with a more premium looking HMI, as well as a lighter inner oven because of the change of material to titanium.



Figure 7: *Collins Aerospace Modus galley inserts.*

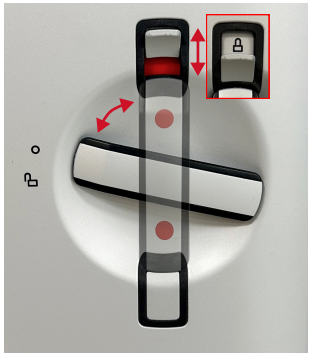


Figure 8: *Double retainment integrated in handle.*

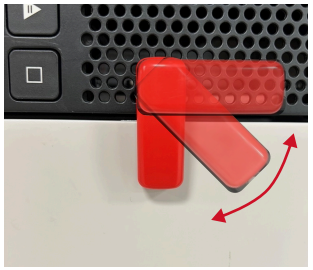


Figure 9: *Modus double retainment with separate quarter turn retainer.*



Figure 10: *Collins Aerospace Essence Premier oven.*

Key insights

- Collins Aerospace's galley insert portfolio evolved from individually developed products into three branded collections: Endura, Essence, and Modus.
- The portfolio includes a wide range of galley inserts and covers premium, standard, and entry-level market segments.
- Collins Aerospace stands out through technical and design innovations.
- The Essence collection introduced the first common design language across galley inserts.

Competitors

There are a few competitors selling similar galley inserts as Collins Aerospace. The French company Safran is the main competitor, Ipeco and Iacobucci are smaller, but also have distinctive products.

Safran offers three galley insert lines. The oldest is the Concert line (see Figure 12), including a steam and convection oven, bun warmer, coffee maker, water boiler, and tri-mode chiller. Their newer and more extensive NUVO line (see Figure 13) offers a steam and convection oven, bun warmer, coffee maker, espresso maker, water boiler, and tri-mode chiller. Lastly they have a business jet line (see Figure 14) with a steam and convection oven, bun warmer, microwave oven, coffee maker, and water boiler. Next to these lines of products, Safran also still offers and old size half oven and half size bun warmer, these have similar sizing as the proposed products of this project. Safran offering these products is one of the reasons it is interesting for Collins Aerospace to possibly add theses products to their portfolio.

Safran uses a double retainer system, where both can be unlocked with one movement, making the use easy and the look consistent and simple. They do this by placing the two handles that unlock the door above each other, together they seem to form one bigger handle. Two green/red indicators helps the user understand the status of the lock. This is best visible in the NUVO products, a close up is shown in Figure 11.



Figure 11: *Safran one handle double retainer (Safran, n.d.).*



Figure 12: *Safran Concert galley inserts line (Safran, n.d.).*



Figure 13: *Safran NUVO galley inserts line (Kirby, 2021).*



Figure 14: *Safran Business jet galley inserts line (Safran, n.d.).*

Ipeco has one unnamed galley inserts line (see Figure 15) with a steam and convection oven, microwave oven, coffee maker, water boiler, tri-mode chiller, and a modular cooktop. Their microwave oven is unique because of its ARINC Size 4. The modular cooktop can be used with different applications, like pans and pots, a rice cooker, and a toaster, this cooktop is aimed at business class food service. Ipeco's newest Saros line (see Figure 16) includes a steam and convection oven, microwave oven (again ARINC Size 4), coffee maker, water boiler, and tri-mode chiller. Ipeco uses a similar double retainer in one handle design as Safran.

Iacobucci has a small range of galley inserts (see Figure 17), including a steam and convection oven, coffee maker, and espresso maker. These are the most basic, and with that most selling, inserts placed in aircraft. As an Italian company they are doing well with their coffee and espresso makers.

While all brands have their differences and specialties, all seem to be working from industrial looking aircraft devices, to more home-like kitchen appliances with a common design language. The HMIs between brands differ, but mostly have the same functions available. Collins Aerospace and Safran are clearly the main players in the galley inserts industry, with the widest range of products in their portfolio.

Key insights

- Safran is the main competitor for Collins Aerospace, followed by smaller players Ipeco and Iacobucci.
- Competitors offer similar galley insert products, each with their own strengths.
- Safran's portfolio includes products similar in size and type to those proposed in this project.
- All brands are transitioning from industrial-looking devices to more home-like design languages.



Figure 15: *Ipeco galley inserts line (Ipeco, 2024).*



Figure 16: *Ipeco Saros galley inserts line (Ipeco, 2024).*



Figure 17: *Iacobucci galley inserts (Iacobucci HF Aerospace, 2025).*

Stakeholders

The galley insert products are sold business to business, multiple stakeholders have a role in this process. The main stakeholders are the airline, equipment OEM, and airframe OEM. For Collins Aerospace this means they have to design products that meet airframe OEMs requirements, while airlines are the ones choosing and using their products. This triangle of stakeholders with their relationships and associated other stakeholders is shown in Figure 18.

The airlines find the capacity and the reliability of the oven important. With a high capacity they can cook many meals at once, leaving more time for flight attendants to perform other tasks. The reliability of the ovens is really important, this can save the airline repair costs, and delays because of broken products. The airframe OEMs set requirements concerning safety, sizing, and performance of the products. This is a collection of requirements from the FAA, EASA, and the OEMs their selves.

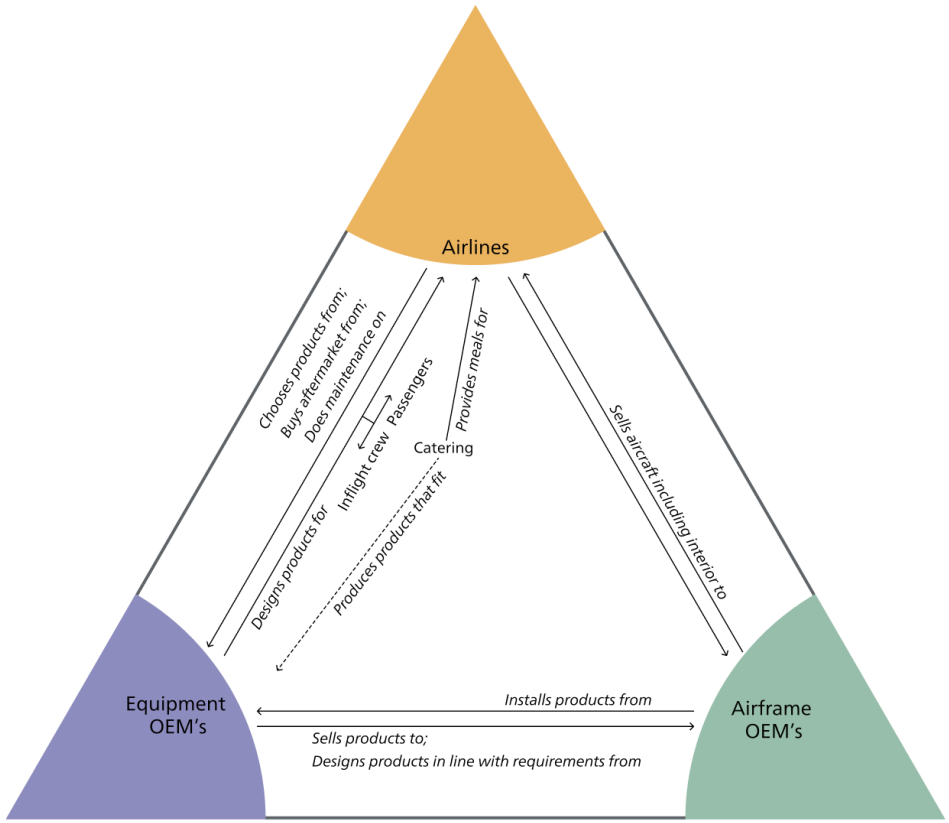


Figure 18: *Stakeholder map.*

Key insights

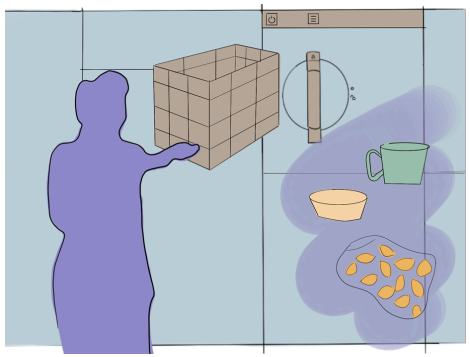
- The main stakeholders for Collins Aerospace to work with are airlines and airframe OEMs.
- Airlines prioritise high capacity and reliability for ovens.
- The airframe OEMs sets safety, sizing, and performance requirements for the ovens.

2.2 User

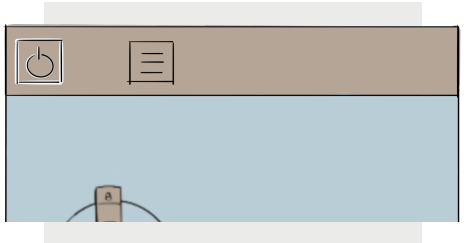
The ovens and bun warmers are used by flight attendants in aircrafts, the context and use cases are therefore important to consider. First, the current use is researched through interviews with flight attendants (Appendix A), catering companies, and experts within Collins Aerospace, as well as desk research and conversations at AIX on catering services.

Use cases

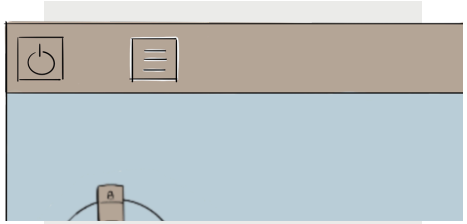
The current use of the oven and bun warmer is shown in Figure 19 below and Figure 21 on the next page.



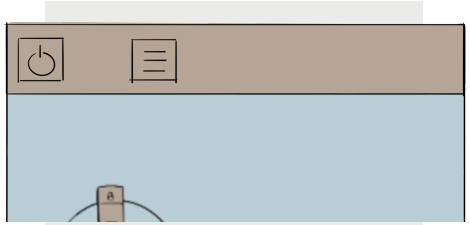
1: The bun warmer is used to warm up buns, cups, and soup bowls. It has a basket in which items can be placed.



2: The bun warmer has two buttons. When turned on, it heats to 80 degrees.



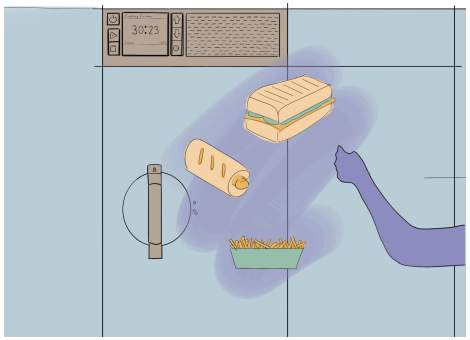
3: With the keep warm function selected, the temperature is kept at 60 degrees.



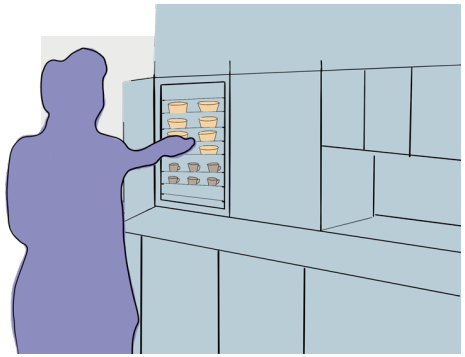
4: The bun warmer turns off after a fixed amount of minutes.

Figure 19: *Current use of bun warmer.*

Next to the standard use cases as shown in the user journeys, there are extra use cases for both products that happen in between meal services. These are interesting for the foreseen products as well, because they could be used for these extra use cases. Next to these existing extra use cases, new possibilities were discussed. Both existing and possible extra use cases are shown in Figure 20.



A: Between meals, snacks can be heat up in the oven.

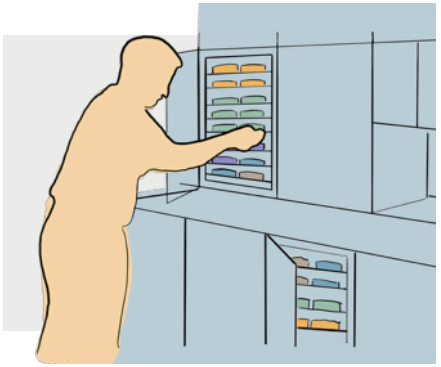


B: After meals have been heated up, soup bowls, cups, and crew meals can be heated.

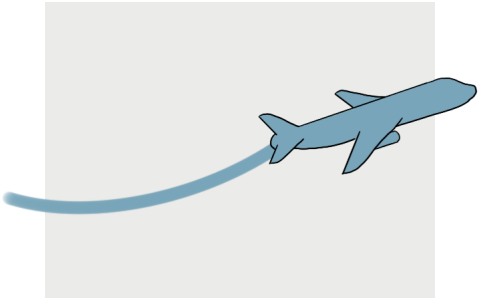
Figure 20: *Extra use cases.*

Key insights

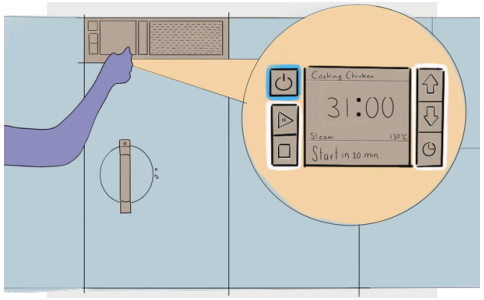
- The oven and bun warmer are used by flight attendants during standard meal services, as shown in the user journeys.
- Additional use cases occur between meal services, offering opportunities for the proposed products.



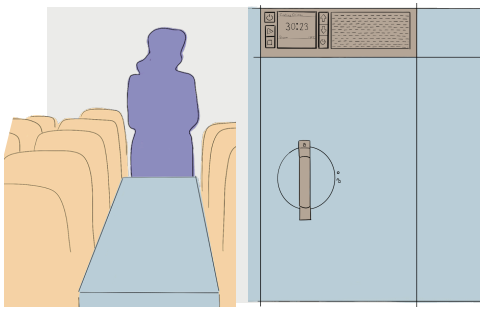
1: Catering puts filled inserts in ovens and chilled trolleys in the galley.



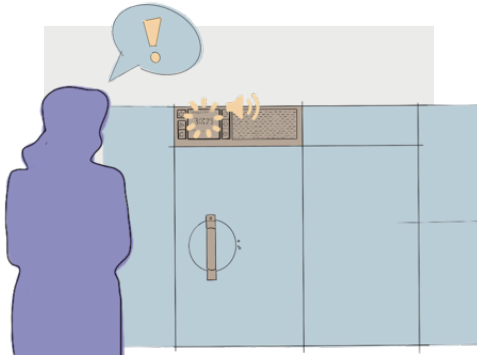
2: Flight starts.



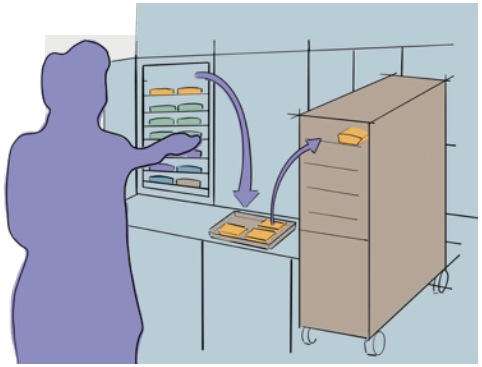
3: FA sets the oven to desired settings, including a delayed start.



4: FA performs other activities, oven starts at set time.



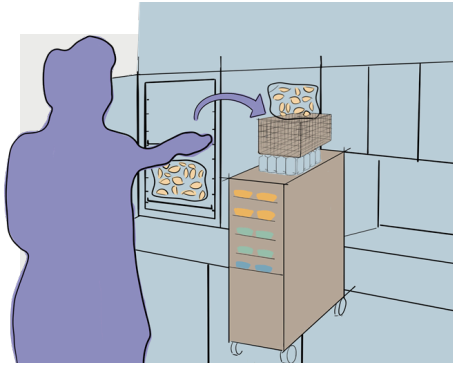
5: FA notices the oven is done, because of sound, light, and a message on the screen.



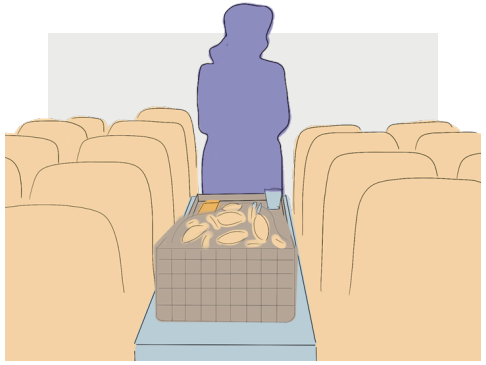
6: The skits are taken out of the oven, the meals are put in the trolley.



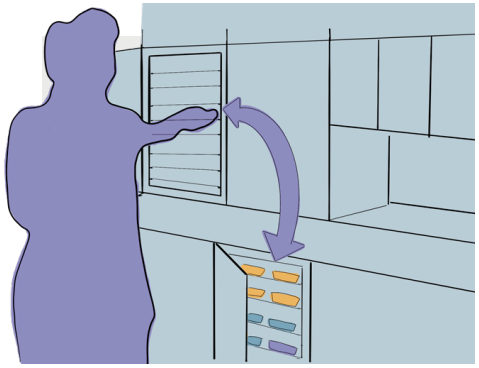
7: While the meals are being put in the trolley, two bags of buns are put in the oven.



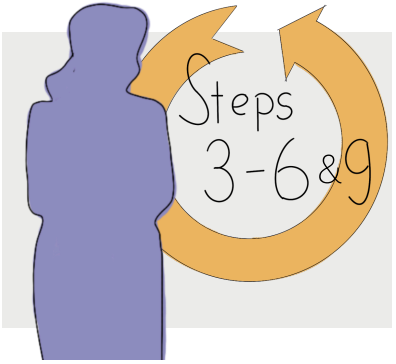
8: Buns are ready. They are placed in a basket on top of the wine bottles on the trolley.



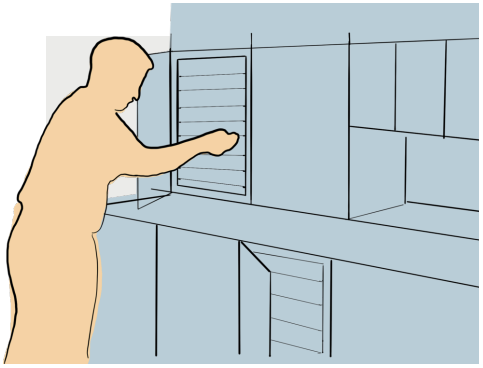
9: FAs hand out meals to passengers.



