

Please Remain Seated: Reshaping the Sedentary Inflight Experience
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University of Washington

Abstract

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To address this problem, I researched and designed an economy passenger seating system aimed at effectively reduce the risk of DVT and reducing the overall negative impacts of sedentary air travel. The concept was developed in consultation with faculty in the UW School of Nursing. The result is an asymmetrical seat design that increases the space for body movements, while integrating a reminder system to encourage mobility.

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Abstract

“Sitting is the new smoking” has become a popular phrase to describe the dangers of a sedentary lifestyle. Previous research has shown that prolonged sitting can cause irreversible damage to the human body, including more than thirty types of chronic illnesses and acute medical issues, such as Deep Vein Thrombosis (DVT). Standing up to walk around and take breaks during long hours of sitting is one way to mitigate these health problems. However, in some cases this is not possible—the long haul flight in an economy seat requires passengers to remain seated for many hours.

To address this problem, I researched and designed an economy passenger seating system aimed at effectively reduce the risk of DVT and reducing the overall negative impacts of sedentary air travel. The concept was developed in consultation with faculty in the UW School of Nursing. An important part of my process was the construction of full-scale prototypes to refine the ergonomic details of the seat. The design also considers the Federal Aviation Regulation guidelines, engineering constraints, and the airline’s concern for a feasible concept. The result is an asymmetrical seat design that increases the space for body movements, while integrating a reminder system to encourage mobility.

Research & Ideation

In “Research Methods for Product Design” by Alex Milton and Paul Rodgers, research is defined as a systematic investigation into materials and sources in order to establish facts and reach new conclusions. Compared with scientific research, which often aims to provide information and theories to explain the nature and properties of the world, design research tries to produce trans-disciplinary and heterogeneous knowledge that seeks to improve the world for human society. Design research does not try to uncover universal truth; instead it looks into the plausibility and appropriateness of proposals (Alex Milton and Paul Rodgers, 2013).

The process of design research varies based upon the goal and resource limitation of each project. For this project, both secondary and primary research play important roles of establishing background knowledge and defining design opportunities.

Secondary Research

Understanding the impact of sedentary behavior in detail is the premise of my following primary research and concept ideation.

To establish my understanding of this topic efficiently, I went to Dr. Brian Liem and Elliot O'Connor's lecture, who are from UW Sports Medicine. They have worked on sedentary issues for years and are well known for their expertise.

Adverse impact of sedentary behavior

Brian and Elliot characterize sedentary behaviors as sitting or reclining, and is in the energy-expenditure range of some 1.0 to 1.5 METs (multiples of the basal metabolic rate). In general this means that any time a person is sitting or lying down, they are engaging in sedentary behavior. It is the repetition of prolonged sitting in a daily routine that can cause damage to human body. According to their research, there is evidence suggests that for every two hours sitting, a person will conserve 352 calories compared with a person who is standing. After 4 hours of sitting, skeletal muscular lipoprotein lipase, which is an indicator for metabolism level, will drop to one half of the level of when a person is active (The Whole U, 2015).

I also searched online for more information and there are a lot of articles providing facts around the relationship between sitting time and its adverse impact. For example, according to Dr. David Agus, five or more hours of sedentary sitting is the health equivalent of smoking a pack and a quarter of cigarettes.

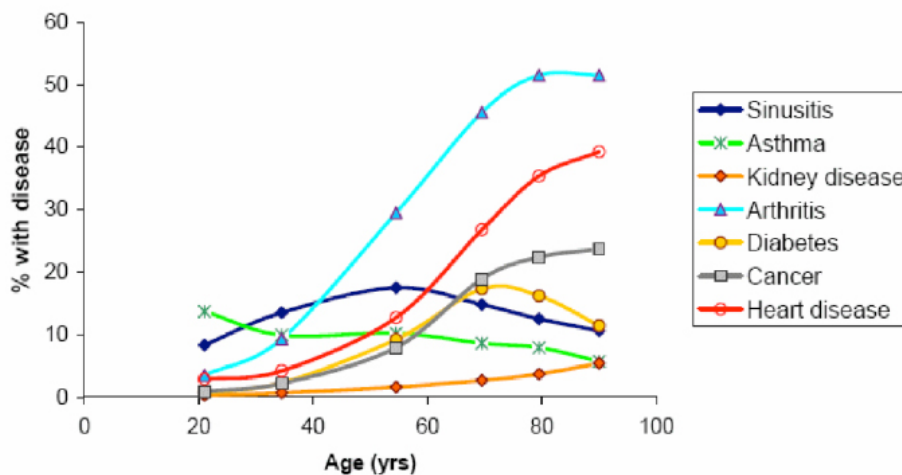
The development of chronic diseases and the increased risk of death is attributed to the habitual prolonged sitting. A study in the American Journal of Preventative Medicine in 2011 suggests that prolonged-sitting is associated with increased risk of 34 chronic diseases including obesity, diabetes, cancer, and cardiovascular disease. Prolonged sitting does not make a dramatic change in the body immediately, but it kills you slowly as time goes by. The harm done to the body by prolonged sitting is gradual and irreversible, just like smoking.

The adverse impact from prolonged sitting starts to accumulate after short amount of sitting time and is independent of exercise afterward. Some may assume that vigorous exercise after prolonged sitting will undo the harm. However, recent research points out that an adult can spend 30 minutes on vigorous exercise per day, following the current public health guidelines, and still fall victim to sedentary diseases (Hamilton, Healy, Dunstan, Zderic & Owen, 2012). Among individuals who meet the physical activity recommendations, time spent sitting appears to independently increase the risk of obesity, diabetes, heart disease and mortality (Owen, 2009).

Defining problem space

After understanding the impact of prolonged sitting, I start to narrow down the problem space.

I made many changes during the process of finding the ideal problem space for this project. I first focused on the middle age people with desk-bound jobs, because these people are starting to develop chronic diseases and sedentary behavior would worsen their situation (What Is Aging, 2003)

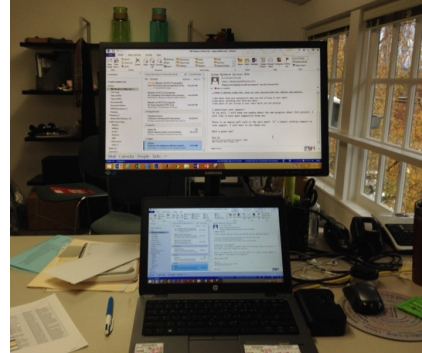


The Process of Aging

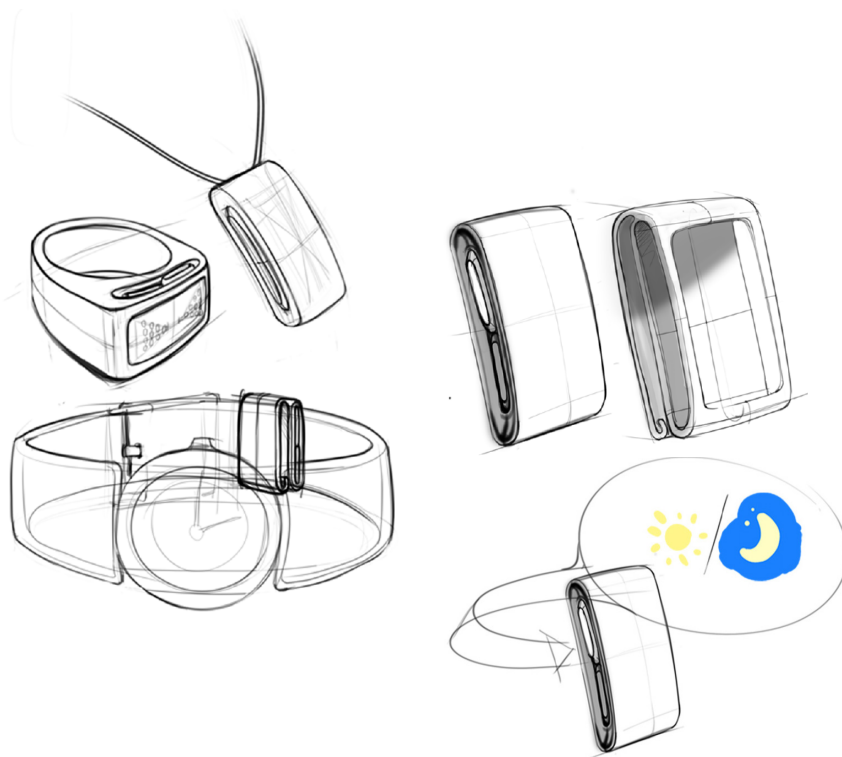
The risk of developing chronic disease increase faster between 55 and 65 years old.

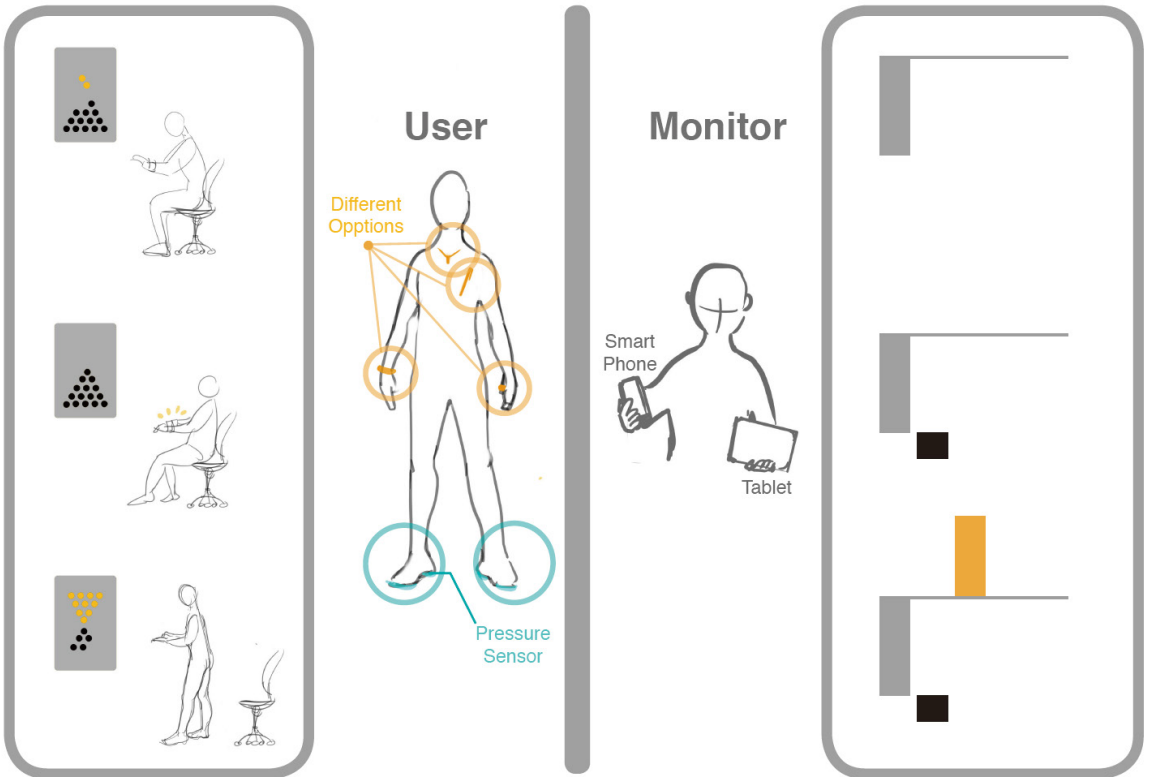
I created several concepts along side secondary and primary research. The goal of these concepts is to implement an intervention system into the users everyday lives and reduce their overall prolonged-sitting time. The key features of the product are its portability and encouraging habit-forming effects.

Interview with target audiences.



Concept of Sensor Based
Sitting Tracker for Late Middle age
Office Worker.





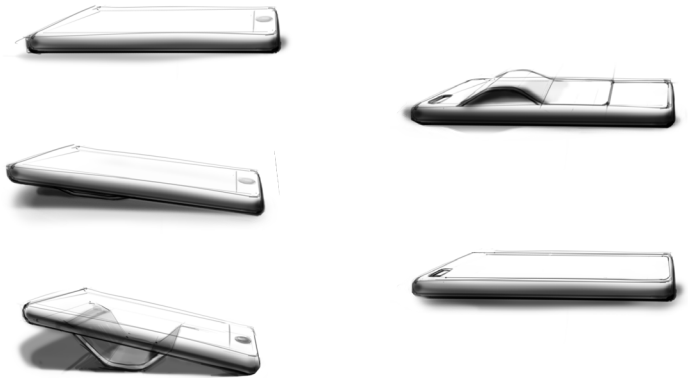
My first attempt was to design something that encourages the users to stand up and move around. However, after looking into the constraints of these types of products, I realized it is a great challenge to design an artifact that completely distinguishes itself from the existing health trackers for this purpose. The current health trackers such as Fitbit One, misfit shine and Jawbone are well designed for urging the users to move around and break up their prolonged sitting.



Different Types of Health Tracker

I then further narrowed down the problem space and focused only on the situation when the users need to do obligated prolonged-sitting. This was one of the few scenarios when I first started ideating. Besides sitting for desk-bound work and entertainment, obligated sitting due to social protocol also contributes to sedentary lifestyle.

In order to solve the problem of obligated sitting, I start to think about if it's possible to help the user to “break up” their prolonged sitting while remaining in their seats.



Phone Case Sitting Reminder
(Concept)

The first scenario that I looked into is a meeting. Although the walking meeting has become more popular (Peck, Emily, 2015) (pic of walking meeting and sitting meeting), most of the people still need to endure the meeting while sitting still by the table, even if they are very aware that it's about time to stand up and move around. I also looked into some other situations include sitting for a formal dinner and sitting for commute. While researching about prolonged sitting during commute, several articles brought my attention to the situation of air traveler.

Lots of previous research results indicate that prolonged-immobility during long-haul flight would lead to severer health issue. What's more, one article reports that the current methods for preventing sedentary related health risk during air traveling do not have noticeable effect. It also suggests that current advice on prevention of travel-related thrombosis may have to be reconsidered (Anja J. M. Schreijer, Suzanne C. Cannegieter, Carine J. M. Doggen and Frits R. Rosendaal, 2008). The previous research inspired me to concentrate solely on the air traveler, especially the passengers in the economy class for long-haul flight.

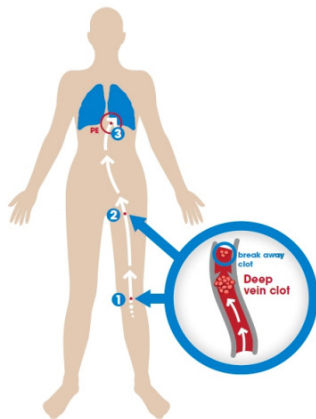
Sedentary and “Economy Class Syndrome”

DVT, PE and VTE

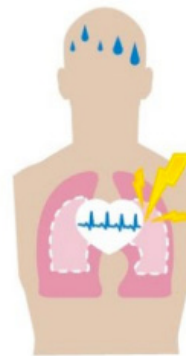
The major health risk for air travelers is Venous Thromboembolism (VTE). There are two different conditions within VTE, deep vein thrombosis (DVT) and its potentially life-threatening acute complication pulmonary embolism (PE).

A deep vein thrombosis (DVT) results from the formation of a blood clot (thrombus) inside a deep vein, usually in the leg or pelvis, which either partially or totally blocks the flow of blood in the vein. If the clot, or a part of it, breaks off from the site of formation and travels through the circulatory system, an embolism may occur, which is known as pulmonary embolism (PE), a life-threatening condition.