10: For the second round of meals, the inserts in the ovens and cooled trolleys are exchanged.



11: Similar steps for as in the first meal round are taken, buns are served this round.



12: The FAs can leave the empty inserts in the ovens and trolleys, the catering picks them up.

Figure 21: *User journey oven.*

Needs and pain points

When using the oven and bun warmer most existing operational functions on the products are used by the flight attendants. Overall they are satisfied with the products, it gives them the right options and are easy to use. Operational functions available and used in the oven and bun warmer are shown in Table 1 below. Besides the 'safe' door position, holding the door slightly open while preventing it from swinging wide (see Figure 22), all operational functions are often used by flight attendants. They emphasise that all these functions should be kept available in future products.

A few other use aspects could be improved. Firstly, the flight attendants note that the packaging, most likely the seal on top, can get stuck in the meal carrier. They have to pull hard to get the meals out, and plastic can rip off and stay behind in the oven. Another downside of the oven mentioned are the downsides of the steam function. After the steam function is used there is hot water on top of the meals, they have to let this slide off before taking out the meals.

Key insights

- Almost every available function of the oven and bun warmer is frequently used and appreciated by flight attendants.
- The available functions are considered complete and easy to use, and should be preserved in future designs.
- Downsides include the packaging seal getting stuck in the meal carrier and the steam function leaving hot water on top of meals.



Figure 22: *Safe door position.*

Operational function	Used in oven	Used in bun warmer
Time setting	Yes	Not available
Temperature setting	Yes	Not available
Delayed start setting	Yes	Not available
Countdown timer display	Yes	Not available
Current settings display	Yes	Yes
Double door lock	Yes	Yes
'Safe' door position	No	No
On/off button(s)	Yes	Yes
Up/down buttons	Yes	Not available
Keep warm button	Not available	Yes

Table 1: *Operational functions oven and bun warmer.*

Catering

Next to flight attendants, the caterer also deals with the ovens and bun warmers. They provide the airline with meal carriers (see Figure 24) filled with meals. The sizing of the meal containers is in line with the meal carriers, each skit fits four meals (see Figure 23). They place these meal carriers in the ovens and cooled trolleys before the flight takes off. After the flight they collect the empty meal carriers, they clean them and fill them again, before they go on a new flight. The meal carriers are thus not only part of the oven, but also of the logistics of the caterer. Another advantage of this process, is the cleaning of the meal carriers by the caterer. The meal carrier can get filthy during use, but prevents the oven itself getting dirty. Because of this the flight attendants rarely have to clean the inside of the oven or meal carriers themselves. The current meal carriers have standard sizes, fitting the ARINC Size 2 ovens. The bun warmers have a similar insert (see Figure 25), but here it is a single basket that is placed inside. This basket is not prefilled, but bags of buns fit in. The baskets have standard sizes fitting ARINC bun warmers as well. The current meal carriers fits 32 standard meal containers. the half size oven should fit at least 12 standard meals, an extended goal of fitting 16 standard meal is given by Collins Aerospace.



Figure 23: *Standard meal container.*

Nowadays on demand services are becoming more popular. Passengers can choose to order snacks or (extra) meals. When hot items are ordered, the ovens are used to heat these up as well, for this the flight attendants have to place the item in the oven themselves. In these situations the meal carriers are less relevant, only the skits would be needed.



Figure 24: *Meal carrier with skits for oven (Airline Suppliers, 2019)*



Figure 25: *Basket insert for bun warmer.*

Key insights

- Ovens are equipped with meal carriers, and bun warmers with baskets to hold items for heating.
- Caterers handle meal carriers filled with meals, filled with meals they place them in ovens and trolleys before flights, after flights they clean and refill them.
- With the growth of on-demand food services, ovens are also used between the standard meal rounds to heat up individual meals or snacks. Flight attendants place these items in the ovens themselves.

Galley placement

The current oven and bun warmer are used on worktop height in the galley (see Figure 26). Galleys have standard sizes and layouts, adjusted to the functions of the galley inserts. Trolleys (ARINC Size 3) go under the worktop, ovens and refrigerators (ARINC Size 2) and bun warmers (ARINC Size 4) are placed directly on the worktop. Slightly higher the coffee makers and water heaters (ARINC Size 1), and microwave (ARINC Size 6) are placed, with the top aligning with the top of the ovens and refrigerators. This is all considered worktop height, ensuring easy use for the flight attendants in combination with the worktop (see Figure 26). Above the galley inserts at worktop height, there is another row where ARINC Size 4 and 5 inserts fit. These places are used for standard containers, these containers provide storage space for loose objects like jugs, coffee and tea bags, and buns for the return flight. However, these places also have the ARINC energy connection in the back, so ovens and bun warmers in ARINC Sizes 4 and 5 could be placed here.

The placement of ovens and bun warmers above worktop height gives airlines more possibilities within the boundaries of the galley. It could give extra heating capacity, for example to heat buns, snacks, and soup bowls, or to keep meals hot. This is not all possible at the same time in the bigger ovens, because they need to be used for the main use cases.

A disadvantage of placing the ovens and bun warmers higher up in the galley would be that the flight attendants would have to use it above shoulder height. The HMI that is on the top of the products would be harder to reach, and the inserts might be harder to get out. These user aspects should be included in the Design phase to see if placement of these products above worktop is desirable.

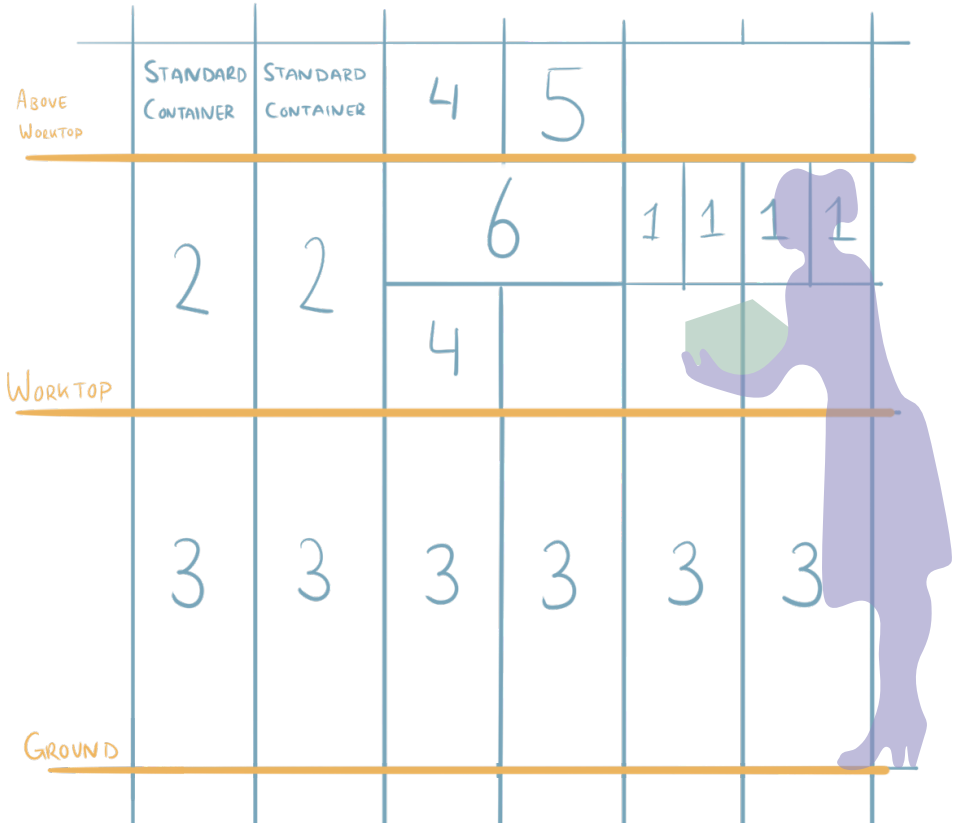


Figure 26: *Galley outlines with ARINC compatibility.*

Key insights

- Galleys follow ARINC sizing, with ovens (Size 2) typically placed at worktop height and bun warmers (Size 4) often placed above.
- The proposed ARINC Size 4 and 5 ovens and bun warmers can be installed in the additional space above the worktop, providing airlines with maximal use of galley space.
- Placing products above worktop height may impact usability for flight attendants and should be carefully considered during the Design phase.

2.3 System breakdown

The ovens and bun warmers consist of similar elements. An overview of all elements and relevant sub-elements with their functions and similarities and differences of the oven and bun warmer is shown in Table 2 on the next page. Figure 27 and 28 on the right show systematic overviews by section views of the oven and bun warmer with their elements.

Differences

The differences originate from variations in size and function. The sizing influences the dimensions of the outer oven, inner oven, door, insulation, and accessories. The differences in functionality between the bun warmer, convection oven, and steam oven makes the amount and specifics of elements vary.

The ovens can reach a temperature of 170 °C, the bun warmer only heats up to 80 °C. Therefore the bun warmer only needs heating elements. The oven also has a heating element, but this is more powerful. Next to this, the oven has a fan to circulate the heated air. To guide the airflow and to separate the food compartment from the fan and heating element, the oven also has a baffle plate. Because the oven reaches higher temperatures, a cooling fan is needed to cool down all elements outside the inner oven (see Figure 27). The front panel of the oven therefore has holes to accommodate galley air to enter the oven. The bun warmer does not require cooling, and thus no room for air in the front panel. The bun warmer also has no screen, unlike the oven. These differences result is sizing differences of the front panels.

For the ovens there are two versions, the basic convection oven, and convection plus steam oven. The steam ovens are equipped with a water and pressure system. For the steam oven, the seal in the door is important to keep pressure and prevent leaking. For the convection oven this seal is less important, but still there to prevent leaking. The bun warmer does not require a seal.

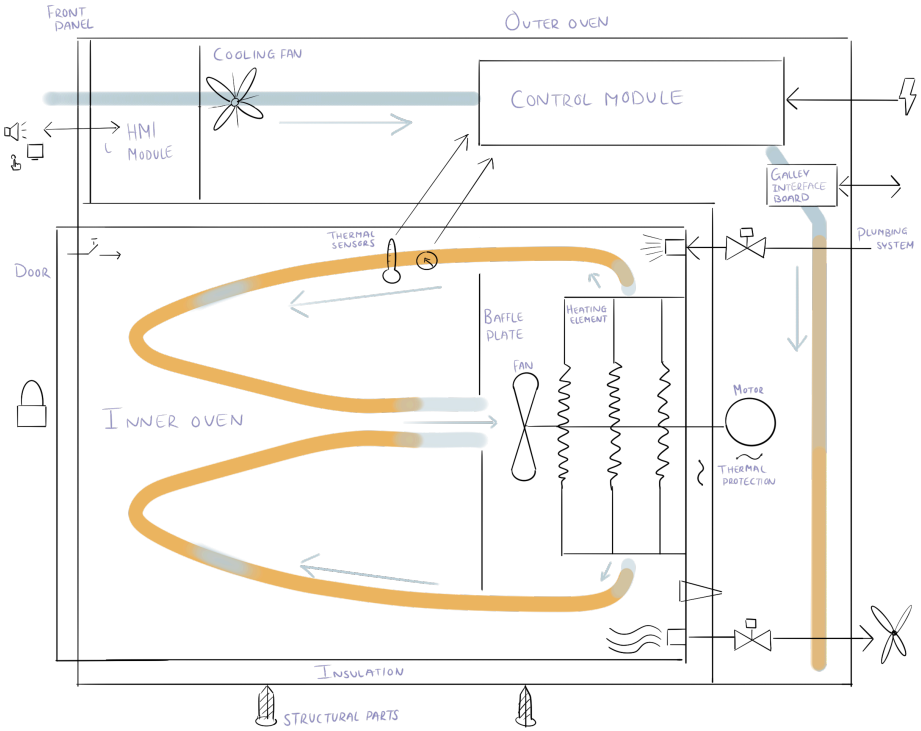


Figure 27: *Schematic overview (steam) oven.*

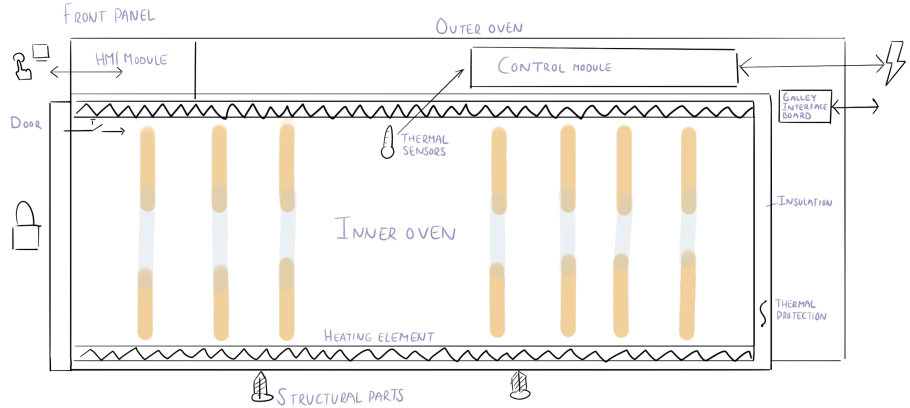


Figure 28: *Schematic overview bun warmer.*

Element number	Element and sub-elements	Function(s)	In current oven	In new oven	In current bun warmer	In new bun warmers
E1	Baffle plate	Split food section from fan and heating element; Provide airflow guidance	✓	✓		
E2	Front panel	Front face oven; Look; Provide ventilation	✓	✓	✓ *Except ventilation holes	✓
E3	Oven ID		✓	✓	✓	✓
E4	Control module	Run and monitor oven; Ensure safety	✓	✓	✓	✓
E5	Cooling fan	Draw galley air into top and rear of oven to cool	✓	✓		
E6	Door	Closing inner oven; Securing content in oven; Provide access to content in oven	✓	✓	✓ *Except door seal	✓
E6.1	Door panel					
E6.2	Door inner plate					
E6.3	Door sensor					
E6.4	Door latches					
E6.5	Door hinges					
E6.6	Door insulation					
E6.7	Door seal					
E7	Fan and motor	Circulate hot air through inner oven	✓	✓		
E7.1	Motor					
E7.2	Fan blade					
E7.3	Motor seal					
E7.4	Motor suspension					
E8	Heating element	Heat source	✓	✓	✓	✓

Element number	Element and sub-elements	Function(s)	In current oven	In new oven	In current bun warmer	In new bun warmers
E9	HMI module	Provide controls and feedback to user	✓	✓	✓	✓
E10	Inner oven	Place for contents	✓	✓	✓	✓
E11	Insulation	Thermal insulation around inner oven to protect environment from heat	✓	✓	✓	✓
E12	Galley interface board	Connection to ARINC 812 galley	✓	✓	✓	✓
E14	Outer oven	Enclosure; Shield internals; Structural strength	✓	✓	✓	✓
E15	Plumbing system	Water supply and pressure relief system	✓ *Only in steam oven	✓		
E16	Structural parts	Parts to tie all system parts together; Additional strength and mechanical attachment galley	✓	✓	✓	✓
E17	Thermal protection	Safety; Thermal runaway	✓	✓	✓	✓
E18	Thermal sensors	Sense temperature in inner oven	✓	✓	✓	✓
E19	Wiring harness	Connecting all electrical components.	✓	✓	✓	✓
E90	Accessories	Placed in inner oven to place meals in	✓	✓	✓	✓
E90.2	Meal carrier					

Table 2: *Elements and functions of oven and bunwarmer.*

Relevance of elements

Next to understanding what elements are in the products and what their function is, the relevance for this project is analysed. Though all elements should be considered, some are more important in the scope of this project. The elements can be categorised in mechanical (ME), electrical and/or software (E/S), and human machine interaction (HMI) elements. From this, the level of relevance for the Design phase of the categories and parts are determined (see Table 3). This specifies if it is relevant to design the part fully (Design), take the sizing and placement within the product into account to make everything fit together (Placement & Size), and where the functionality of the element should be taken into account when placed somewhere in the product (Functionality).

All elements and functions related to the steam function of the oven are considered irrelevant in this project. The main reason for this is the absence of the needed connections to the galley in the places these products can be placed. To comply with this standard, the oven (and bun warmers) cannot have a water system that needs connection to the galley. Possibilities to overcome this in the future would be to either adjust the galley or to look at possible intern water systems. A second reason to not include steam options is the budget for the desired products, it is in this project's scope to include cost saving aspects.

Key insights

- The oven and bun warmer consist of similar elements, but are tailored to fit the size and functionality of the specific product.
- The needed elements and their relevance for this project is determined.
- The new oven should only have a convection option, the steam option is excluded.

Element number	Element and sub-elements	Category	Level of relevance
E1	Baffle plate	ME	Design
E2	Front panel	ME	Design
E3	Oven ID	HMI	Not relevant
E4	Control module	E/S	Placement & Size
E5	Cooling fan	ME	Placement, Size & Functionality
E6	Door		
E6.1	Door panel	ME	Design
E6.2	Door inner plate	ME	Design
E6.3	Door sensor	E/S	Placement & Size
E6.4	Door latches	ME & HMI	Design
E6.5	Door hinges	ME	Design
E6.6	Door insulation	ME	Placement, Size & Functionality
E6.7	Door seal	ME	Design
E7	Fan and motor	ME	Placement, Size &Functionality
E8	Heating element	ME	Placement, Size & Functionality
E9	HMI module	HMI & E/S	Placement, Size & Functionality
E10	Inner oven	ME	Design
E11	Insulation	ME	Placement, Size & Functionality
E12	Galley interface	ME	Placement & Size
E13	Insulation	ME	Placement, Size & Functionality
E14	Outer oven	ME	Size
E15	Plumbing system	ME	Not relevant
E16	Structural parts	ME	If needed
E17	Thermal protection	E/S	Not relevant
E18	Thermal sensors	E/S	Placement & Size
E19	Wiring harness	E/S	Not relevant
E90.2	Meal carrier	HMI & ME	Design

Table 3: *Categories of elements and their relevance in the project.*

Materials

The materials for galley inserts are carefully chosen. They have to be in line with regulations, be as lightweight as possible, provide enough strength, be producible, but at the same time have to be affordable.

The inner oven and baffle plate are made out of a food safe stainless steal , except in the Essence Premier, where it is made of lightweight titanium. These parts must last throughout the entire life cycle of the products, as replacement is not realistic. This aspect is less relevant for the meal carrier, which can be replaced if needed, therefore aluminium can be used for this part. The outer oven is made out of (non food safe) stainless steel, for this part the structural integrity is an important aspect.

For the door and front face ULTEM (see Appendix B) is used, this is a high performance injection moulded thermoplastic. Injection moulding for the low production quantities of these products in unusual. However due to strict regulations, injection moulding of this plastic is the best way found so far. This highlights the unusual design considerations made for aircraft products.

Legislation

A lot of standards and rules are relevant in the design of aircraft products. These come from industry standards, like the ARINC compatibility with the galley, aircraft and food safety regulations, aircraft manufacturers, customers, and Collins Aerospace itself.

These standards and rules vary in feasibility for this project. General sizing, capacity, operational, material, and retainment requirements are important to include in the design. Strength, performance, vibration, electrical and safety requirements are very hard to design and test for, even for a full design team, therefor they are kept in mind, but are not a priority in the scope of this project. The list of requirements in Chapter 3.2 includes the part of all requirements found for these products that are deemed of influence for the outcome of this project.

Highest cost drivers

Because of materials, production methods, and legislation, elements can become quite expensive. Because it is within the scope of this project to design for costs saving, the highest cost drivers are important and can lead to design focus and choices. An important cost driver is the door, because of the high performance material being injection moulded. Next to this the double retainment system and strength requirements are applicable for the door in open and closed status. Besides the door, electronics, the HMI, the motor, heating element, and PCB are the highest cost drivers. Relatively cheaper elements are the outer plates and isolation material.

Key insights

- Industry standards, rules, and regulations influence design choices a lot. For this project sizing, capacity, operational, material, and retainment requirements are the most important.
- The door, electronics, the HMI, the motor, heating element, and PCB are the highest cost drivers in the products.

2.4 Trends

Even in the slow moving conservative aircraft business, innovation is an important topic. If you can bind a client for years because of your new and improved product, it makes a great difference. But, offering a reliable products with known and expected functions is still the most important thing. With a visit to the Aircraft Interior Expo (AIX) in Hamburg, this view is confirmed. A few trends related to galley inserts and catering where identified.

Sustainability

The main sustainability concern right now is weight. On short term reducing weight to save fuel and emissions is the most impactful, until more sustainable forms of aircrafts are developed (Trigueros Alonso et al., 2025). On a long-haul Boeing 777 flight one kilogram weight reduction on board, saves 563 kilograms CO2 in a year (Trigueros Alonso et al., 2025). So wherever weight reduction in products is possible, it is worth considering. This can mean using less material, lightweight material, or less elements, but lowering the need for products by changing the way of use or enhancing performance is also an option.

Smart galley

Smart products are becoming more common in home kitchens, this trend is also reaching the aircraft galley world. With a connected galley using AI and data, accurate maintenance needs can be indicated and ultimately even predictive maintenance can prevent broken and unusable products (Military Aerospace Electronics, 2023). The connected galley also offers opportunities to let galley inserts work with each other and with flight attendants, to optimise inflight catering and passenger experience.

Passenger expectations

Passengers paying for full-service flights are expecting more en more in addition to a save flight. The need for arriving well rested at their destination is growing. Seating, ambiance, and service improvements are implemented to offer this to passengers. For the catering service this means more luxury and high-quality food and drinks are expected, as well as more on-demand service. By offering this passengers can feel more special and luxurious. To achieve this the galley must be equipped to be used flexible. The standard meal preparations still need to happen, but in between meals on demand food and drinks are becoming more important, so it should be possible to do both.

The changes in catering service was visible at AIX, where caterers and galley inserts providers try to offer a wider variety to offer comfort, luxury, and on demand service. For example SkyTender Solutions aims at future beverage catering solutions with their mobile beverage cart (see Figure 29) (World Travel Catering & Onboard Services Expo, 2025). Dester hosted an interview with French Olympic medal winner Auriane Mallo-Bretonto to highlight the use of isotone drinks, normally used as sports drinks, inflight to support a fresh arrival.



Figure 29: *Mobile beverage trolleys (Skytender Solutions, 2024).*

Home feeling

Coming from very industrial and technical driven product design, galley inserts, and other interior products, are nowadays also designed with the user and aesthetics in mind. A big step made towards this new view on galley inserts design was made with the Essence line. Now the trend of making passengers (and cabin crew) feel like being in a home-like environment is rising. Since galley inserts are a direct translation of home kitchen appliances to aircraft kitchen appliances, this can be used in the design of galley inserts, in appearance as well as use. An example of designing for feeling at home in an aircraft is made by Dester, their concept design of more round shaped inflight tableware (see Figure 31) shows their effort to change the feeling of passengers.

Short to long haul

With more efficient aircrafts, narrowbody (single-aisle) aircrafts (see Figure 30) can make long-haul flights, something that used to be a widebody job (Eccles, 2025). With this comes the challenge to offer long-haul flight service in a small aircraft. In this case it is extra important to use all space available in a galley to provide meal services that come with these flights. With this, the design scope of galley inserts widens.

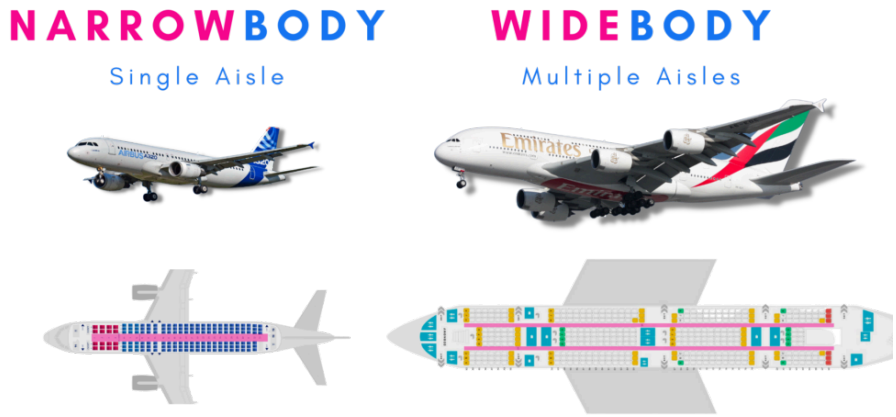


Figure 30: *Narrow- and widebody aircrafts (Pilot Institute, 2023).*



Figure 31: *Dester round 'at home' inflight catering experience concept.*

Key insights

- Weight reduction is currently the primary sustainability focus in aviation, as it offers fuel savings and CO2 reduction sooner than other sustainability initiatives.
- Smart, connected galleys are emerging, providing efficiency through predictive maintenance and better communication between galley inserts and flight attendants.
- Passengers have a growing desire for personalisation, increasing the need for on-demand services and flexible, full-time galley use.
- The design of galley inserts is shifting toward a user-centered and aesthetic appeal, creating a more home-like experience in the galley.
- As narrowbody aircrafts are increasingly used for long-haul flights, the design scope for galley inserts is expanding to support both short and long-haul services in smaller spaces.

3. Define



In this chapter the findings of the first Analyse phase are used to define a focus for the Design phase. This is done by means of main design drivers and lists of requirements and wishes.

3.1 Main design drivers
3.2 List of requirements and wishes

3.1 Main design drivers

The key insights gathered in the Analyse phase, together with the requirements and wishes, form the input for the next Design phase (see Figure 32 below). To set direction and focus, the key insights are used to determine the main design drivers for the design. This is done by identifying similarities, contradictions, and challenges within the insights. By using these main design drivers as a starting point, a relevant product that responds to the assignment and findings of the analysis can be designed. The main design drivers are shown in the blue box on the right, the formation of the main design drivers from the key insights is shown in Appendix C.

Main design drivers

- The products must be usable for flight attendants when placed above worktop height.
- All three products share a common door design and fit product specific elements within a shared frame. Next to the door, shared components should be commonly designed wherever possible.
- The three products fit in the existing design language of the Essence and Modus collection.
- The oven should have a capacity of at least 12 meals, with and extended goal of 16 meals.

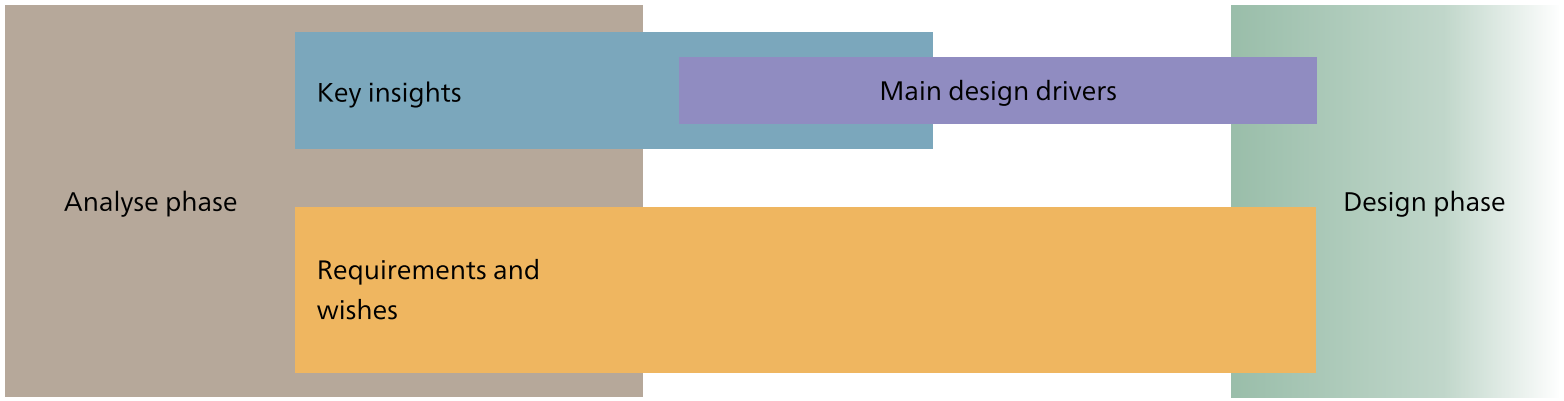


Figure 32: *From analysis to design.*

3.2 List of requirements and wishes

Next to the main design drivers, the findings from the Analyse phase also result in a list of requirements and wishes (LoRW). First, a shared LoRW, relevant to all three proposed products, is presented. Then, three separate LoRWs outline the product-specific aspects. To set up the lists in a systematical way, the method from Delft Design Guide (2020) is used.

The LoRWs are:
0: LoRW shared
1: LoRW bun warmer size 4
2: LoRW bun warmer size 5
3: LoRW oven size 4

The requirements and wishes are ordered in the following categories:
A: Modularity
B: Performance
C: Product positioning
D: Size and weight
E: Standards, rules, and safety
F: User aspects
G: Product policy
H: Sustainability

The requirements and wishes are given a number, category, a requirement or wish label, description, qualitative or quantitative label, and an origin. The full LoRWs are presented in Appendix B.

Together with the main design drivers, the LoRWs are input for the Design phase. A few important requirements and wishes are listed in Table 4 below as an example.

LoRW 0: All products			
Catergory & number	Number	Requirement or wish?	Description
0A Modularity (similarity)	0A1	W	The products should have as many shared elements as possible.
	0A2	W	The products should be in line with the existing design language of the Modus and Essence collections.
0F User aspects	0F1	W	Retaining devices must be operatable by a single motion with one hand, left and right handed.
	0F2	R	All functions of product must be reachable and usable by hand at specified ARINC 4 and 5 placements in the galley.
LoRW 3: Oven Size 4			
Catergory & number	Number	Requirement or wish?	Description
3B Performance	3B6	R	Product must fit 12 industry standard economy class meals.
	3B7	W	Product could fit 16 industry standard economy class meals.
LoRW 1:Bun Warmer Size 4			
Catergory & number	Number	Requirement or wish?	Description
1B Performance	1B4	R	Product must fit 60 stand airline bread rolls.
LoRW 2: Bun Warmer Size 5			
Catergory & number	Number	Requirement or wish?	Description
2B Performance	2B3	R	Product must fit 30 stand airline bread rolls.

Table 4: *Examples from the LoRWs.*

4. Design



With the main design drivers and List of Wishes and Requirements defined, the Design phase can start. The main design drivers are used as input for the ideation phase, from this different design directions are found. These design directions are scored and tested based on the LoWRs and main design drivers to choose the direction of the final design.

4.1 Ideation and design directions
4.2 Design choice
4.3 Concept development

4.1 Ideation and design directions

With the four main design drivers, the focus of the ideation phase is set. The main design drivers are repeated in the blue box below. For driver number one, ideation focusses on finding solutions to make the HMI best usable at height. Driver two is all about making the different elements fit, while using shared elements between the products. Driver three is more overarching and about the aesthetics, in the first ideation phase the existing Essence and Modus products are used as inspiration in the ideation for drivers one and two. Lastly driver 4 highlight the wish of customers for a high capacity oven.

Ideation on usability

Ideation on making the HMI best usable at height is done by sketching. First the 'How-Tos' method from the Delft Design Guide (van Boeijen et al., 2013) is used, with questions like 'How to touch buttons at 1,60 m?' and 'How to make the screen visible?'. Next to this the 'Think like a zebra' method is used to get different, more out-of-the-box, solutions. With both methods a variety of solutions was generated. With clustering these ideas are grouped, resulting in five design directions.

Main design drivers

1. The products must be usable for flight attendants when placed above worktop height.
2. All three products share a common door design and fit product specific elements within a shared frame. Next to the door, shared components should be commonly designed wherever possible.
3. The three products fit in the existing design language of the Essence and Modus collection.
4. The oven should have a capacity of at least 12 meals, with and extended goal of 16 meals.

Three of the design directions are about the placement of the HMI. This can be above, under, or to the side of the door (see Figure 33). Next to the placement, there are also two directions concerning the orientation of the HMI. These differ in the angle the HMI is placed at, this can be flat or with an angle facing the user (see Figure 33).

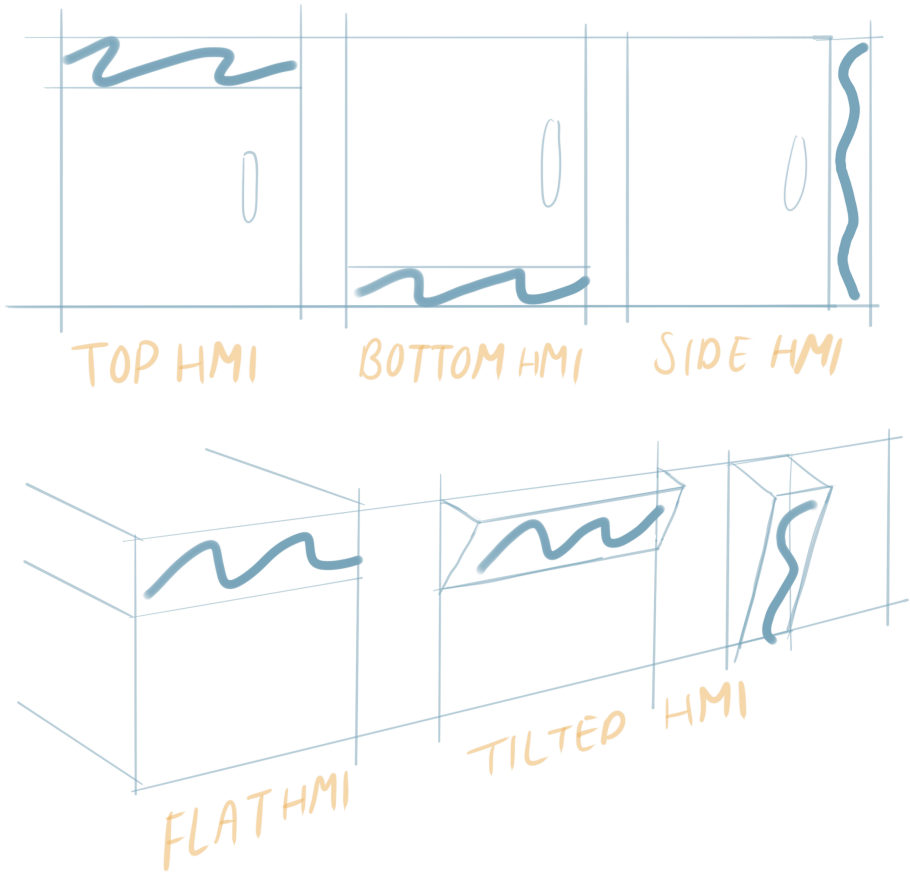


Figure 33: *Design directions usability of HMI.*

Ideation on fit and modularity

To fit the modular and product specific elements in the given frame, exploration by sketching is done to find possible arrangements of all the elements. From this three directions came, with the main difference between the directions being the fit of the HMI and control module (see Figure 34). The first design direction in this category is fitting all elements within the boundaries of ARINC Size 4 (and 5). In the second and third direction, the HMI and control module are seen as loose parts, placed against or completely loose from the main product.

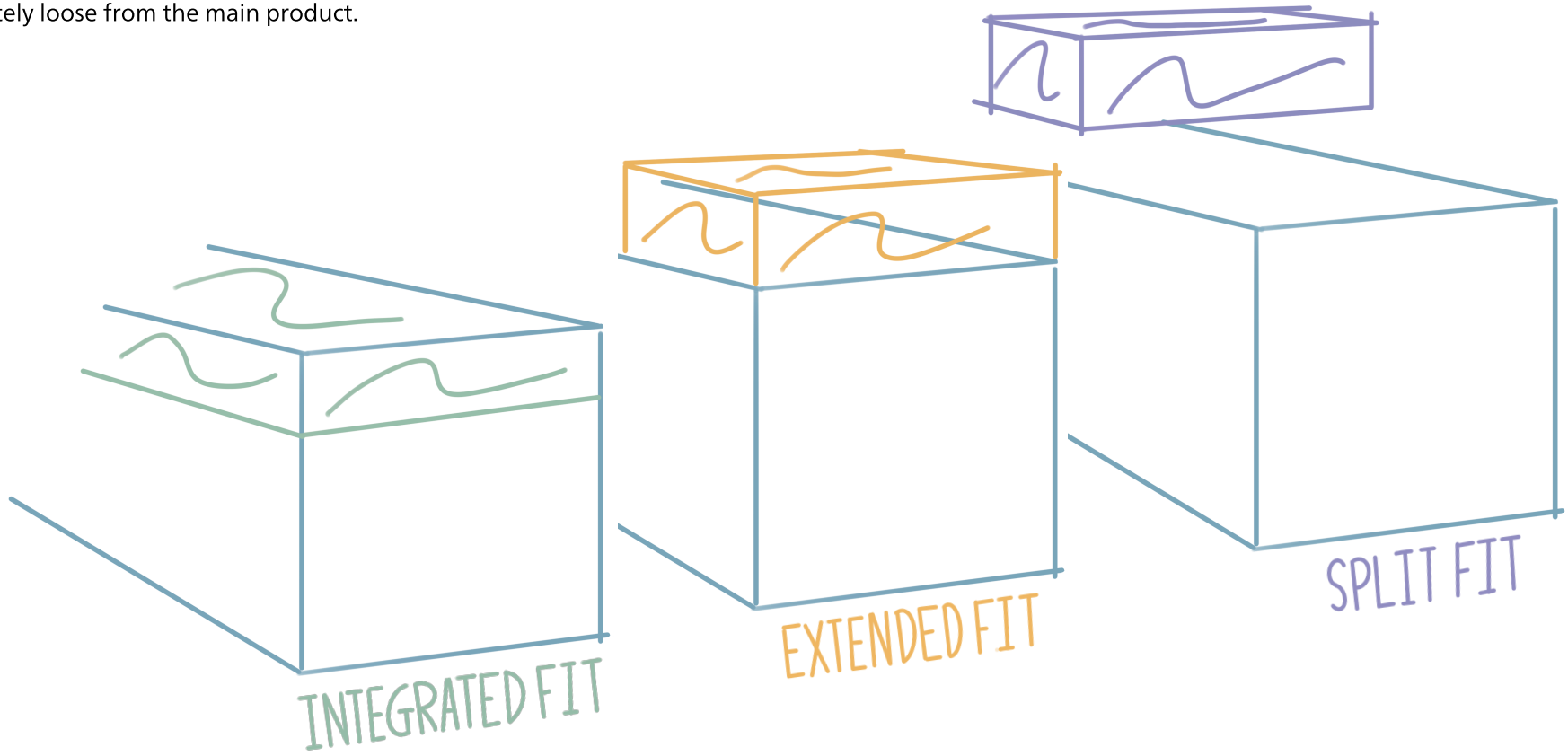


Figure 34: *Design directions fit.*

4.2 Design choice

Between the directions found in the ideation phase, there are three choices to be made: the placement of the HMI, the orientation of the HMI, and the fit of the elements relative to the ARINC sizes (see Figure 35).