The majority of people with deep vein thrombosis do not feel any symptoms. If there are symptoms of deep vein thrombosis, they usually occur in one leg only. People with deep vein thrombosis may experience swelling, pain and tenderness, prominent veins and increased skin temperature. Approximately one third of patients with symptomatic deep vein thrombosis may also develop a pulmonary embolism. People suffering from pulmonary embolism may experience acute shortness of breath, chest pain, sweating, and rapid heart rate (Cynthia, A. Kos, 2015).



The formation of blood clot



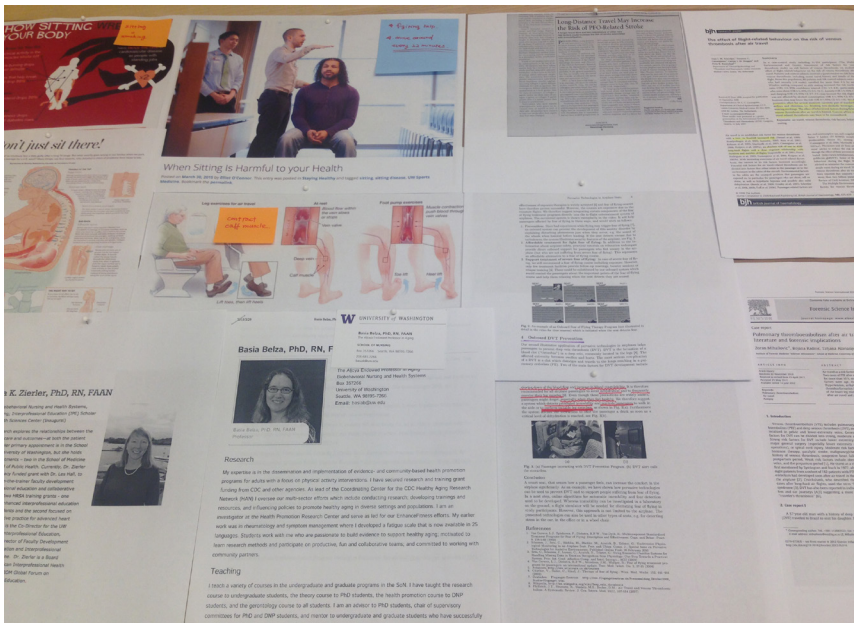
symptoms of deep vein thrombosis

In the past, DVT were often referring as 'economic class syndrome'. People assume that it is because of the cramped space and the stress it generates that brings DVT to the passengers. In recent years, however, researchers have changed their opinions on this issue because DVT has also been reported amongst business class travelers. The risk of DVT formation does not vary dramatically between business class and economy class. Researchers suggest that it is long time of immobilization rather than cramped space that leads to high risk of DVT (Signorelli C, 2013).

A control study conducted by Leiden University of Netherland shows the relationship between the risk of DVT and prolonged sitting in detail. According to their research, those who slept during the flight had a 1.5 fold increased risk compared to passengers who did not sleep during the flight. This is because the passengers will have a long period of time sitting still in cramped space while sleeping during the flight. They also found that passengers seated in a window seat had a more than twofold-increased risk of venous thrombosis than passengers who were seated at an aisle seat. The researchers deduce it is probably because that the passengers have a harder time coming to the aisle to walk around and easier time sleeping that lead to this result. The result also shows that there is no distinct difference between economy class passenger and business class passenger on the risk of developing DVT. This again supports their argument that long-term immobility is the leading cause of air-travel related DVT (Anja J. M. Schreijer et al.).

Air Quality

Air quality is another factor that may lead to DVT. Research from the World Health Organization suggests that the low pressure and low oxygen environment during air travel may contribute to the development of DVT. Low oxygen, low humidity, and low cabin pressure at high elevations have a dehydrating effect that concentrates the blood, making it sluggish. This effect is worsened when passengers consume alcohol, or do not adequately replenish fluids lost by dehydration (Cynthia A. Kos, 2015).



Secondary Research's
thinking board

Stakeholder Analysis

It is reported that as many as 10% of airline passengers travelling without practicing any preventive methods for long distances may develop a venous thrombosis (Jacobson F. Berry, 2013 et al.).

Although researchers in the medical field have addressed this issue frequently for decades, few efforts have been done to improve the situation in design or the aviation industry. A lot of time, the problem of a design or a system is a manifestation of the conflict between different stakeholders. As artifacts have to work within many dimensions, human-centered designers must have an encompassing mentality and be able to work with all relevant stakeholders addressing different dimensions of the artifact (Krippendorff K., 2006).

In order to ensure the concept's value for all the parties, I did secondary research on the stakeholders. The major things I investigated are the common interest of the stakeholders and their current conflicts. I will elaborate according each stakeholders in the following paragraphs, they are airlines, passengers and original equipment manufacturer (OEM).

Airlines

Airlines have been struggling with business for a long time. In order to improve business, they have to find ways to cut cost and increase revenue.

When it comes to the design of economy class cabin, one of the main methods that airlines apply to reduce cost is to cut down on the weight of all the components, especially the weight of product for each passenger, such as passenger seat.

At the same time, they also try to pack more seats in the cabin in order to sell more tickets. For example, Airbus unveiled their upcoming A380 new cabin layout “budget” at 2015’s Aircraft Interior EXPO, in which they manage to cram one more seat in every row.

From this we can predict that situation may get worse for the economy class passengers in the near future.



Airbus manage to cram one more seat in every row

In order to survive in the business competition, airlines also have to improve passengers' travelling experience, so the passenger will choose their service again in the future. To do that, airlines try different methods to keep the passengers comfortable during the flight. For example, the in-flight entertainment system has been improved a lot in the last few years.

Airlines also improve passengers' experience by providing special service with affordable plan, catering the passengers who have additional needs. For instance, Delta provides special ticket "Comfort Plus", which is seat with extra knee room, for a little more charge.

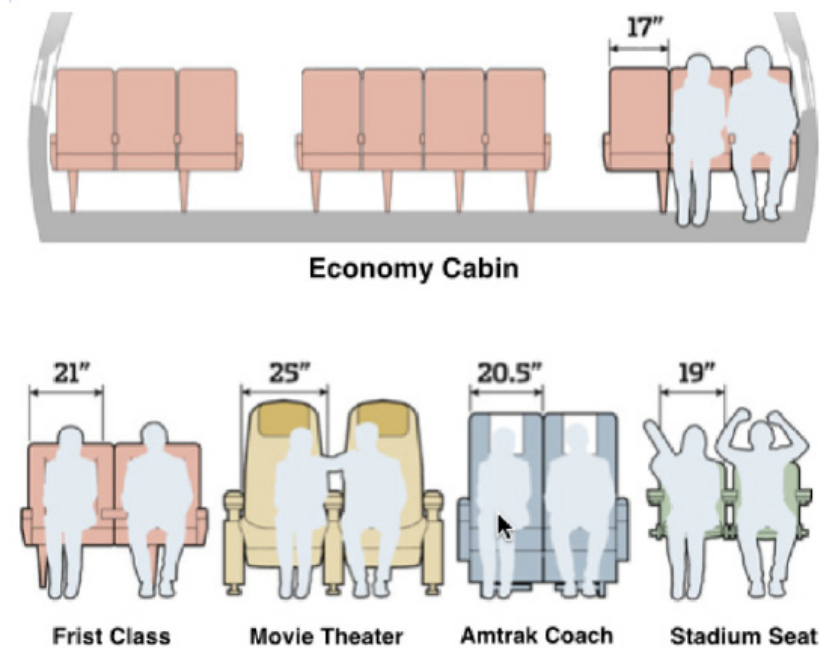
This gives the passengers, especially those taller than average, an affordable option comparing with business class or first class.

These types of affordable services such as premium economy seat can improve the experience of economy class passengers while increasing the airlines' revenue. In light of these considerations, it is possible that more airlines will provide special services options to meet various needs of different types of passengers in the upcoming years.

Passengers

Air travelers have been complaining about the ever-shrinking passenger seats in the economy cabin.

For them, economy cabin is a space that creates discomfort. Individuals' space in the economy class is much less compared to other public situations.