Fit choice

To choose between the directions concerning the fit, weighted objectives are used. The criteria are based on the main design drivers, as well as the wishes from the LoRWs. The most important criterium is the usability at height. Next to this, the amount of shared parts, the fit in the frame, the design fitting in the existing collections, and the capacity are chosen. These five criteria are all crucial aspects for the design to succeed.

The integrated fit gets the highest score in the weighted objectives (see Table 5 on the next page). To substantiate the choice for this direction the advantages and disadvantages of the directions are pointed out in Table 6 on the next page. Though the capacity possibilities for Direction 2 and 3 are interesting, Direction 1 scores well in the weighted objectives and has potential to solve the condition for continuation. By choosing to remove the meal carrier and only use the skits in the new oven, enough space is available to fit at least 16 meals (space for meals is presented in 4.3 Concept development). The choice to remove the meal carrier is validated with users and Collins Aerospace. While the meal carriers serves a role in the Size 2 oven for the caterer, the new oven can be filled up more dynamically with meals, snacks, and/or tableware by flight attendants themselves. This capacity solving solution makes the choice for Direction 1: Integrated fit appropriate.

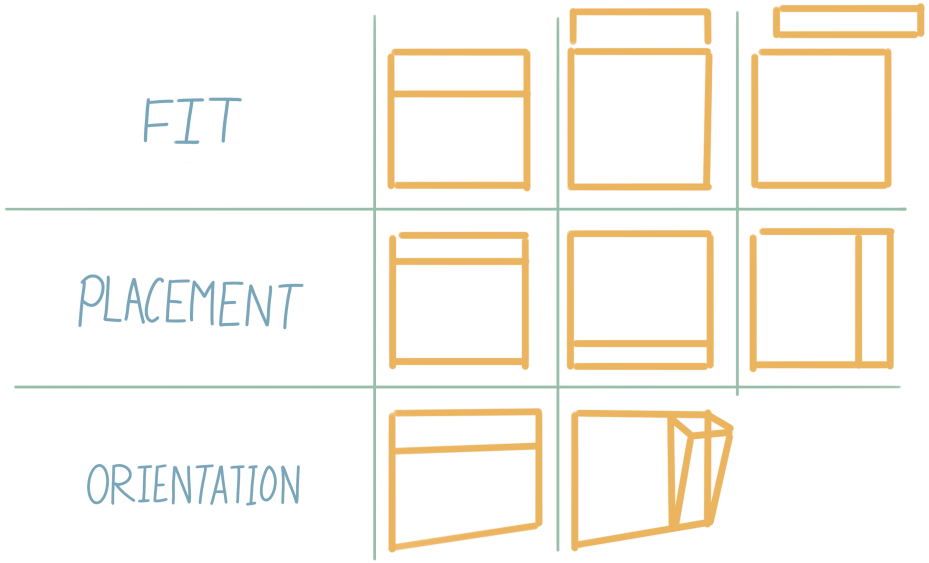


Figure 35: *Morphological chart.*

	Criterium	Weight	Direction 1: Integrated fit	Weighted score	Direction 2: Extended fit	Weighted score	Direction 3: Split fit	Weighted score
1	Usability at height	25	4	100	2	50	4	100
2	Fitting in frame/galley	20	5	100	3	60	2	40
3	Capacity of inner oven	15	3	45	5	75	5	75
4	Design fits in collections	18	5	90	4	72	1	18
5	Amount of shared parts	22	4	88	3	66	3	66
	Total	100		423		323		299

Table 5: *Weighted objectives fit.*

	Direction 1: Integrated fit	Direction 2: Extended fit	Direction 3: Split fit
Advantages	• Fits best within existing design language. • Fits best within existing industry standards. • Two products placed on top of each other fit existing Size 2 galley places.	• High capacity possible. • Fits within existing design language.	• High capacity possible. • Main component fits existing industry standards.
Disadvantages	• Lower capacity compared to other directions.	• Does not fit within existing industry standards.	• Does not completely fit within existing industry standards. • Does not fit within existing design language.
Condition for continuation	• Capacity of 16 meals should be made possible.	• Galley layout change is needed to fit the products.	• Galley layout change is needed to fit the products.

Table 6: *Advantages and disadvantages of design directions.*

Use choices

The two choices concerning the placement and orientation of the HMI are made based on testing. A mockup of a galley is created to imitate the context of use (see Figure 37). In this mockup low-fi prototypes of the directions are placed, to test which one works best for the user.

The test shows (see Figure 36) that a HMI on the bottom or on the side are both easily reachable for users, the HMI on top was harder to reach. The flat and tilted HMI are both possible in the side an bottom position. However a tilted HMI works better and shows that it is meant to be used at an height, this is preferred by the users. A tilted HMI on the bottom would interfere with the meal carrier being taken in and out. Next to this the bottom HMI is seen as a disadvantage by Collins Aerospace because spillage of food and liquids in the HMI would be more likely. Because the HMI on the side works as well as the HMI on the bottom, the tilted HMI on the side is chosen. The precise angle it is placed at should be specified to optimise for up-close use and further away looking.

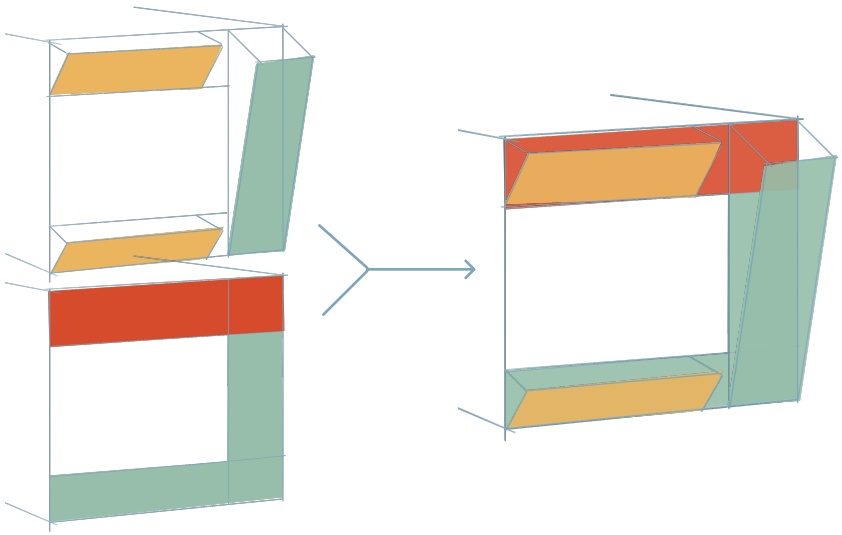


Figure 36: *HMI options rated.*



Figure 37: *Galley mockup for testing.*

4.3 Concept development

The different choices made result in a concept where all elements are included in the Size 4 and 5 frame, with a tilted HMI on the side (see 38). For further development the precise sizing en placements of the elements are needed, as well as a layout for the HMI and front face

The 3D layout of the elements is dependent on the size and form of the front face (see Figure 38). Therefore the layout of the HMI is first set, together with the layout of the rest of the front face. The sizing of the front face should also take into account the room needed for the control module behind it, as well as the cooling of the control module. With these elements complete, the sizing of the door can be set, from which the front size and placement of the inner oven can be determined. The depth of the inner oven is dependent on the size of the heating element and fan, that are behind it. Around the inner oven there needs to be room for insulation and the connection to the galley. Because of all these dependencies between elements, they are designed step by step, the process of the design is further explained on the following pages.

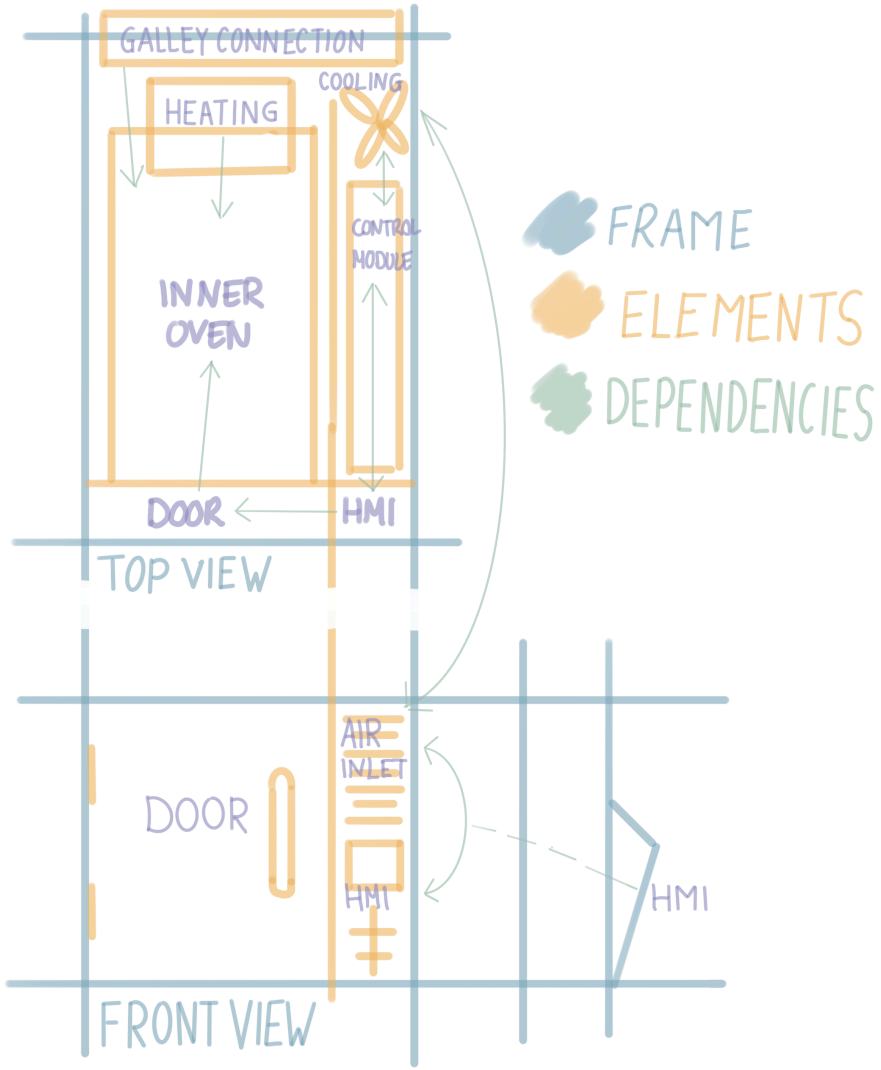


Figure 38: *Dependencies between elements.*

Front face

To determine the final form and sizing of the front face, first the parts of the HMI are defined. The HMI of the oven needs at least a screen, five setting buttons, an on/off button, and two failure indicators. To make maximum use of the space available, these parts need to be small and closely together, while maintaining ease of use and visibility. To find solutions for this, existing HMIs of the Modus and Essence collection are mapped out (see Figures 39 to 42).

The Modus oven has a small and simple screen, it is black and white and shows the current temperature and time, the set temperature modus, and the current status (see Figure 39). The Modus oven is operated with six buttons, an of/off button, a temperature button, two arrow buttons, a start/pause button, and a stop button (see Figure 40).

The Essence and Essence Premier ovens screen (see Figure 41) is more extensive and bigger than the Modus screen. It shows a menu with pre-set and manual choices, an overview screen, and an end screen. The Essence oven has six buttons (see Figure 42), similar to the Modus oven, the difference is the time button, instead of the temperature setting, but operation is similar. The Essence Premier oven is a little different, it has five buttons, the use of the time or temperature button is replaced by a long-hold of the start/pause button. The Essence Premier also has the smallest buttons.



Figure 39: *Modus screen.*

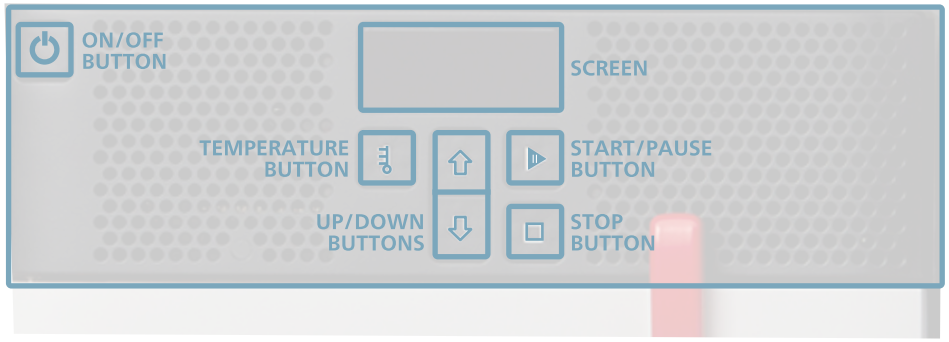


Figure 40: *Modus HMI.*



Figure 41: *Essence screen.*

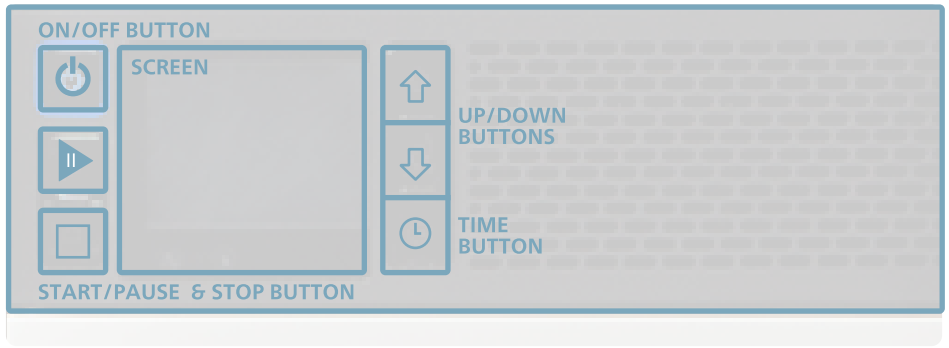


Figure 42: *Essence HMI.*

For the concept, the size of the buttons of the Essence Premier is used, these are 14x14 mm. The functionality of the Modus buttons is needed to operate the oven. So there will be six buttons: an on/off, up, down, stop, start/pause, and temperature button (see Figure 44). The screen needs to be able to show the time at 12,5 mm text height, making it readable from 2,5 meters distance (Ruiter, 2019). For this to fit, the screen size must be at least 45 mm wide. Next to the time, it also needs to show the temperature setting, current temperature, and the status of the oven. This result in the screen shown in Figure 43, with a size of 45 by 31 mm. The screen is black and white, like the Modus screen, furthermore the style of the Modus screen is applied, fitting with the functionality similarities between the new product and Modus. Because the bun warmers have less functionality options, only a few HMI features are needed. These are the on/off button and a temperature button (see Figure 45).

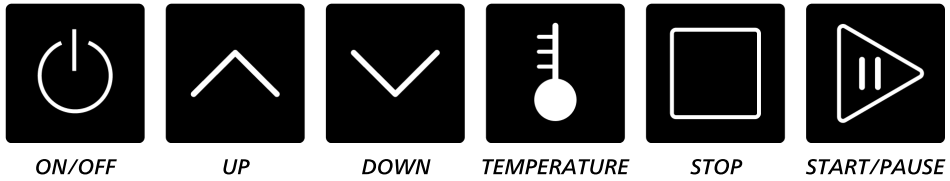


Figure 44: *Buttons for concept oven.*

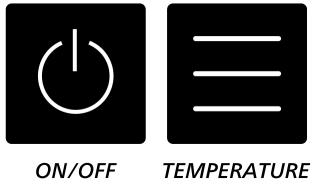
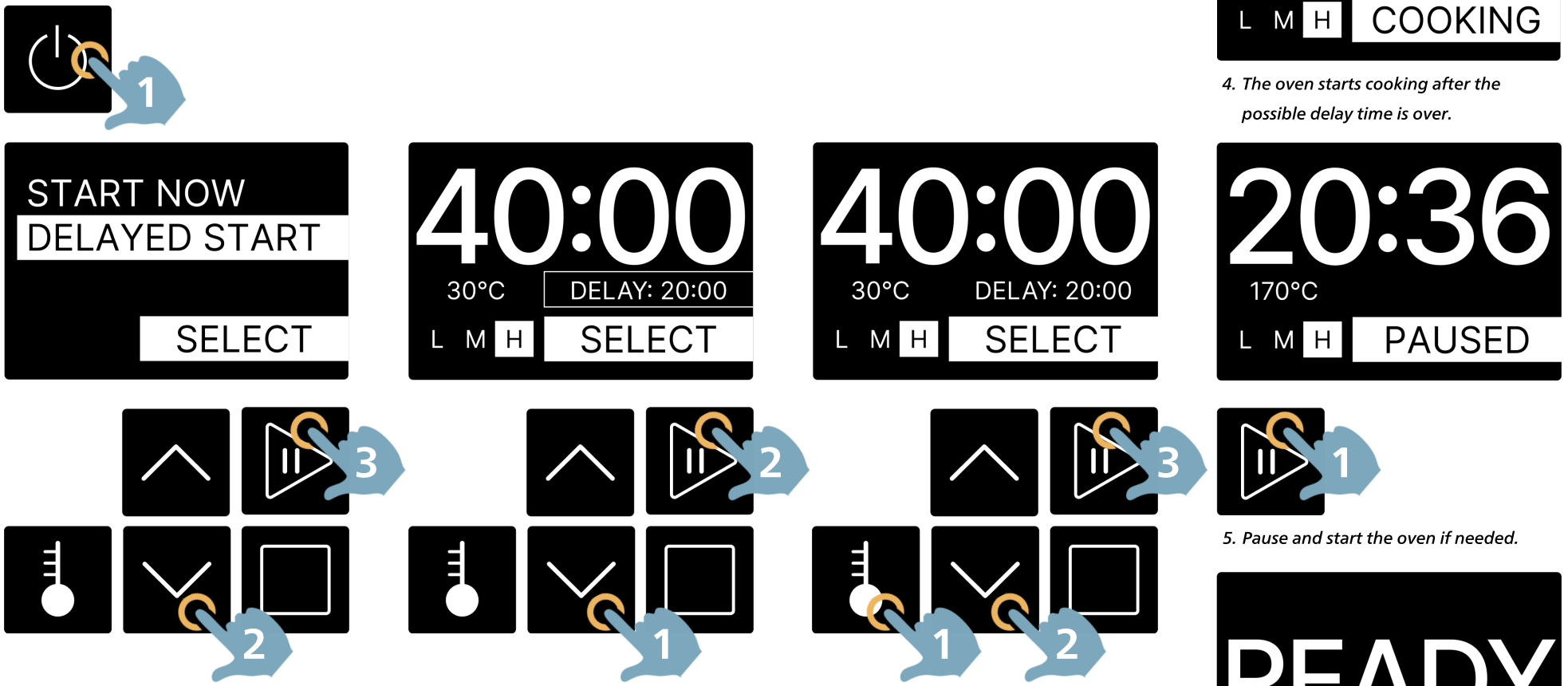


Figure 45: *Buttons for concept bun warmers.*



Figure 43: *Screen for concept oven.*

The operation of the concept oven is similar to the Modus oven, but with the extra functionality of the delayed start, because this functionality is important to the user. For this, a menu screen is added for easy use. Figure 46 shows the operation of the oven with the screen and buttons.



1. *Turn on the oven and select direct or delayed start.*
2. *Select the delay time.*
3. *Select the temperature and cooking time, then start the oven.*
4. *The oven starts cooking after the possible delay time is over.*
5. *Pause and start the oven if needed.*
6. *The oven indicated when it is done cooking.*

Figure 46: *Operation of concept oven.*

The HMI is placed on the tilted part of the front face. To determine the final angle of the HMI user tests are done with the concept front face (see Figure 48), in Chapter 5.2: Validation more information about this is presented. From the test it became clear that the angled part is of help for smaller flight attendant and flight attendants sitting down, while longer, standing up, flight attendants should also be able to use it. To achieve this, an angle of 15 degrees is chosen. To let the front face with a tilted part fit in the existing design language, a form derived from existing products is designed (see Appendix E).

After the HMI, the space needed for the control module behind the front face, and the cooling of the control module are set. Like with the HMI, existing layouts of the Modus and Essence products are used for reference. In the Modus and Essence oven, the control module is almost as high as the front face, leaving little space to minimise the dimensions of the front face. In the Essence Premier oven, the control module is flattened, resulting in a longer, but thinner control module, and thus opportunities for minimising the size of the front face (see Figure 47).

The control modules of the existing ovens are designed to let cooling air pass at placed it needs cooling the most. This is done by making the middle of the control module thinner (see Figure 47). By doing this, less space around the control module is needed to let the cooling air pass. The use of a thin control module optimised for cooling results in the needed space for the control module, including the space needed around it, in the concept oven being 50x275x280 mm. To provide sufficient airflow through the front face to cool the control module, 82 mm^2 surface of holes is needed. The existing design language is used to design a pattern of holes in the front face to accommodate this.

The surroundings of the door are also part of the front face. It provides place for the locks and hinges of the door. On the top and bottom this needs a height of 20 mm, the side of the hinge needs a width of 20 mm, the side of the HMI needs 11 mm.

The control module, HMI, cooling pattern, and surrounding frame are combined into a front face for the concept (see Figure 48). The HMI part of the front face is tilted, the rest is flat. Behind the front face the inner oven and control module are shown.

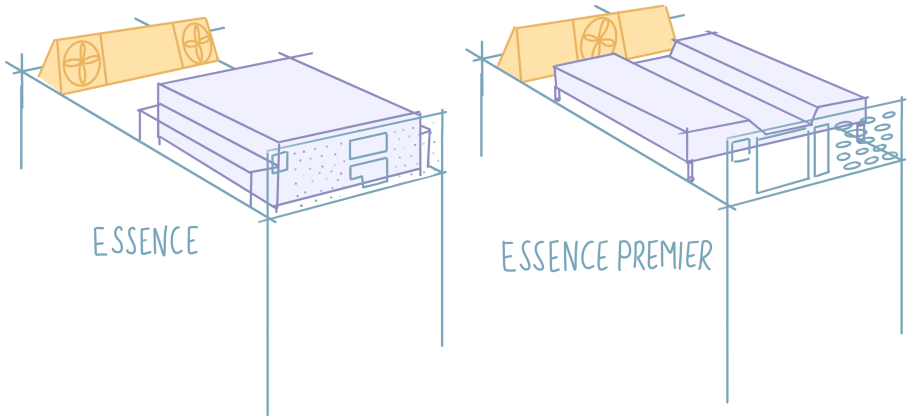


Figure 47: *Essence and Essence Premier control modules.*



Figure 48: *Front face concept.*

Door

The door covers most of the front of the products. Its sizing is dependent on the front face. With the width of the HMI and cooling parts of the front face being 50 mm, there is 237 mm left for the door. With the room for the locks needed above and below the door, the height of the door will be 260 mm. The door includes an outer shell, a double lock, hinges, insulation, and the front part of the inner oven. For this to fit the door must be 35 mm thick.

The existing double lock integrated into one handle is chosen for the concept. This is an important part to fit in the existing design language. It is also preferred over the quarter turn lock because of its use at height. The quarter turn lock should be on the top, which makes it more difficult to reach. With the double lock integrated in the handle, the user can reach it more easily.

The hinges of the door are placed on the opposite side as the HMI. This is important, because if it would be placed on the HMI side it would not be able to open far enough. On the opposite side this is no problem. The door has a rounding on the side of the hinges, just like existing oven doors, to fit in the design language. On the side of the HMI this rounding is excluded, because it would interrupt the overall form of the front of the oven. The concept design for the door is shown in Figure 49.

Inner oven

The size of the inner oven is important to reach the capacity goals. Because the HMI and control module take up minimal space, and the door is covering a great part of the front, there is maximum space available from the front for the inner oven. This results in the front of the inner oven being 204,4 mm wide and 235,2 mm high. The depth of the inner oven in dependent on the parts that need to go behind it. These are the elements that provide the heating for the oven, and the connection to the galley. Together, these need a depth of 64 mm behind the inner oven, leaving 428 mm depth for the inner oven. In the inner oven, the heating element, fan, and baffle plate take up a depth of 43,6 mm, leaving a cavity of 384,4 mm depth where the trays with food can go. The inner oven behind the front face is shown in Figure 49.

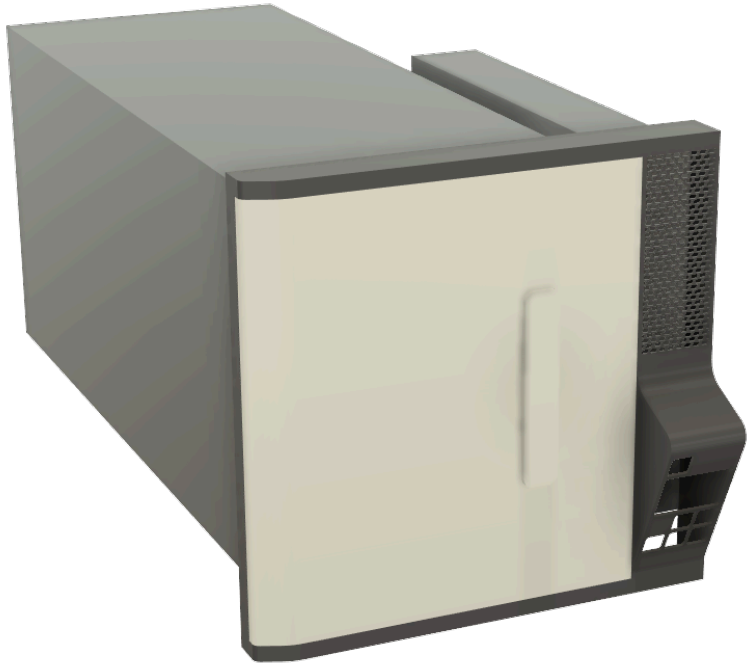


Figure 49: *Door and inner oven concept.*

Capacity

With the meal carrier excluded from the oven, a rack is needed on the sides of the inner oven for the trays to be slid in. This is a simple L-profile placed against the sides, this way the trays will stay in place (see Figure 50). This is done before in an older Collins Aerospace oven. With this system, there is place for four trays with four meals each, making the capacity of the oven 16 meals. For the bun warmers there is enough space for 60 standard buns in the Size 4 bun warmer and 30 buns in the Size 5 bun warmer. In Chapter 5 'Deliver' 3D views are presented for further clarification of the layout of elements.

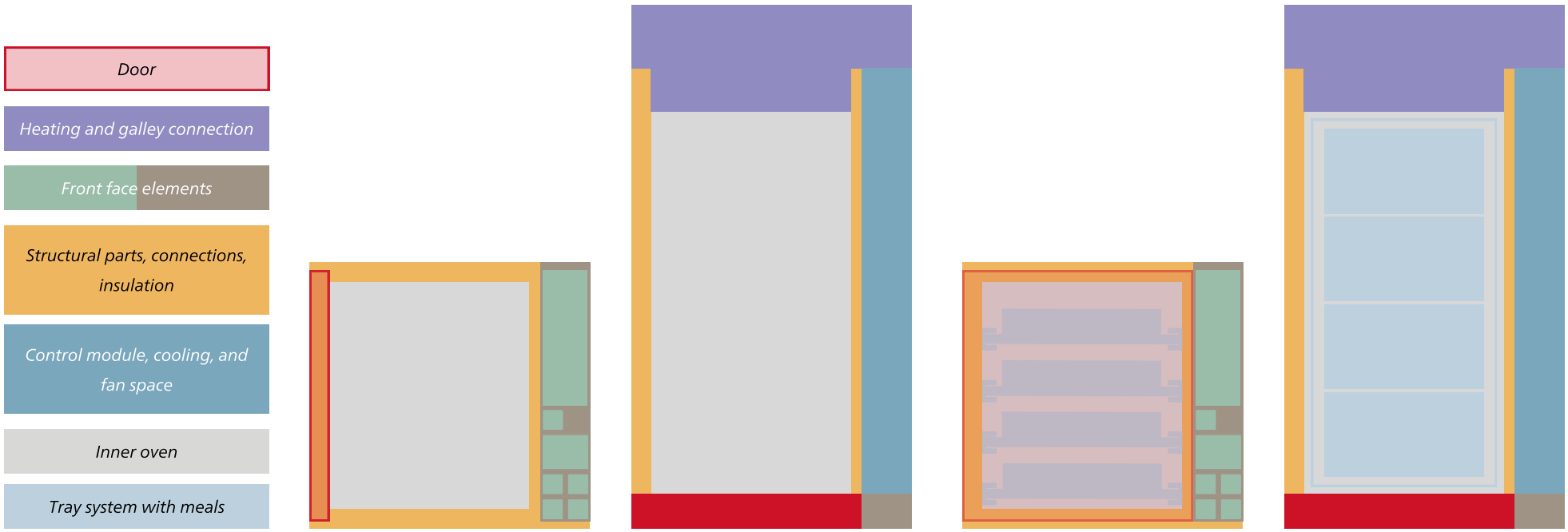


Figure 50: *Overview parts layout for oven.*

5. Deliver



This chapter presents the final design and its technical, business, and user aspects. To validate the final design the feasibility, viability, and desirability are discussed.

5.1 Final Design
5.2 Validation

5.1 Final design

The final designs of the three products have a basis of an ARINC Size 4 or 5 frame, filled with modular and product specific elements. The modular elements are shared between the product, the product specific elements make the three products unique. An overview of the three products in shown in Figure 51. The specifics about the products are further explained in the product breakdown, user, and business sections on the next pages.



Figure 51: *Final design for the three modular products.*

Product breakdown

The lay out of the three products is shown in Figure 52 (on this page and the next page). They consist of a basis of a ARINC Size 4 or Size 5 frame, modular shared parts, and product specific parts.

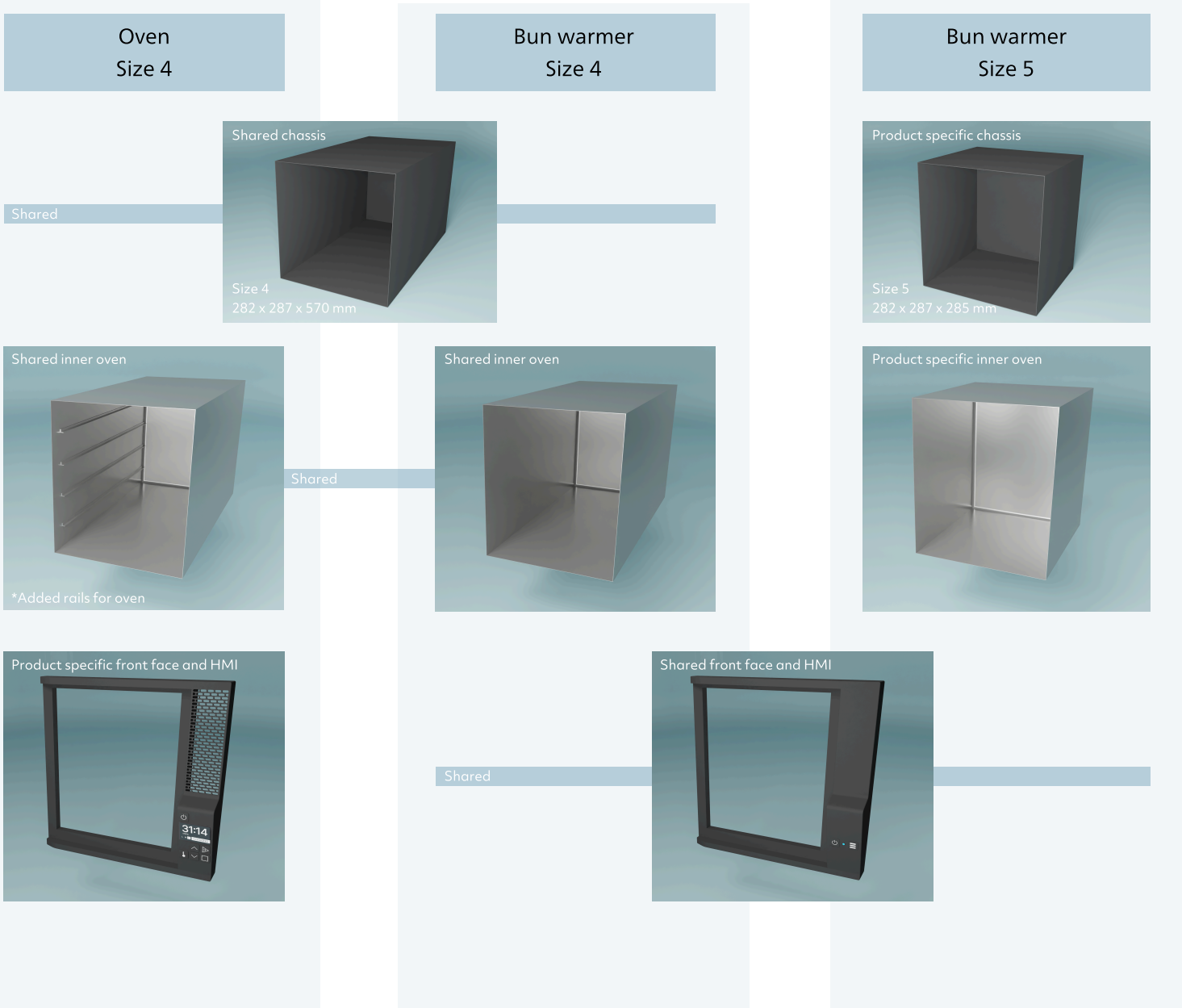


Figure 52a: *Product breakdown of the three modular products.*

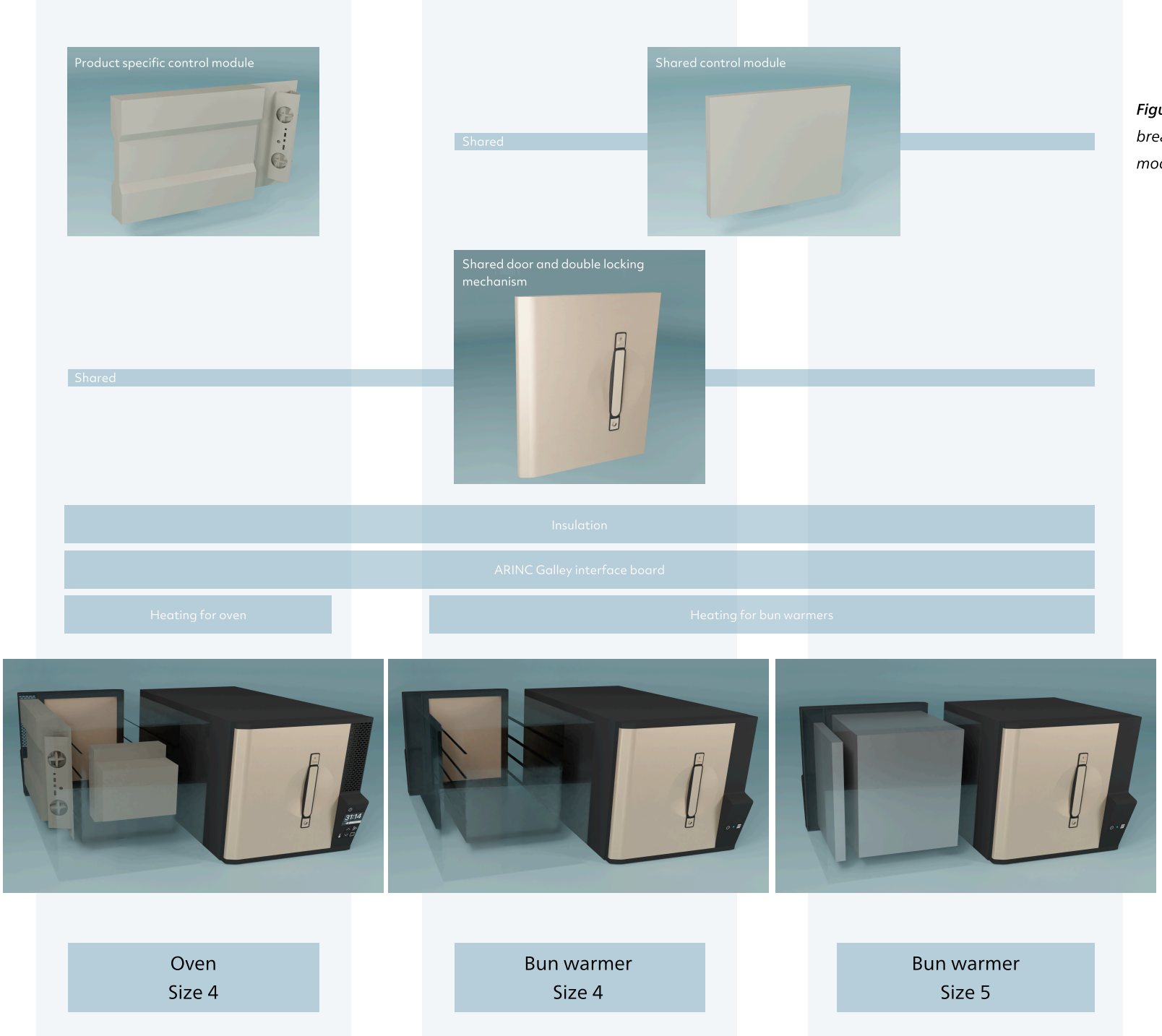


Figure 52b: *Product breakdown of the three modular products.*

User

The final products are developed with an emphasis on the user and the context of use. The products are used by flight attendants in a galley, where these products are placed above worktop height. A key usability feature for this context is the tilted HMI on the side of the products. The screen and buttons are placed at an angle of 15 degrees (see Figure 53 and 54). In this position, it offers an ergonomic control of the buttons, as well as a clear view on the screen when looking at from a distance (see Figure 56 on the next page). Not only the true ergonomic advantage makes it user friendly, with the tilted HMI you also show the user that it is designed to be used at an height. Next to the HMI, the handle is at reachable height. With the handle including both locks, the user is able to (un)lock the door easily with one hand.