The Incredible Shrinking Plane
Seat

As a result, people come up with ad hoc solutions, such as Knee Defender, elbow divider, to improve their own experience. Some people need compression socks to prevent deep vein thrombosis. These designs demonstrate the problems that have been bothering the passengers for long time and have not been resolved so far.



"b-tourist"

A design aimed to provide privacy.



Soarigami - Airmail

"The Soarigami is a consumer product that attaches onto any armrest to extend the space and allow two people to comfortably share."

Original Equipment Manufacturer (OEM) situations

Aircraft OEM provides airlines with aircrafts. They design and manufacture aircraft according to regulations, airlines' requirements, and engineering constraints.

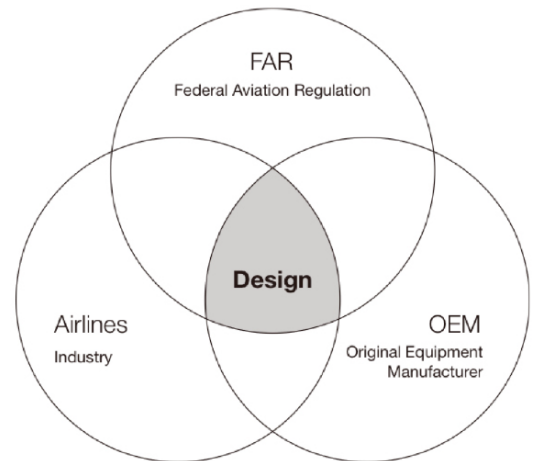
Lots of designers working in OEMs have been eager to improve the situation for years. Though numerous concepts for improving the economy passengers' experience have been created, they rarely have been put into production. It's very hard to implement improvements in aviation field for variety of reasons.

For one, in-house designers in this industry have less time and resource to conduct cross-disciplinary research. To create game-changing design, cross-disciplinary research is a key. It provides designers new perspectives and insights, which will enable them to identify and solve problems innovatively. Without a painstaking research process that involve cross disciplinary research, the results of an industrial design often end up to be a new look instead of a better user experience.

Secondly, aviation concept involve numberless of constraints to be qualified for implement. Designers that are not experienced with aircraft interior design have hard time to develop feasible concepts that align with business interests and engineering feasibility at the same time. This is a major reason why so many aircraft interior related concepts have not been turned into reality.

Thirdly, the cost for designing and testing aircraft interior related product, especially big size product, is too high to be founded easily. For user testing and ergonomic analysis, the mock-ups are often required to be both precise and durable. Designers in aviation industry often need to use high cost methods, such as 3D printing or CNC to create large size mock-ups, such as a full size seat or even a lavatory. The size and the precision level of the mock-ups became an obstacle for fast iterations.

Last but not the least, the opportunity to kick-start a design project that highly focus on passenger's need is rare, especially for in-house designers. Unlike many other product industries, where the end customers are the direct clients of the product manufactures, the most important stake holders for an aircraft interior industrial design projects are the airlines. In this case, to meet the interest of airlines is the manufactures and designers' priority. As a result, in-house designers have a harder time to design around the need of the passengers. This situation is not a singular case, but a commonly seen issue in socio-technical system, where the people who has the largest impact over the result of a design project are not those who will be influenced the most, which often leads to unsatisfying end-user experience.



Design activity in aviation field are constrained by aviation regulation, airlines requirement, and manufacturing constraints. However, passengers, who are the end user of the design activity, may not be one of the important stakeholders.

Primary Research

To find the pivot that satisfies the interests of various stakeholders, I conducted interdisciplinary research and worked with two professors from UW school of nursing. With cross-disciplinary research, I found opportunity that allows me to change the conflict between airlines and passengers into design opportunity, while still satisfying the regulators and manufacturers' constraints.

I went on field trip to collect information for design ideation. I took two four-hour flights. During the field trip I took photos of the details in the surrounding of an economy class passenger.

I counted the ratio of people who have walked on aisle compared to who did not. Only few stand up in the first two hours. Since I was sitting in the window seat, I fall asleep after around two hours of counting both times.





Lots of passengers stay sleeping during the trip.



The cramped space create creates body conflicts.

The photos were later arranged on boards for the ideation process. I kept the boards around my workspace while ideating concepts after the field trip.

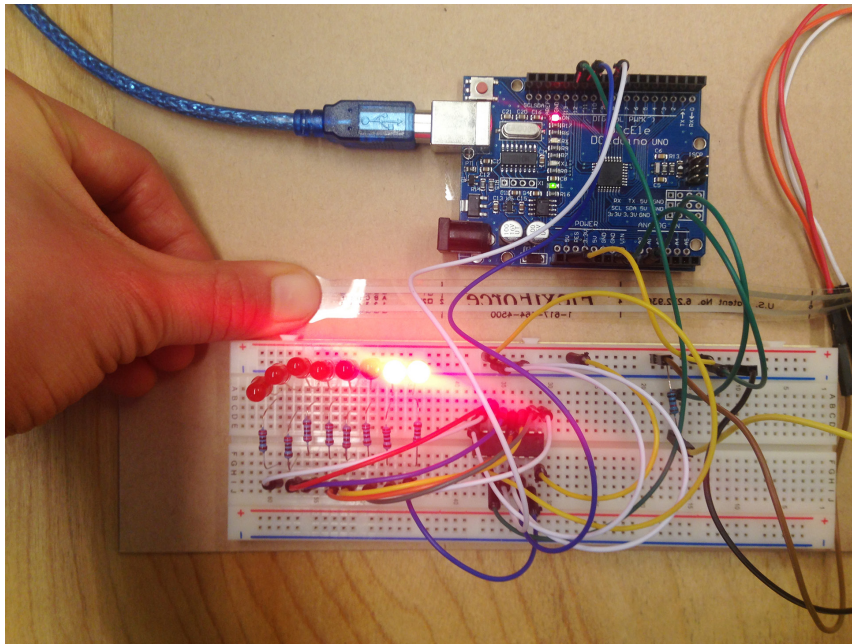


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The Aljoya Endowed Professor in Aging

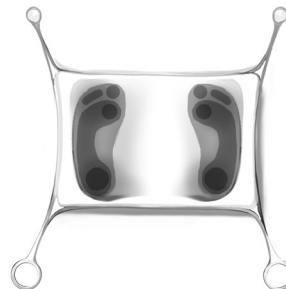
I consulted with Dr. Brenda Zierler, an expert of DVT; Basia Belza, who has spent years on health promotion for elder adults and physical activity interventions.



I made a pressure sensor prototype to understand the possibility and limitation of sensor based interaction design.



One of the first concepts:
A foot pad that track prolonged-sitting by pressure sensor.





Iteration & User Testing

An important part of my process was the construction of full-scale prototypes to refine the ergonomic details of the seat.

After making several quick sketches, I started to make rapid prototypes to evaluate those ideas.

The physical interface of the concept was defined little by little with users' feedback.