Figure 53: *Tilted HMI.*



Figure 54: *15 Degree angled HMI.*

The oven offers the user a simple menu to choose from, first the choice for a delayed start is presented, furthermore the user can choose between low (130 °C), medium (150 °C), or high (170 °C) temperature, as well as the cooking time, with the use of six buttons. The screen will show the user the current status of the oven and indicates when it is done. With the optimised inner oven the oven has a capacity of 16 meals. The Size 4 and Size 5 bun warmers give the user the option for heating or keeping warm, with a capacity of a full or half bag of buns. Both the oven and the bun warmers can also be used more flexible for heating or keeping warm snacks, tableware, or crew meals.

The bun warmers have two buttons, one for turning the bun warmer on and off, the other buttton is for choosing the temperature (see Figure 55).The blue light indicates indicates the status of the bun warmer and potential errors, a similar indicator is also included in the oven HMI.



Figure 55: *Bun warmer and oven HMI.*

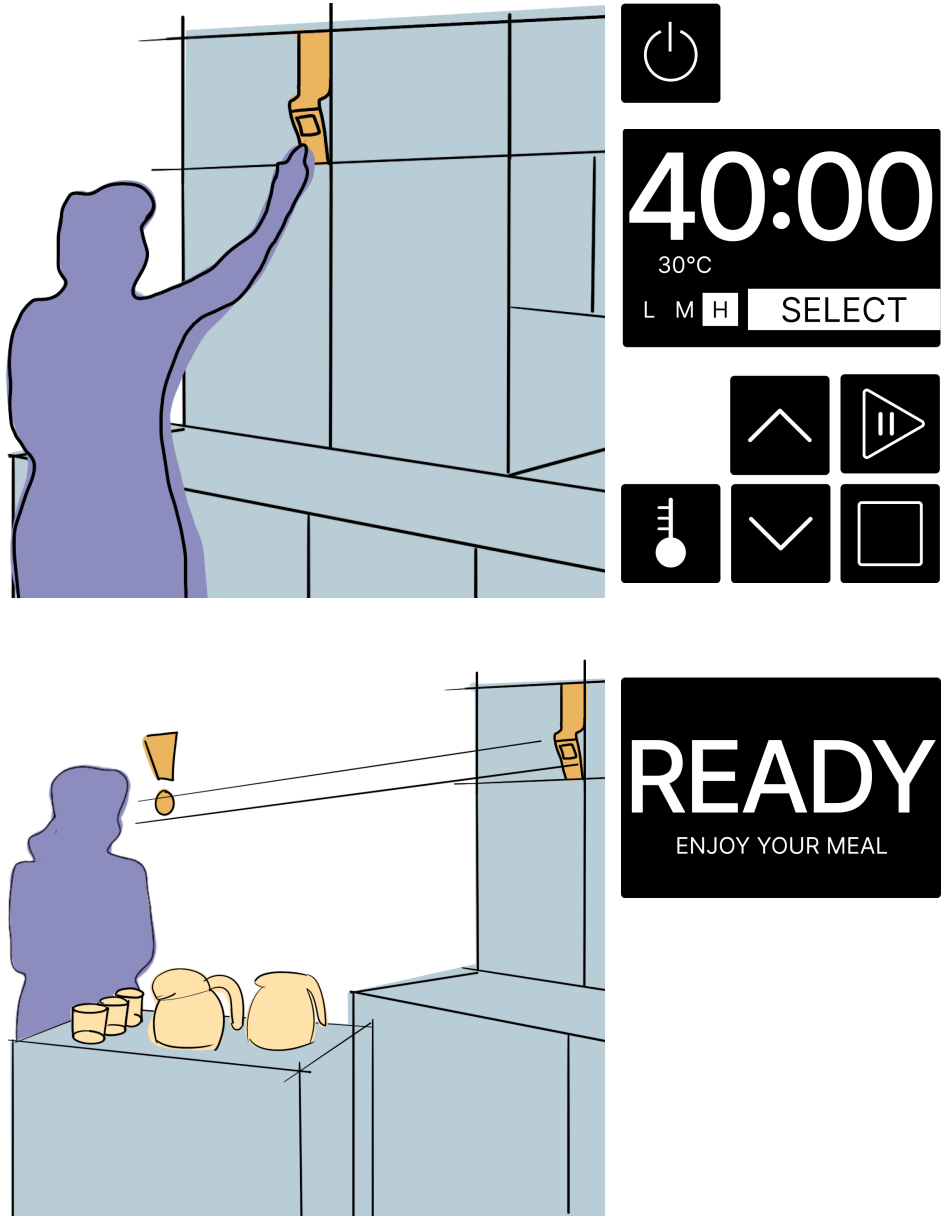


Figure 56: *Comfortable user interaction from close by and far away.*

Business

The modular design of the three products makes them an interesting addition to the galley inserts portfolio of Collins Aerospace. The modular door that can be used for all three products plays an important part in this, because this element is a high cost driver. Besides using modular elements in the products, the capacity is an important selling point. So the inner oven, and therefore door, should provide enough space for meals to fit. With these products a capacity of 16 meals for the oven, and a full or half bag for the bun warmers is reached.

Although the layout of the products are significantly different than existing Collins Aerospace products, they are designed to fit in the current collections. This is done by implementing the existing design language of the Essence and Modus collections (see Figure 57 and 58). By doing this, the products can be offered within these collections and does not stand out in the galley context (see Figure 59 on the next page).



Figure 58: *New oven presented in existing Modus collection.*



Figure 57: *New oven presented in existing Essence collection.*



Figure 59: *New oven in galley context.*

5.2 Validation

Throughout the design process, the user, business, and technical perspective are used to create a design answering to the assignment. To validate the final design, the desirability, viability, and feasibility are considered. These three factors ensure that the solution meets user needs (desirability), business goals (viability), and technical requirements (feasibility). Interviews with users and airlines (see Figure 60 and Appendix F) and validation within Collins Aerospace is performed to asses these aspects. Further research and design suggestions to address the desirability, viability, and feasibility are discussed in Chapter 7 Recommendations.

Desirability

First, the desirability for the user is validated by user interviews at Transavia. During a crew event, where Transavia shows new products and procedures to their crew, the new product is presented to nine flight attendants by means of a prototype in a mockup galley (see Figure 60). The flight attendant are asked a series of questions about how they use the current ovens and bun warmers, and about their opinion on the usability and looks of the new product.

Overall the flight attendant found the new design desirable. The HMI placed on the side is different that they are used to, but the flight attendants expect it to work fine.

The tilted part of the HMI is appreciated mostly by shorter people, who preferred it over the flat HMI. Next to it making reaching the buttons and reading the screen more easily, the suggestion that the product is made for the user is appreciated.



Figure 60: *User interviews at Transavia crew event with galley mockup prototype.*

Longer people had no preference, they would be able to work with both options. For them a disadvantage would be if they could hit their head against it, but mentioned this was unlikely due to placement relatively behind the worktop. Advantages of the HMI facing downwards is the prevention of light glaring at the screen and good visibility of the screen when sitting down.

To accommodate for both short and long people, the angle of the HMI is lowered from 25 to 15 degrees. With this the ergonomic benefit and user friendly look is preserved, while longer people are also able to use the HMI. Next to this, the HMI is now also usable when it would be placed at worktop height (see Figure 61).

The flight attendants mentioned the possibilities they see with smaller sized ovens. They would prefer to have two smaller ovens on top of each other instead of one big oven. This would allow them to put different snacks in different ovens, with optimal settings per oven. This is especially relevant for airlines like Transavia that offer on-demand snacks during short-haul flights.

Next to flight attendants, cabin operation and inflight services experts gave their opinion and insights on the product. For them, the biggest advantage of the new products is the size. Just as the flight attendants they saw great opportunities with smaller ovens. They believe the smaller oven would fit their inflight services better than the bigger existing ovens, especially with the possibility to stack two on top of each other in an existing Size 2 place.

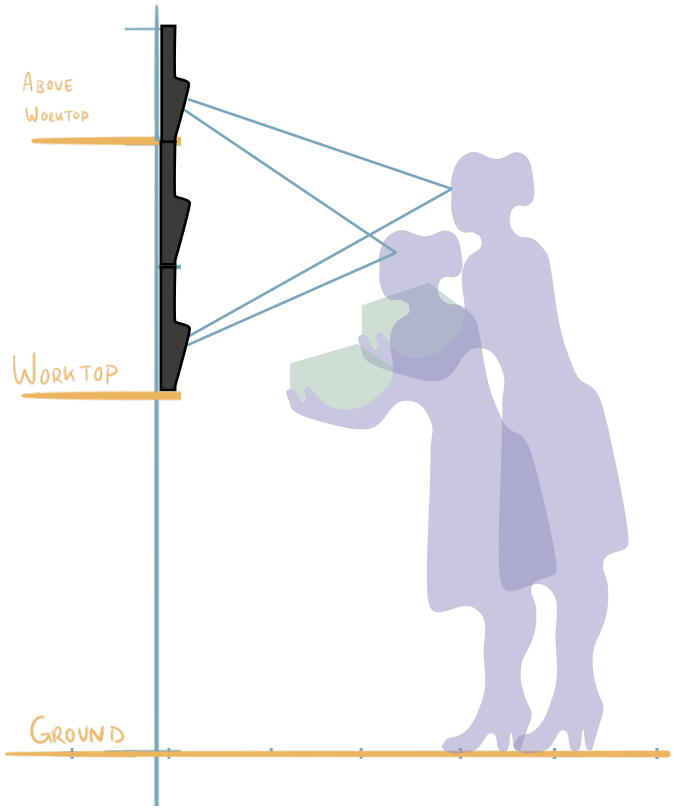


Figure 61: *Interface above and on worktop height.*

Viability

In the interviews with Transavia the added value for the small oven for airlines is confirmed. Next to desirablity, this also adds to the viability of the product. With the business case for the new products being the start and reason for this project, it was already clear that from the Collins Aerospace perspective it has value. With this validation is becomes clear that there is a business case, and one of the targeted client groups is determined to be short-haul (low-cost) airlines.

Remarkably, mostly the small oven is confirmed to be desirable, the interviewees are not familiar with the bun warmer. To confirm the viability for all three new product this should be further investigated, this is discussed further in Chapter 7 Recommendations.

The capacity of the new oven is 16 meals, which was the extended goal for this project. With this extension from 12 to 16 meals, the new oven can be a valued new asset in the Collins Aerospace oven portfolio.

To confirm the viability of all three products as a modular concept, the shared elements and the fit of the elements within a shared frame are decisive. With the design of a common door for all three product, a high costs driver is covered. Next to that the placement and size of the door and its surrounding elements, make sure all elements fit in the three products. With this the shared chassis between the Size 4 oven and bun warmer is possible. For the bun warmers a shared front face is used, making only limited differences between the Size 4 and Size 5 bun warmers possible. A limitation is that because of the changed size of the door and inner oven compared to the current bun warmer, the current insert can not be used in the new bun warmer. A new insert fitting the new bun warmer does have the same capacity.

Feasibility

The technical goal of this project is mostly about fitting the needed elements into the given frames. The feasibility is thus focused on confirming this is achieved. With the 3D CAD model, the fit of the modular and product specific elements within the frame and relative to each other is confirmed. The elements in the new design are validated on feasibility throughout the design process, mostly by comparing them with existing elements and consulting Collins Aerospace experts. Because the new design uses similar elements as former Collins Aerospace products, existing production methods and materials can be used.

With the tilted HMI a new design feature is introduced. The HMI moving to the side of the product does not impact material or production choices. The angled part that protrudes the product on the front results in the part being usable as a support surface. With the safety regulation stating that such parts must be able to handle a 300 pounds (~136 kg) abuse load, a validation test is set up. The material ULTEM (see Appendix B) is used, this is the same material used in existing galley inserts. A static stress simulation with a 1335 N force on the top of the protrude is performed for the oven and bun warmer front face, showing a wall thickness of 2 mm, in combination with ribs in the top of the tilted part, for the front face is sufficient (see Figure 62).

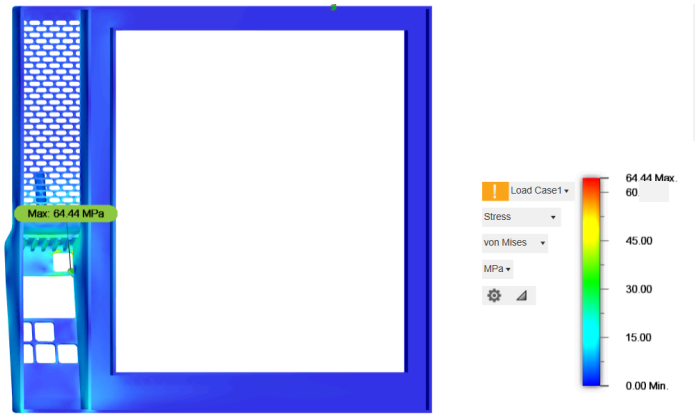


Figure 62: *Strength test similation of protrude HMI.*

6. Conclusion



The assignment set at the beginning of this thesis:

> **"Develop a concept for three modular aerospace galley oven products sharing a common chassis and have a minimum amount of unique parts to create a new business opportunity in the form of new products for Collins Aerospace."**

has been addressed through the development and presentation of the final design. By integrating the user, business, and technical perspectives throughout the design process, the final design offers three new galley oven products for Collins Aerospace, that fit their existing portfolio, are technically feasible within aerospace industry standards, and are ergonomic in use.

The final design answers the assignment by proposing a modular concept meeting the set requirements for three products: an Size 4 oven, Size 4 bun warmer, and Size 5 bun warmer. All three products share a common door with a double locking mechanism and ARINC galley connection. The Size 4 oven and bun warmer share a common chassis, and inner oven. The Size 4 and Size 5 bun warmers share a common front face, HMI, and control module. A minimal amount of unique, product specific, elements are needed to define the different products. These are the heating elements with their related elements, a HMI for the oven, and an inner oven and chassis for the Size 5 bun warmer.

The design introduced a new HMI on the side of the products, with a 15 degree to optimise ergonomics for the flight attendant using the products.

Lastly the design language of the existing Collins Aerospace Modus and Essence collection is applied to the new product to make them fit in.







7. Recommendations



Desirability

Though the user perspective is considered throughout the design, only a select group of users was available for interviews. The interviewees are al Dutch flight attendants familiar with the ovens, but not the bun warmers. The interviews in the Analyse phase were conducted with KLM flight attendants that fly both long- and short-haul flights at a full-service airline. The interviews in the validation phase were conducted with Transavia flight attendants that fly short-haul flights at a low-cost carrier. To get a complete view on the user needs, it is recommended to do further user research with a broader group of international flight attendants working on long- and short-haul flights at low-cost and full-service airlines, that are familiar with ovens and bun warmers.

User aspects to explore further are usability at height, the presence of a steam function in the oven, the use cases of the bun warmers, the impact of the height and removal of the meal carrier on the cleanability of the inner ovens, and whether users can intuitively recognize which HMI belongs to which product, given its placement on the side.

Viability

With the shared components between the products and the use of existing elements in the new products, the viability of the products is validated. However, the exact costs of the products is not yet determined. To further develop the product, it is needed to map the costs of the products.

The products being designed with the existing design language of the Modus and Essences makes integration in the portfolio possible. The exact positioning of the new products within the portfolio should be determined. In the Modus collection an entry model, like the non-steam oven, would be fitting. However, with the single-handle double locking mechanism of the Essence collection used in the doors, a place in the Essence collection would also be possible. Here, the new HMI could also be introduced as a more exclusive feature.

Feasibility

With the layout of the elements determined and validated, the feasibility for the products is set. To further develop the technical side of the products, testing with a complete prototype for element fitting, manufacturing, and validation technical related requirements is needed. A part that should be tested and optimised is the heating. Because the inner ovens are smaller compared to existing ovens, and the fact that the meal carrier is no longer needed, the heating distribution and performance should be researched to decide on the final heating elements in the product. If found desirable adding a steam function to the oven could be an option, for this the galley connection should be considered, as well as the extra space needed for the steam function within the frame.

An aspect that has not been adressed is sustainability. The energy consumption and weight of the products compared to the existing products should be researched. Possibly in specific use cases like on-demand food services it might benefit the energy use and weight compared to the use of bigger ovens, this could be a selling point. The removal of the meal carrier could also result in a reduction of weight brought on board of an aircraft.

Reflection

Working on a mostly individual project for five months was both fun and challenging. Reflecting now, there are several aspects I feel I approached well, and others where I realise I could have made things a bit easier for myself. I want to elaborate on a few key aspects that were most important throughout the process.

One of the things that helped me throughout the project was having a clear overarching framework to guide my process, both the Double Diamond and the user, technology, and business perspective approach offered structure.

Within this process I once again learned that I should not stay in the Analyse phase for too long. A reason why I tend to do this is my hesitation about entering the ideation phase. In this project I also struggled a bit during this ideation phase. Luckily I was able to discuss this to my mentors, who helped me get through this. We did this by introducing the key insights and main design drivers. This really helped my to make the connection between the phases. With this out of the way I started to enjoy the project again. This approach is definitely something I would use again.

The writing of the report was something I enjoyed doing. At the start of the project I had the intention to consistently document my work, and I was able to stick to that. This documentation helped shape the first rough version of the report. With this basis I was able to start refining into the final report. With extended feedback from the different perspectives of my mentors I could also keep improving my report from the mid term onwards.

Despite the process going well and receiving good feedback, I was still a bit unsure about my work during the project. I think the pressure that comes with a graduation project distracted me from the great trust I got from my mentors. I am not used to asking for advice a lot, but I think being more proactive in this could have given me more trust in myself, because when I did ask for help, my mentors were always there with useful advice.

Overall, I feel that I was able to apply the design skills I acquired during my Industrial Design Engineering studies. In addition to that, this project allowed me to explore some personal interests related to working in a technical and business-oriented environment, like at Collins Aerospace, this is something I had not done before.

I got the change to work at the Collins Aerospace office in Houten, where I could participate in meetings about the company and my project. It was motivating to see the employees being so engaged and passionate about the business. Even though they sometimes face challenges their enthusiasm for their products remained, this was inspiring for me.

The people at the office were very welcoming and showed genuine interest in my project, especially since I was the only one working on an IDE-related topic. This experience taught me that, even as someone with little experience, the skills and knowledge I've acquired during my studies are already appreciated.

References

Airline Suppliers. (2019, April 29). Aluflite Atlas Standard Oven Rack – Inflight Galley Equipment - Airline Suppliers. https://www.airline-suppliers.com/product/aluflite-atlas-standard-oven-rack-inflight-galley-equipment/

van Boeijen, A.G.C., Daalhuizen, J.J., & Zijlstra, J.J.M. (Eds.), (2020, Rev. ed.). Delft Design Guide: Perspectives-Models-Approaches-Methods. Amsterdam: BISPublishers

Eccles, G. (2025, February 4). The emergence of long-haul narrowbody aircraft. AeroTime. https://www.aerotime.aero/articles/emergence-long-haul-leisure-narrowbody-aircraft

Ensinger. (2023, December 11). Ultem® 1000 (Polyetherimide) | High Performance Injection Molding & Plastic Manufacturing | Ensinger Precision Components. High Performance Injection Molding & Plastic Manufacturing |

Ensinger Precision Components. https://www.ensinger-pc.com/injection-molding-materials/our-plastic-stock-shapes/ultem-1000-polyetherimide/

Iacobucci HF Aerospace. (2025, April 7). Galley Insert - IACobucci HF Aerospace. https://www.iacobucci.aero/galley-insert/

Ipeco. (2024, October 17). IPECO Products & Services | Aircraft Crew Seating | Executive Seating | Galley Inserts. https://ipeco.com/products-and-services/#galley-inserts

Kirby, M. (2021, May 27). Products more closely resembling the home are in high demand.: Safran cabin. Runway Girl. https://runwaygirlnetwork.com/2019/05/new-airline-galley-equipment-offers-better-food-beverages-and-iot/

Military Aerospace Electronics. (2023, June 8). Collins Aerospace introduces new connected galley inserts for commercial aircraft. https://www.militaryaerospace.com/commercial-aerospace/article/14294903/collins-aerospace-introduces-new-connected-galley-inserts-for-commercial-aircraft

Pilot Institute. (2023, April 4). Narrowbody vs. Widebody Aircraft: What's the Difference? https://pilotinstitute.com/narrowbody-vs-widebody-aircraft/

Roozenburg, N., & Eekels, J. (1998). Productontwerpen,
structuur en methoden.

Ruiter, I. (2019, September 9). Sensorische Ergonomie [Slide show; Mens en Product Brightspace TU Delft].

Safran. (n.d.). Safran Concert Galley inserts. https://www.safran-group.com/products-services?search=&company%5B%5D=582-safran-cabin&category%5B%5D=330-electrical-inserts&sort_by=field_product_name&display=list

Skytender Solutions. (2024, September 23). SkyTender Solutions. https://skytendersolutions.com/

Teague. (2023, May 5). Collins Aerospace Essence Inserts collection. https://teague.com/work/collins-aerospace

Trigueros Alonso, A., Zarnowska, A., Proesmans, P.-J., Gangoli Rao, A., Faculty of Aerospace Engineering, Delft University of Technology, & Advanced Technologies Laboratory, Collins Aerospace. (2025). Every kilogram counts: a simplified model for estimating aircraft emissions reduction through mass minimization. In Towards Sustainable Aviation Summit 2025. https://www.3af-tsas.com/images/DOI/TSAS25/DocFinal-26-724-.pdf

World Travel Catering & Onboard Services Expo. (2025). SkyBarista | ONE. https://www.worldtravelcateringexpo.com/en-gb/exhibitor-directory/product-directory/product-details.exh-0dc265ae-b590-4047-86a5-f76a39980dc8.skybarista%20%20one.pro-268248cd-7e34-4874-a659-8739fef67f4d.html#/

Appendix A: User interviews for analysis set-up

Gebruikers interview: gebruik huidige producten en ontdekken eisen en wensen. (semi-structured with following questions)
Opening
Producten laten zien (prints maken van productfoto's) (next page)
Vragen of ze er bekend mee zijn.

Vragen over het gebruik van de producten:

· Oven:

o Heb je ervaring met het gebruik van de oven?
o Wat maak je er allemaal in klaar?
o Kun je in stappen uitleggen hoe je hem gebruikt?
o Zijn er stappen die vervelend zijn?
o Zijn er onderdelen die niet handig te gebruiken zijn?
o Zijn er dingen die juist heel handig en goed werken?

· Zelfde vragen over de bun warmer:

o Heb je ervaring met het gebruik van de bunwarmer?
o Wat maak je er allemaal in klaar?
o Kun je in stappen uitleggen hoe je hem gebruikt?
o Zijn er stappen die vervelend zijn?
o Zijn er onderdelen die niet handig te gebruiken zijn?
o Zijn er dingen die juist heel handig en goed werken?

· Use cases:

o Zijn er verschillen tussen economy en business gebruik?
o Gebruik je de producten ook voor je eigen eten?
o Hoe maken sommige specifieke maaltijden klaar? Bijvoorbeeld bij allergieën of als iemand iets extra's bested?
o Waarvoor zou je de oven allemaal kunnen gebruiken?
o Waarvoor zou je een kleinere (halve) oven kunnen gebruiken? Bv business class, allergies, on demand? Hoe doe je dit nu?
o Waarvoor zou je een bun warmer kunnen gebruiken?
o Heb je ideeën over hoe je dit soort producten (warm maak producten) nog meer zou kunnen gebruiken?
o Heb je ervaring met on demand eten/andere dingen klaarmaken? (maak je weleens een enkele maaltijd klaar?)
o Zou je opties die op de oven/bunwarmer zitten weglaten? En toevoegen?

· Overhead use:

o Welke producten gebruik je die bovenin de galley zitten?
o Als je een Kleine oven bovenin de galley zou zetten, zou je er dan nog goed bij kunnen?

· Rekjes:

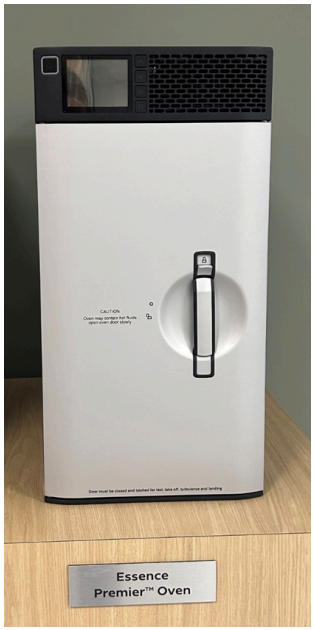
o In de oven zit een groot rek met daarin trays: hoe gebruik je deze?
o Zou je voor een kleinere oven ook dat grote rek nodig hebben, of zijn alleen de trays ook voldoende?
o Past altijd alles dat je in de oven wil doen? Of mis je bepaalde plek/vorm in de tray?

These pictures were brought (printed) to the interviews to make clear what the questions were about, and to encourage further conversations about the products.

















Appendix B: ULTEM, PEI

Overview

- Thermoplastic
- High temperature resistance
- Resistant to hot water and steam
- FDA compliant
- High dielectric strengths (strength of insulator before material breaks down)
- High flame resistance
- High tensile strength
- Lower density than PEEK, PESU, PAI

Pro's:

- Much cheaper than PEEK
- Higher tensile strength @ room temp. than PESU or PSU
- Lower water absorption than PES
- High continuous use temperature (170 C) similar to PESU
- Highest flame resistance of all thermoplastics (except fluoropolymers)
- Low smoke emission (lower than PESU)
- Transparent (though amber colored)

Con's:

- Lower maximum service temperature and impact strength than PEEK
- Relatively low notched impact strength
- Lower tensile strenght than PAI
- Prone to stress cracking in chlorinated solvents
- Yellow tint

Price					
Price	ⓘ	* 11.6	-	14.3	EUR/kg
Price per unit volume	ⓘ	* 1.45e4	-	1.83e4	EUR/m^3
Physical properties					
Density	ⓘ	1.26e3	-	1.28e3	kg/m^3
Mechanical properties					
Young's modulus	ⓘ	2.89	-	3.04	GPa
Specific stiffness	ⓘ	2.27	-	2.4	MN.m/kg
Yield strength (elastic limit)	ⓘ	* 73.5	-	81.1	MPa
Tensile strength	ⓘ	91.9	-	101	MPa
Specific strength	ⓘ	* 57.9	-	63.9	kN.m/kg
Elongation	ⓘ	55.8	-	64.5	% strain
Elongation at yield	ⓘ	2	-	12	% strain
Compressive modulus	ⓘ	3.22	-	3.38	GPa
Compressive strength	ⓘ	* 144	-	159	MPa
Flexural modulus	ⓘ	3.22	-	3.38	GPa
Flexural strength (modulus of rupture)	ⓘ	144	-	159	MPa
Shear modulus	ⓘ	* 1.04	-	1.09	GPa
Bulk modulus	ⓘ	* 4.51	-	4.73	GPa
Poisson's ratio	ⓘ	* 0.385	-	0.401	
Shape factor	ⓘ	5			
Hardness - Vickers	ⓘ	* 22	-	24	HV
Hardness - Rockwell M	ⓘ	109	-	110	
Hardness - Rockwell R	ⓘ	* 121	-	134	
Elastic stored energy (springs)	ⓘ	* 911	-	1.11e3	kJ/m^3
Fatigue strength at 10^7 cycles	ⓘ	* 33.9	-	44.1	MPa
Impact & fracture properties					
Fracture toughness	ⓘ	* 1.99	-	4.03	MPa.m^0.5
Toughness (G)	ⓘ	* 1.46	-	5	kJ/m^2
Impact strength, notched 23 °C	ⓘ	3.81	-	4.2	kJ/m^2
Impact strength, notched -30 °C	ⓘ	3.81	-	4.2	kJ/m^2

Appendix C: From key insights to main design drivers

Key insights from the Analyse phase:

Key insights
- Collins Aerospace's galley insert portfolio evolved from individually developed products into three **branded collections**: Endura, Essence, and Modus.
- The portfolio includes a wide range of galley inserts and covers premium, standard, and entry-level market segments.
- Collins Aerospace stands out through technical and design innovations.
- The Essence collection introduced the first **common design language** across galley inserts.

Key insights
- Safran is the main competitor for Collins Aerospace, followed by smaller players Ipeco and Iacobucci.
- Competitors offer similar galley insert products, each with their own strengths.
- Safran's portfolio includes products similar in size and type to those proposed in this project.
- All brands are transitioning from industrial-looking devices to more **home-like design languages**.

Key insights
- The main stakeholders for Collins Aerospace to work with are airlines and airframe OEMs.
- Airlines **prioritise high capacity** and reliability for ovens.
- The airframe OEMs sets safety, sizing, and performance requirements for the ovens.

Key insights
- The oven and bun warmer are used by flight attendants during standard meal services, as shown in the user journeys.
- Additional use cases occur between meal services, offering opportunities for the proposed products.

Key insights
- Almost every available function of the oven and bun warmer is frequently used and appreciated by flight attendants.
- The available functions are considered complete and easy to use, and should be preserved in future designs.
- Downsides include the packaging seal getting stuck in the meal carrier and the steam function leaving hot water on top of meals.

Key insights
- Ovens are equipped with meal carriers, and bun warmers with baskets to hold items for heating.
- Caterers handle meal carriers filled with meals, filled with meals they place them in ovens and trolleys before flights, after flights they clean and refill them.
- With the growth of on-demand food services, ovens are also used between the standard meal rounds to heat up individual meals or snacks. Flight attendants place these items in the ovens themselves.

Key insights
- Galleys follow ARINC sizing, with ovens (Size 2) typically placed at worktop height and bun warmers (Size 4) often placed above.
- **The proposed ARINC Size 4 and 5 ovens and bun warmers can be installed in the additional space above the worktop, providing airlines with maximal use of galley space.**
- **Placing products above worktop height may impact usability for flight attendants and should be carefully considered during the Design phase.**

Key insights
- The oven and bun warmer consist of similar elements, but are tailored to fit the size and functionality of the specific product.
- The needed elements and their relevance for this project is determined.
- The new oven should only have a convection option, the steam option is excluded.

Key insights
- **Industry standards, rules, and regulations influence design choices a lot. For this project sizing, capacity, operational, material, and retainment requirements are the most important.**
- **The door, electronics, the HMI, the motor, heating element, and PCB are the highest cost drivers in the products.**

Key insights
- Weight reduction is currently the primary sustainability focus in aviation, as it offers fuel savings and CO2 reduction sooner than other sustainability initiatives.
- Smart, connected galleys are emerging, providing efficiency through predictive maintenance and better communication between galley inserts and flight attendants.
- Passengers have a growing desire for personalisation, increasing the need for **on-demand services and flexible, full-time galley use.**
- The design of galley inserts is shifting toward a **user-centered and aesthetic appeal, creating a more home-like experience in the galley.**
- As narrowbody aircrafts are increasingly used for long-haul flights, **the design scope for galley inserts is expanding to support both short and long-haul services in smaller spaces.**

The key insights from the Analyse phase offer opportunities and important aspects to consider in the design, interesting insights for this project are highlighted in bold in the key insight boxes. Clustering these the following points of attention come up:

- Branded collections, with common design language, user-centered home-like design.
- Airlines prioritise high capacity ovens.
- The new products can be used above worktop height to maximise galley space. This may impact usability.
- Galley inserts are nowadays used in wide-body, narrow-body, long-haul, and short-haul fligts, making flexibility in use more important.
- More and more on-demand inflights services are offered, impacting galley use.
- Strict rules and standards apply.
- The door, electronics, the HMI, the motor, heating element, and PCB are the highest cost drivers in the products.

These points of attention are used to form the main design drivers that form the start of the Design phase, together with the LoRWs.

Main design drivers
- The products must be usable for flight attendants when placed above worktop height.
- All three products share a common door design and fit product specific elements within a shared frame. Next to the door, shared components should be commonly designed wherever possible.
- The three products fit in the existing design language of the Essence and Modus collection.
- The oven should have a capacity of at least 12 meals, with and extended goal of 16 meals.