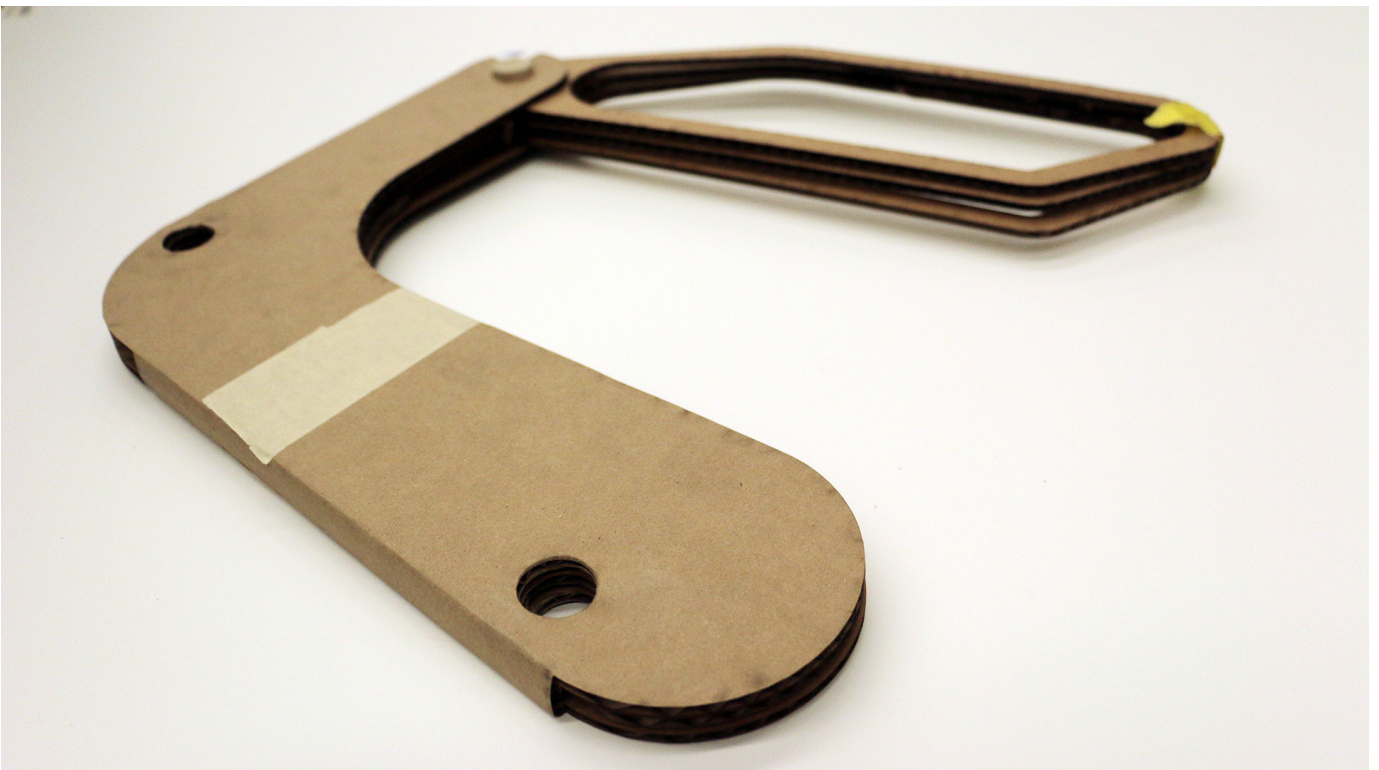




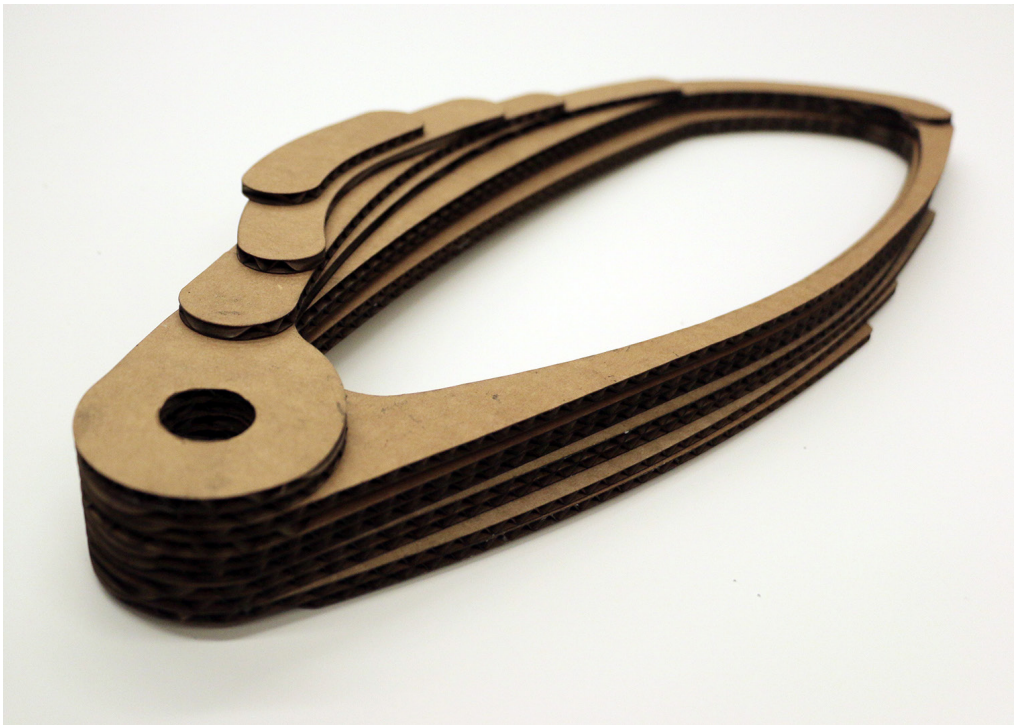
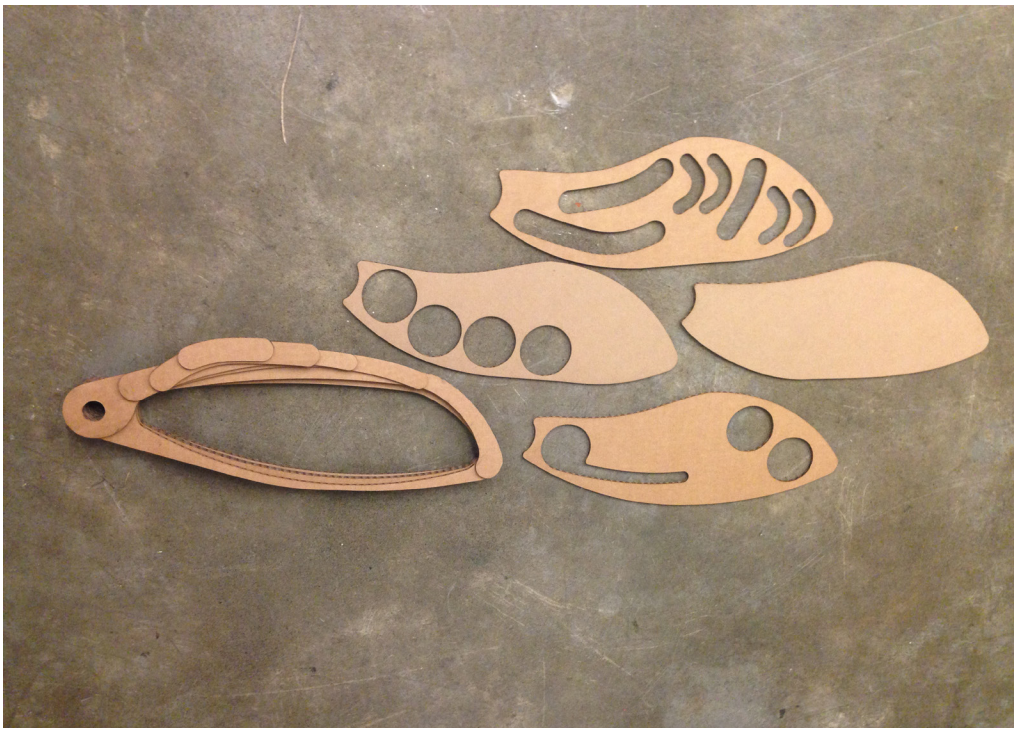
The iteration process started with tin foil to help me create a rough shape of the concept in few minutes.

I found a seat with dimensions that are similar to a standard economy class passenger seat and I used it to create full scale prototypes.

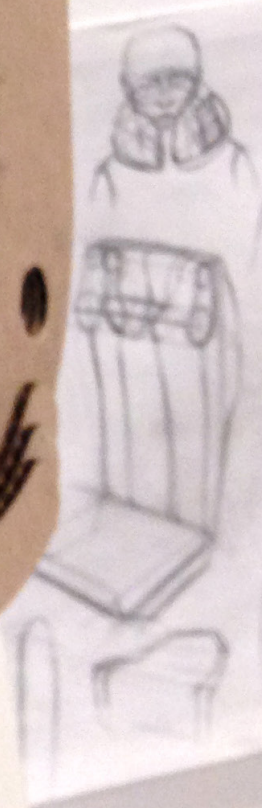
The first version of the handle prototype was too small for the concept's scenario.