Appendix D: LoRWs

LoRW 0: All products					
Catergory number	Category	Number	Requirement or wish?	Description	Qualitative/Quantitative
0A	Modularity (similarity)	0A1	W	The products should have as many shared elements as possible.	Quantitative
		0A2	W	The products should be in line with the existing design language of the Modus and Essence collections.	Quantitative
		0A3	W	The products should have as few parts that need certification as possible.	Quantitative
0C	Product positioning	0C1	R	Product must sustain 15 years of use, with (preventative) mainanance allowed.	Qualitative
0E	Standards, rules and safety	0E1	R	Surfaces that are in contact with food must be FDA compliant.	Qualitative
		0E2	R	Product must adhere to flammability requirements (FAR 25.853).	Qualitative
		0E3	R	Product must run on aircraft power (3 phase 115 VA).	Qualitative
		0E4	R	Any loose/movable component that by its motion can cause injury or impede emergeny evacuation must be secured by dual retaining devices.	Qualitative
		0E5	R	Parts that can be used as a support surface must be able to handle a 300 pounds (~136 kg) abuse load	Qualitative
		0E6	R	Product must not have sharp corners or edges that can cause injuries or damage.	Qualitative
		0E7	R	Product must prevent heat escaping the product on the front.	Qualitative
		0E8	R	The product must have a safe open position, similar to the current oven doors safe position.	Qualitative
		0E9	R	Front face must not have voids or crevices that allow for mold.	Qualitative
		0E10	R	Heating must only be able to be turned on when product is fully closed.	Qualitative
		0E11	R	Maximum surface temperature of plastic within reach is 49 °C.	Qualitative
		0E12	R	Maximum surface temperature of metal within reach is 71 °C.	Qualitative
		0E13	W	The product should be able to sustain aircraft vibrations.	Quantitative
		0E14	W	The product should be able to sustain pressure changes.	Quantitative
0F	User aspects	0F1	W	Retaining devices must be operatable by a single motion with one hand, left and right handed.	Qualitative
		0F2	R	All functions of product must be reachable and usable by hand at specified ARINC 4 and 5 placements in the galley.	Qualitative
		0F3	R	The product should provide full access to the cavity of the product from the front.	Qualitative
		0F4	R	The product must be usable for the reference crew of the anthropometric range of 5% German female to 95% North American.	Qualitative
		0F5	R	The product must be interpretable from 2,5 m with 20/20 vision.	Qualitative
		0F6	R	Products can be carried by one person.	Quantitative
		0F7	R	The product must be operable by one flight attendant.	Qualitative
		0F8	R	The product must be operable with and without oven gloves.	Qualitative
		0F9	R	The product must be operable with long nails.	Qualitative
		0F10	W	The product must be intuitively usable by a flight attendant without intructions.	Quantitative
		0F11	R	The product must provide the flight attendant with an on/off setting.	Qualitative
		0F12	R	All functions must be indicated by icons and/or text.	Qualitative
		0F13	R	Images and text on surfaces must be able to withstand 10 years of use.	Qualitative
		0F14	W	The insert should provide space for meals, soup bowls, buns, coffee cups, plates.	Quantitative
0G	Product policy	0G1	W	The design must be producable with as many production methods that are already in use.	Quantitative
		0G2	W	Should have a design language which can be applied to other products within the same product line.	Quantitative
0H	Sustainability	0H1	W	The product should be as lightweight as possible.	Quantitative
		0H2	W	The product should have as few parts as possible.	Quantitative
		0H3	W	The product should use as little energy as possible.	Quantitative
		0H4	W	The product should be easily demountable into recyclable parts.	Quantitative
		0H5	W	The product and its connectors should make replacement and maintance of parts easy.	Quantitative
		0H6	W	The product could be predictive of maintanance.	Qualitative
		0H7	W	The product should be made of as many sustainable materials as possible.	Quantitative

LoRW 1:Bun Warmer Size 4

Catergory	Category	Number	Requirement or wish?	Description	Qualitative/Quantitative
1B	Performance	1B1	R	Product must have a heating mode.	Qualitative
		1B2	R	Product must use a maximum power of 750 W.	Qualitative
		1B3	R	Product must have a capacity to heat up 60 buns.	Qualitative
		1B4	R	Product must fit 60 stand airline bread rolls.	Qualitative
		1B5	R	Product should heat up the empty cavity to a temperature of 88 °C within 5 minutes and 30 seconds.	Qualitative
		1B6	W	Product could have an hold mode which holds the cavity temperature above 60 °C.	Qualitative
		1B7	R	Product should stop operation in heating mode after 60 minutes.	Qualitative
1C	Product positioning	1C1	R	BoM costs must not exceed $3200.	Qualitative
		1C2	R	The product should remain part of the Collins portfolio, with 150–200 bun warmers per year.	Qualitative
1D	Size and weight	1D1	R	Product must have a maximum empty weight of 7,4 kg.	Qualitative
		1D2	R	Product must have a maximum gross weight of 13 kg.	Qualitative
		1D3	R	Product size must be in accordance with ARINC 810 standard size 4.	Qualitative
1E	Standards, rules and safety	1E1	R	Product interface must be in accordance with ARINC 810 standard size 4.	Qualitative
1F	User aspects	1F1	R	Items to be heated must be easily and intuitively placable and removable in and out the oven.	Qualitative
		1F2	W	The product could provide the flight attendant with temperature settings.	Qualitative
		1F3	W	The product could provide the flight attendant with time settings.	Qualitative
		1F4	W	The product could inform the user of the current settings of the oven.	Qualitative
		1F5	W	The product should provide the user to insert food, cutlery pieces, towels, and possible other items in the bun warmer.	Quantitative
		1F6	R	The product must inform the user of the current status of the oven.	Qualitative
		1F7	W	The product could provide the flight attendant with presettings.	Qualitative
1G	Product policy	1G1	W	The product should be as similar in use as previous Collins bun warmers.	Quantitative

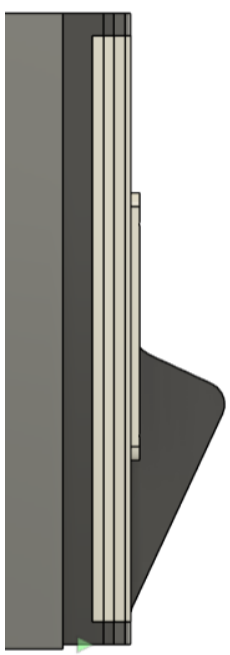
LoRW 2: Bun Warmer Size 5

ɛrgory	Category	Number	Requirement or wish?	Description	Qualitative/Quantitative
1B	Performance	2B1	R	Product must have a heating mode.	Qualitative
		2B2	R	Product must use a maximum power of 450 W.	Qualitative
		2B3	R	Product must fit 30 stand airline bread rolls.	Qualitative
		2B4	R	Product should heat up the empty cavity to a temperature of 88 °C within 5 minutes and 30 seconds.	Qualitative
		2B5	W	Product could have an hold mode which holds the cavity temperature above 60 °C.	Qualitative
		2B6	R	Product should stop operation in heating mode after 60 minutes.	Qualitative
1C	Product positioning	2C1	R	BoM costs must not exceed $2700.	Qualitative
		2C2	R	Product must fill up Collins' portfolio with 50-75 bun warmers per year.	Qualitative
1D	Size and weight	2D1	R	Product must have a maximum empty weight of 5,1 kg.	Qualitative
		2D2	R	Product must have a maximum gross weight of x kg.	Qualitative
		2D3	R	Product size must be in accordance with ARINC 810 standard size 5.	Qualitative
1E	Standards, rules and safety	2E1	R	Product interface must be in accordance with ARINC 810 standard size 5.	Qualitative
1F	User aspects	2F1	R	Items to be heated must be easily and intuitively placable and removable in and out the oven.	Qualitative
		2F2	W	The product could provide the flight attendant with temperature settings.	Qualitative
		2F3	W	The product could provide the flight attendant with time settings.	Qualitative
		2F4	W	The product could inform the user of the current settings of the oven.	Qualitative
		2F5	W	The product should provide the user to insert food, cutlery pieces, towels, and possible other items in the bun warmer.	Quantitative
		2F6	R	The product must inform the user of the current status of the oven.	Qualitative
		2F7	W	The product could provide the flight attendant with presettings.	Qualitative
1G	Product policy	2G1	W	The product should be as similar in use as previous Collins bun warmers.	Quantitative

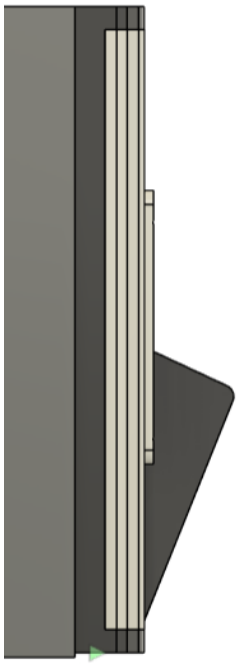
LoRW 3: Oven Size 4				
Catergory number	Category	Number	Requirement or wish	Description	Qualitative/Quantitative
3B	Performance	3B1	R	Product must have a convection oven mode.	Qualitative
		3B2	R	Product must have recirculation of heated air in inner oven cavity.	Qualitative
		3B3	R	Product must use a maximum power of 1450 W.	Qualitative
3B	Performance	3B4	R	Product must have a capacity to heat up 12 meals of 280 grams.	Qualitative
		3B5	W	Product could have a capacity to heat up 16 meals of 280 grams.	Qualitative
		3B6	R	Product must fit 12 industry standard economy class meals.	Qualitative
		3B7	W	Product could fit 16 industry standard economy class meals.	Qualitative
		3B8	W	Product could fit as many as possible industry standard business class meals.	Quantitative
		3B9	W	Product should reach target temperature of 71°C within 28 minutes for chilled meals (4°C).	Qualitative
3C	Product positioning	3C1	R	BoM costs must not exceed $3800.	Qualitative
		3C2	R	Product must fill up Collins' portfolio with 25-50 ovens per year.	Qualitative
3D	Size and weight	3D1	R	Product must have a maximum empty weight of 7.4 kg.	Qualitative
		3D2	R	Product must have a maximum gross weight of 13 kg.	Qualitative
		3D3	R	Product size must be in accordance with ARINC 810 standard size 4.	Qualitative
3E	Standards, rules and safety	3E1	R	Product interface must be in accordance with ARINC 810 standard size 4.	Qualitative
		3E2	R	Product must provide cooling to parts outside the oven cavity, keeping the temperature of components at acceptable levels and lower the temperature of the outer surfaces.	Qualitative
3F	User aspects	3F1	R	The meals must be easily and intuitively placable and removable in and out the oven.	Quantitative
		3F2	R	The product must provide the flight attendant with temperature settings.	Qualitative
		3F3	R	The product must provide the flight attendant with time settings.	Qualitative
		3F4	R	The product must provide the flight attendant with presettings.	Qualitative
		3F5	R	The product must inform the user of the current settings and status of the oven.	Qualitative
3G	Product policy	3G1	W	The product should be as similar in use as previous Collins ovens.	Quantitative

Appendix E: Form of pretrude HMI

Existing products of the Modus and Essence collection inspire the form of the design. For this part, the Nespresso maker is used as a reference point, because it has a somewhat similar pretrude on the front. Several rounding options are considered. Because of the change of angle from 25 to 15 degrees, the pretrude turned out to be a bit less remarkable. With the subtle rounding the overall form of the existing products is followed. Overall, with this design, the usualness of the pretrude is kept to a minimum.



First concept



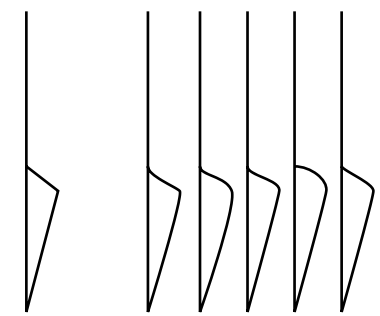
First concept with minimalised rounding



Concept altered to 15 degrees angle



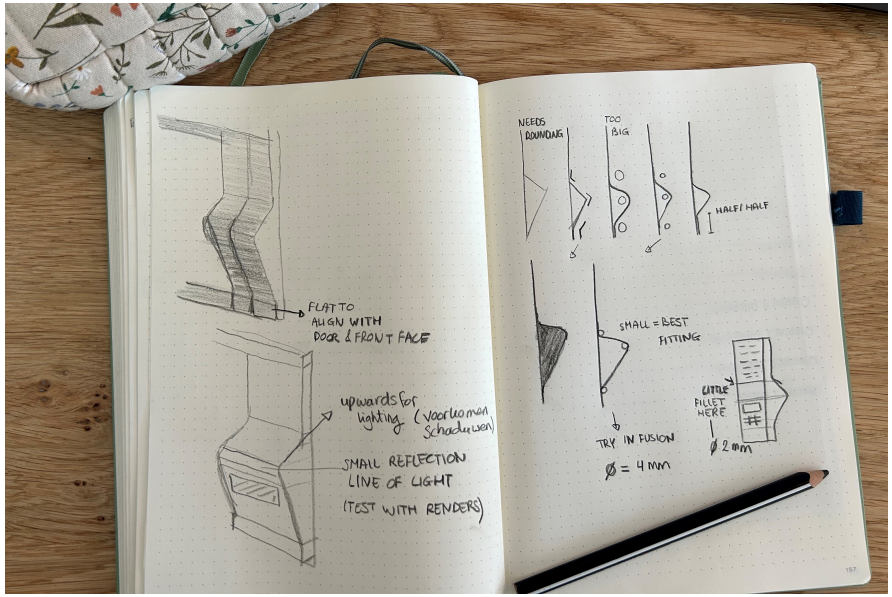
Final design



Basis for 15 degree angled HMI

Exloration of form





Exloration of form

Appendix F: User interviews for validation set-up

Doel: gebruik en vormgeving in context testen/valideren
Middel: interview over galley mockup met prototype.

1. Laten zien concept versie van het nieuwe product op de galley mockup.

V: Wat is je eerste indruk van dit product? Evt direct vragen naar de HMI en/ of vormgeving

V: Vind je het gebruikspaneel die onder een hoek staat handig om mee te werken als je in de galley staat?

V: Helpt de hoek om het scherm te zien en de knoppen te kunnen gebruiken?

V: Wat is de beste hoek om te gebruiken? (hoeken laten zien)

V: Zijn er dingen die deze interface makkelijker te gebruiken kunnen maken?

V: Stel je voor dat je dit product gebruikt tijdens een vlucht, maak je je ergens zorgen om dat het niet zou werken?

Looks:

V: Hoe vind je dat het eruit ziet? Wat vind je mooi? Wat vind je minder mooi? Wat zou je veranderen?

V: Denk je dat dit product goed tussen de andere producten in de galley past?



Appendix G: Graduation Project Brief



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IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

STUDENT DATA & MASTER PROGRAMME

Complete all fields and indicate which master(s) you are in

Family name	Binnendijk	7598	
Initials	A.M.		
Given name	Emma		
Student number	5043875		

IDE master(s) IPD ✔ DfI ☐ SPD ☐

2nd non-IDE master

Individual programme *(date of approval)*

Medisign ☐

HPM ☐

SUPERVISORY TEAM

Fill in he required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	Daan van Eijk	dept./section	HCD/HF
mentor	André Valkenhoff	dept./section	HCD/HF
2nd mentor			
client:	Collins Aerospace		
city:	Houten	country:	The Netherlands

optional comments: The two team members are from the same Human Factors section, though they have very different profiles. Daan van Eijk has an Applied Ergonomics research background while Andre Valkenhoff has a holistic integrating approach as Industrial Design Engineer.

! Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.

! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.

! 2nd mentor only applies when a client is involved.

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in **by the Chair** of the supervisory team

Sign for approval (Chair)

tudelft.protect Jamf Protect CSR Identity

Digitally signed by tudelft.protect Jamf Protect CSR Identity
Date: 2025.03.11 20:55:34 +01'00'

Name Daan van Eijk Date 11 Mar 2025 Signature

CHECK ON STUDY PROGRESS

To be filled in **by SSC E&SA** (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total ____ EC

Of which, taking conditional requirements into account, can be part of the exam programme ____ EC

★	**YES**	all 1st year master courses passed
	NO	missing 1st year courses

Comments:

Sign for approval (SSC E&SA)

L. Boot Digitaal ondertekend door L. Boot Datum: 2025.03.17 16:03:55 +01'00'

Name Lisette Boot Date 17 mrt 2025 Signature

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	★	Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is ...

★	**ALLOWED** to start the graduation project
	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

Monique von Morgen Digitally signed by Monique von Morgen Date: 2025.03.18 10:04:02 +01'00'

Name Monique von Morgen Date 18 Mar 2025 Signature

DESIGN FOR our future

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Personal Project Brief – IDE Master Graduation Project

Name student Emma Binnendijk **Student number** 5,043,875

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

Project title Modular aircraft galley oven design for Collins Aerospace.

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

1. The company: Collins Aerospace

Collins Aerospace, an RTX Business, is a leading provider of aerospace and defense solutions. The company's galley inserts business is a division that specializes in designing and manufacturing various products for aircraft galleys. These include a wide range of equipment and components that cater to the needs of both passengers and crew during flights.

Collins Aerospace's galley inserts (see Figure 1) business offers innovative and high-quality solutions to airlines, aircraft manufacturers, and operators. These inserts are designed with a focus on efficiency, weight reduction, and maximizing space utilization to meet the strict requirements of the aviation industry. The company aims to enhance the in-flight experience for passengers while also streamlining operations for airlines and crew members.

2. Background

Many generations of ovens have been developed by our team in Houten, meeting most demands requested by our customers (buyer: aircraft manufacturer (Boing/Airbus) or airline), cabin crew (user), and passengers. Some specific demands for smaller sized ovens cannot be met due to the high development and certification cost, and low product volumes. There are three products we have in mind that individually do not make a positive business case but are expected to make commercially sense if they are developed together. A drive for common parts and clever integration of functionality will be key to make this project commercially viable

→ *space available for images / figures on next page*

introduction (continued): space for images



image / figure 1 Collins Aerospace galley inserts (Collins Aerospace, 2019).



image / figure 2 Oven in use by flight attendant.

DESIGN FOR our future

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Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

To fill the need of specific oven configurations/versions that cannot be individually developed due to costs. There is a limited demand for small ovens and bunwarmers, which are now not available due to this problem. Collins sees an opportunity to develop these ovens by combining the options into a modular design. This way, less development costs are needed, since it is one product instead of multiple. They would also share appearance and way of use (shared/similar HMI). It could also be an inspiration for other future aircraft galley products that could be made modular.
Three oven configurations are requested:
1. Bun warmer, ARINC size 4
2. Bun warmer, ARINC size 5
3. Half size oven, ARINC size 4
All with performance at least at good as current bun warmers/ovens, weight/power/costs/more.. requirements available at Collins per configuration.
In the time frame of 100 days, I see a possibility for analysing Collins' current (oven) products, researching the technical possibilities for such a modular design, refining the set of requirements, followed by a design phase to design a concept in which the use of the product(s) should also be taken into account. Ending with a final design proposal with CAD model.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Develop a concept for three modular aerospace galley oven products sharing a common chassis and have a minimum amount of unique parts to create a new business opportunity in the form of a new product for Collins Aerospace.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

Explore/research Collins' and competitors current ovens, how does such an oven work. What is the basis of an oven. What do the three different configurations need. -> Use physical existing products and CAD models at Collins to investigate.
What functions do these current ovens offer to the user? For what purposes are they used (heating meals, other (sub) functions?)
Determine what you would want to achieve with making a modular oven: what should you be able to modify? -> What are the needs?
Research user needs (oa. HMI) and implement in requirements and design. What aspects of the use of current ovens are worth keeping, what should/could be changed to make the use better?
Do the (new) user needs result in the need for more/less/new components?
Refining set of requirement.
Design a concept for a modular oven basis, standard parts, and modular parts.
Deliver final concept design and CAD model

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting**, **mid-term evaluation meeting**, **green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	17 Feb 2025
Mid-term evaluation	11 Apr 2025
Green light meeting	6 Jun 2025
Graduation ceremony	4 Jul 2025

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

I am interested in diving deeper into a specific technical design field, to combine the design skills (like the design process, methods, and collaboration) aquired at IDE with new, more specific, technical knowledge of the aircraft design world. I would like to specialise in a design field, such as the aircraft design world. The reason behind this is my interest in being an industrial designer that also has knowledge on mechanical engineering, to be able to work as a designer collaborating with engineers.
To learn to work in a company as a design engineer. At Collins I also get the chance to participate in company meetings to learn more about the corporate world. I think collaborating in a big international company could be interesting for a beginning designer, because it offers connections with lots of experienced people with different kinds of knowledge. I would like to find out if this is true, and how I can learn the most from this.
To come up with a final deliverable that has strong argumentation, so I can be proud of the work and am able to defend it convincingly. I would like to be able to understand and explain the technical functions, the similirities between te products, and the use cases and HMI.

Of course the first reason for this project is to succesfully complete my MSc IPD and be ready to work as an industrial design engineer.