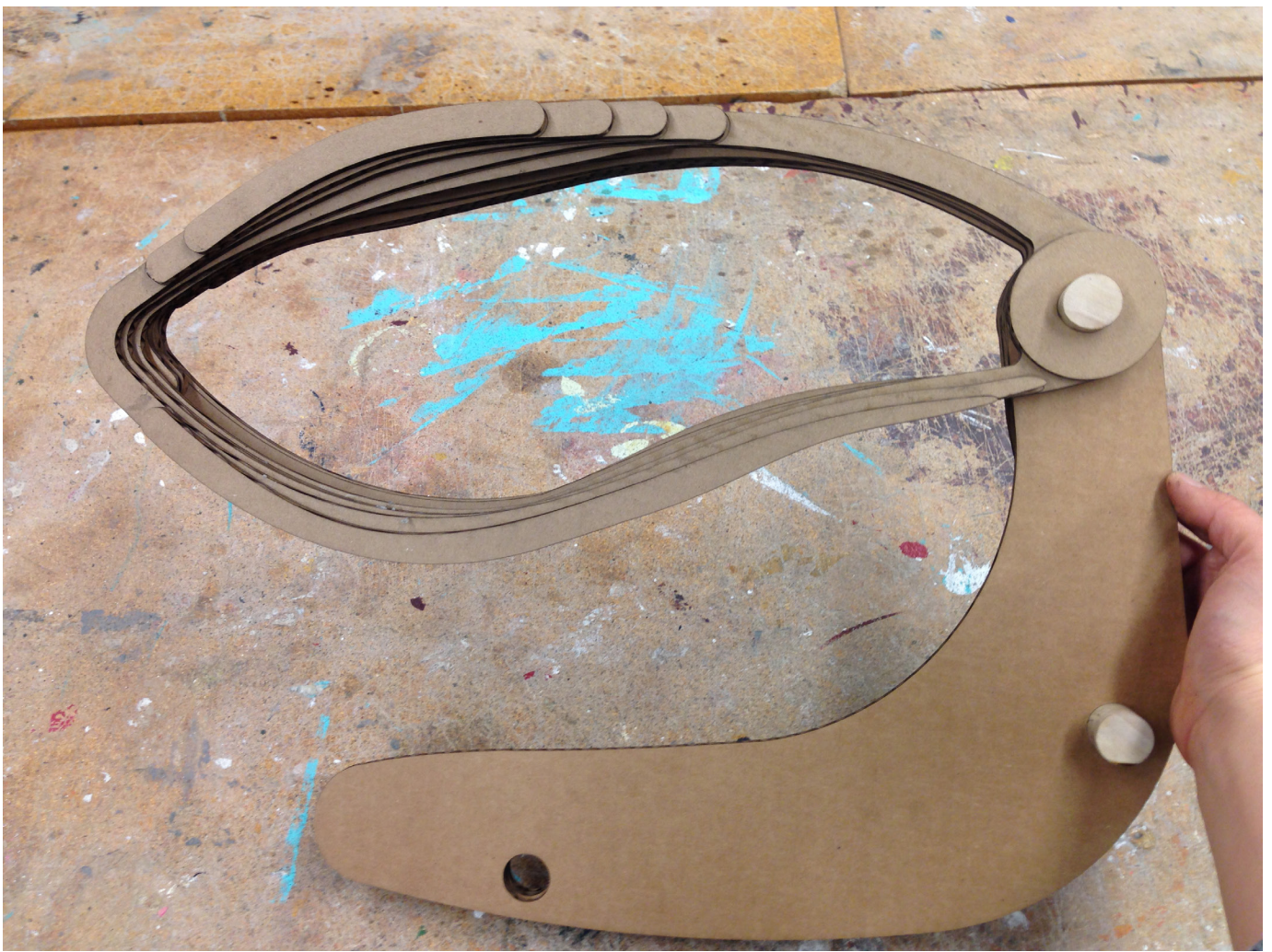






I improved the technical details of the prototype.
The width of the surface was also increased to mimic
the real size.





The friction at the pivotal point was just enough to allow the handle to stay at any angle.



The cardboard prototype is useful for exploring the ideal dimensions for basic ergonomic concerns. However, it does not allow the users to experience whether the armrests are comfortable or not.

To bring the users' experience closer to the real scenario, I created tangible surfaces on the armrest with the cardboard structures.



Users' feedback helped to shape the concept in detail. The ergonomics of the handle was improved greatly after several rounds of feedback.









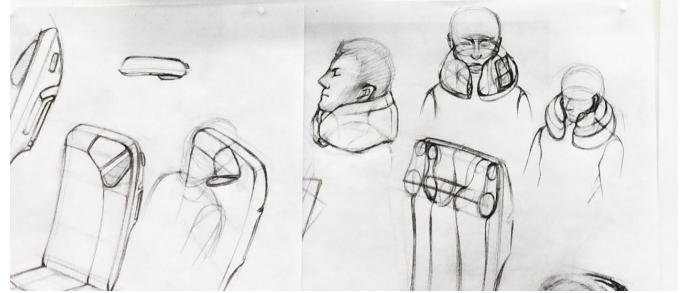
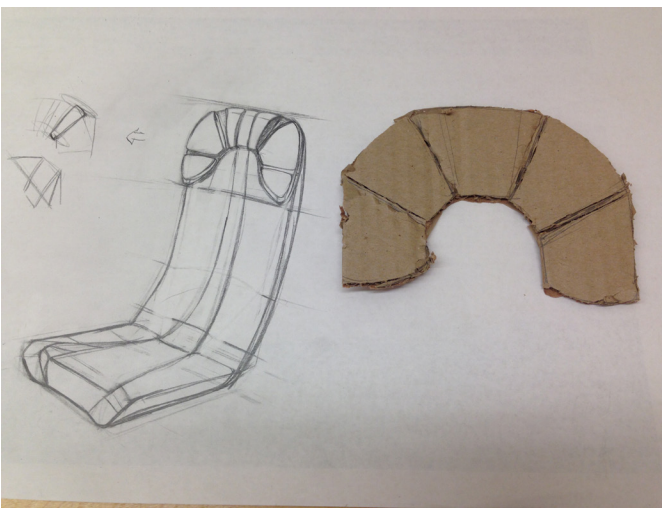


An important part of the prototyping is to evaluate the user's experience in the asymmetrical sitting position

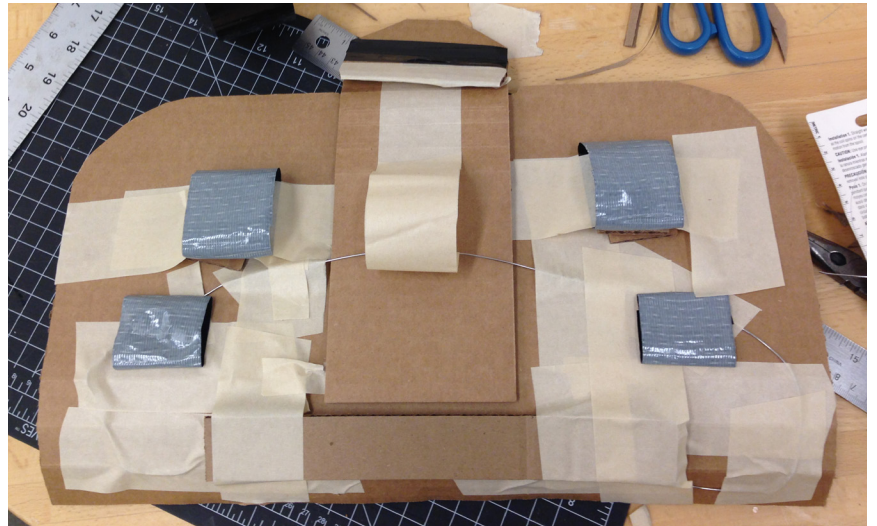
and the location of the interface on the armrest.



To create an innovative passenger seat's headrest for better head support, I made a full scale prototype.







The full scale headrest can be slid horizontally to mimic the real concept.





The back of the passenger seat is highly integrated for multiple functions. I started designing the back of the

seat by identifying its essential parts and rearranging them for more knee room.





The attempt of relocating the magazine pocket behind the table failed.

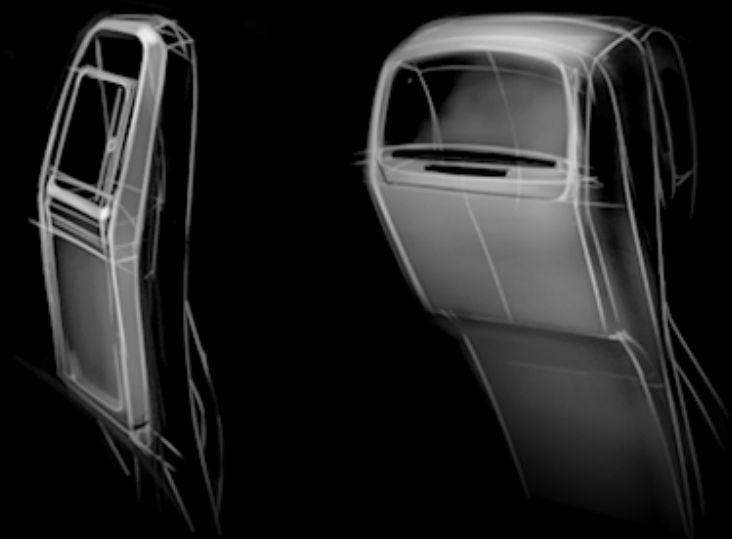


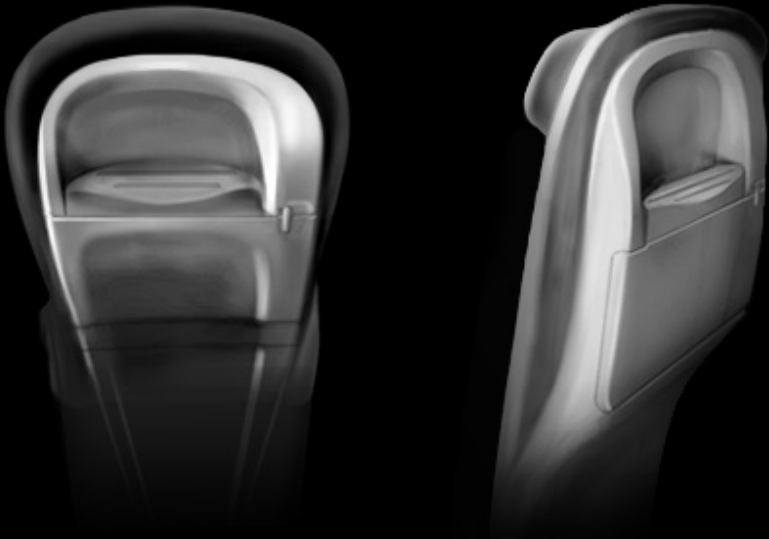
Users who would like to sleep on the table, would not have enough space for their head with this concept.





After the dimensions of each components on the seat back were decided, I used thin paper, digital sketches and clay to explore the suitable style for the seat.





Digital Sketching

Design Concept

Based on the result of research and prototyping, I designed a premium economy passenger seat "Expanse".

It is an asymmetrical seat that increases the space for an individual's body movements while integrating a mobility reminder system into the structure of the seat.







The mysterious loop in the middle serves as two armrests for the passengers on both sides, so as to eliminate arm wrestling.

In order to help the passengers identify their own armrests, different color schemes are used to differentiate two sets of armrests from each other.

As you can see, the armrests are asymmetrical, one higher, one lower. It's the same for both of the passengers. With this setting, both of them gain a little bit more room to stretch their bodies. They also have a higher chance of leaning in the same direction while sleeping.



The cushions can be folded two times and be pulled to the side for more privacy.

They work together with armrest to assist passengers in sleeping on the same side of the seat, so they have no worries of napping on their neighbors' shoulders.



The pressure sensors are installed beneath the seat pan and capture the motions of passengers. The system understands how long the passenger has been staying still.

Base on the passenger's own preference setting, the light indicator on the armrest will remind the passenger to move after sitting still for too long.

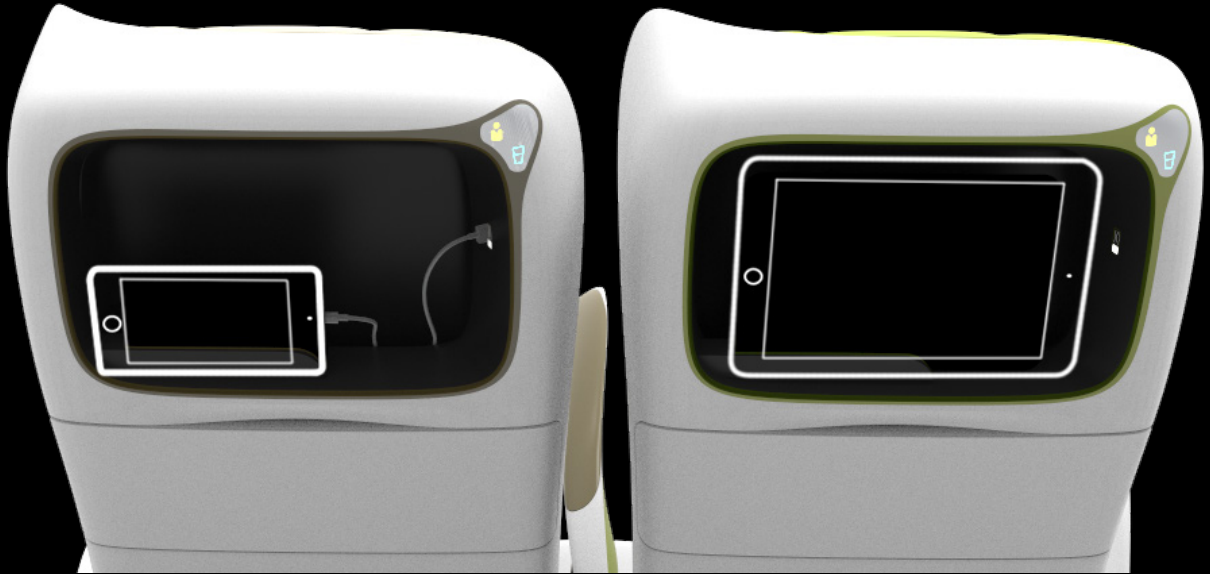


The passengers can play a motion game with small movements. By lifting and dropping their feet, the passengers control the avatar in the game. This is done by the sensor beneath the seat pan that is detecting their movements.



On the backside of the seat, there is a call button that is dedicated to asking for water. It saves the attendant a trip, and each passenger will feel more comfortable asking for water, knowing it's less inconvenient for the attendants.

There is an extra pocket at eye level for airline handouts and a second pocket in front of the knee for each passenger's personal stuff.



There is a hub for phones and tablets of different sizes. It sits inside the nook to give the passenger a bit more privacy.

Next Step

Although I have tried to cover as much as I can, this concept still needs a lot more testing and modification before it can be engineered and implemented in the cabin.

The next step of this project is to organize a focus group with people who are frequent long-haul flight passengers. It will be helpful to get more feedback from the experienced users and improve the concept.

To examine the effect of this concept, it is also necessary to create a space that mimics a real long-haul flight situation and measure whether or not this concept can significantly improve the passenger's experience.

Conclusion

Expanse is a concept that focuses on the health of air travelers. Based on the design research and results of user testing, Expanse can help passengers to mitigate the adverse health factors of prolonged-sitting during the long-haul flight.

Expanse encourages passengers to do more in-seat exercise and have more water in an engaging way. It also improves the individuals ability to stretch while sitting in a cramped space without disturbing their neighbors.

In the past, there has been a constant conflict between airlines reducing seat pitch and passengers requesting a better experience. Considering the airline's business model and passenger' needs, the concept provides a balance point. It allows each airline to stay with the current seat pitch while upgrading its service and fee. For the passengers who have a high risk of DVT but can not afford to travel in business class all the time, Expanse can help them lower the risk of developing DVT without paying for 2 or 3 times the ticket fee.

The realistic approach throughout the design process ensures that this concept is not fantasy, but a feasible solution that is agreeable to the interests of airlines, aircraft manufacturers and passengers.

Compared to the current economy cabin interior design, Expanse has several features that may be useful as inspiration for future design, such as using the inflight entertainment system (IFE) as a way to promote inflight exercise, and increase an individual's space by reorganizing the posture of the passengers.

Although the feedback from the aviation industry designer and my committees are positive, this concept may still have a hard time to be produced and installed into the current aircrafts. It may take more test and research to prove its value. Lots of modification to the current concept may also need for airworthiness and engineering consideration before it could be approved for production and installation.

Reflection

I found that there are two factors in the design project that could deeply influence the quality of its result: the structure of the process and the accessible resources related to the design topic.

Although there is no perfect design process for all projects, the good projects always share some similarities in their process. For example, focusing on defining certain problems in the early stage can avoid a lot of detours in the ensuing process. For my project, I spent too much time on making plans for the final product that I want to create without a clearly defined problem at the beginning. As a result, I created a lot of concepts that does not have value for this project. I also learned that in a project that does not have a real client, an in-depth analysis of one's motivations is very necessary. To do a design project as a graduate student is a challenging task. If one is not passionate enough to be a self-starter during every step in the project, it is foreseeable that the topic may be changed from time-to-time.

Having rich resources for the topic is another crucial factor.

I was benefited greatly from my working contacts in the aviation industry when designing Expanse. I also had very effective support from my committee Karen Cheng, who helped me connected with professors in the School of Nursing.

Valuable innovative products are usually generated from in-depth knowledge of the current situation of the industry and interdisciplinary collaboration. Without these resources, the concept that I came up with will be more of my own fantasy.

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Appendix

EXPANSE

A new airplane seat that encourages healthy movement.



FRONT VIEW



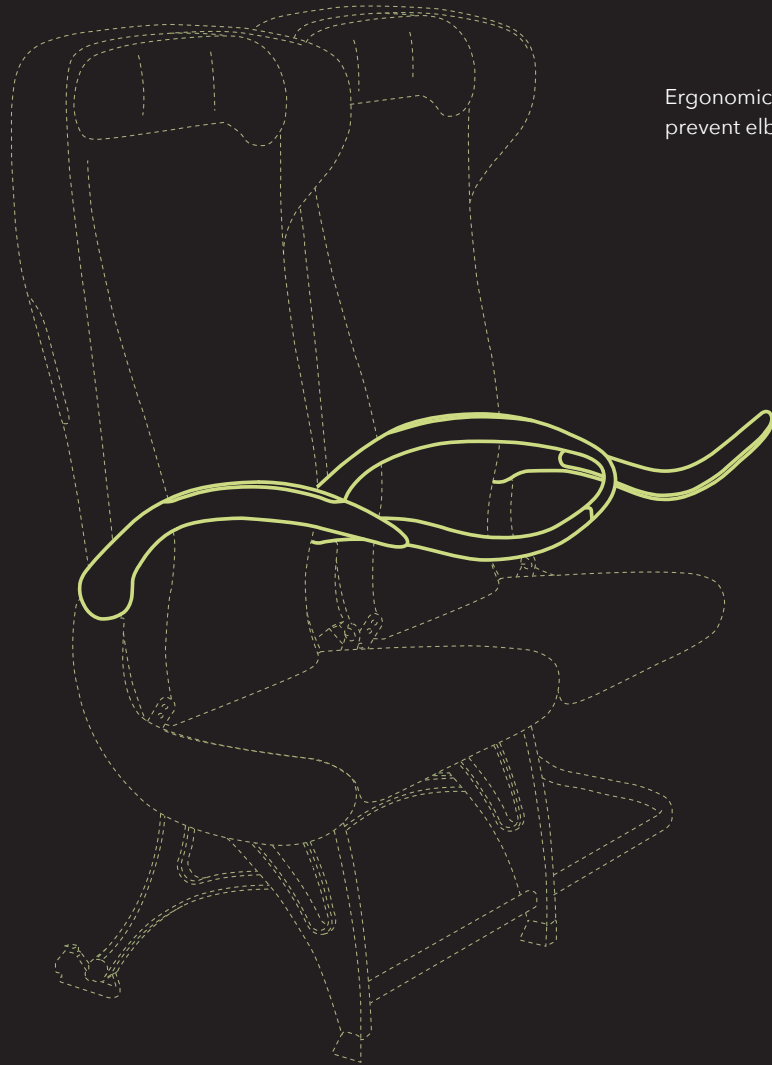
KUN XU

MDES THESIS EXHIBITION

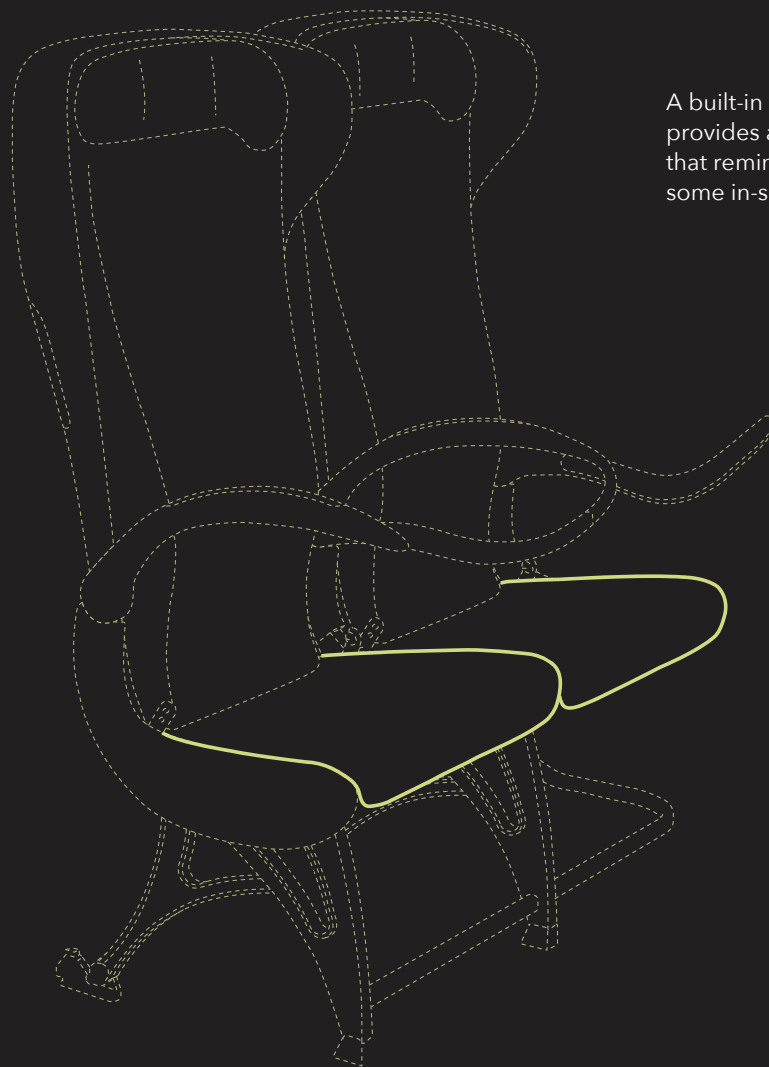
UNIVERSITY OF WASHINGTON



Asymmetrically designed head cushions keep you from napping on your neighbor's shoulder.

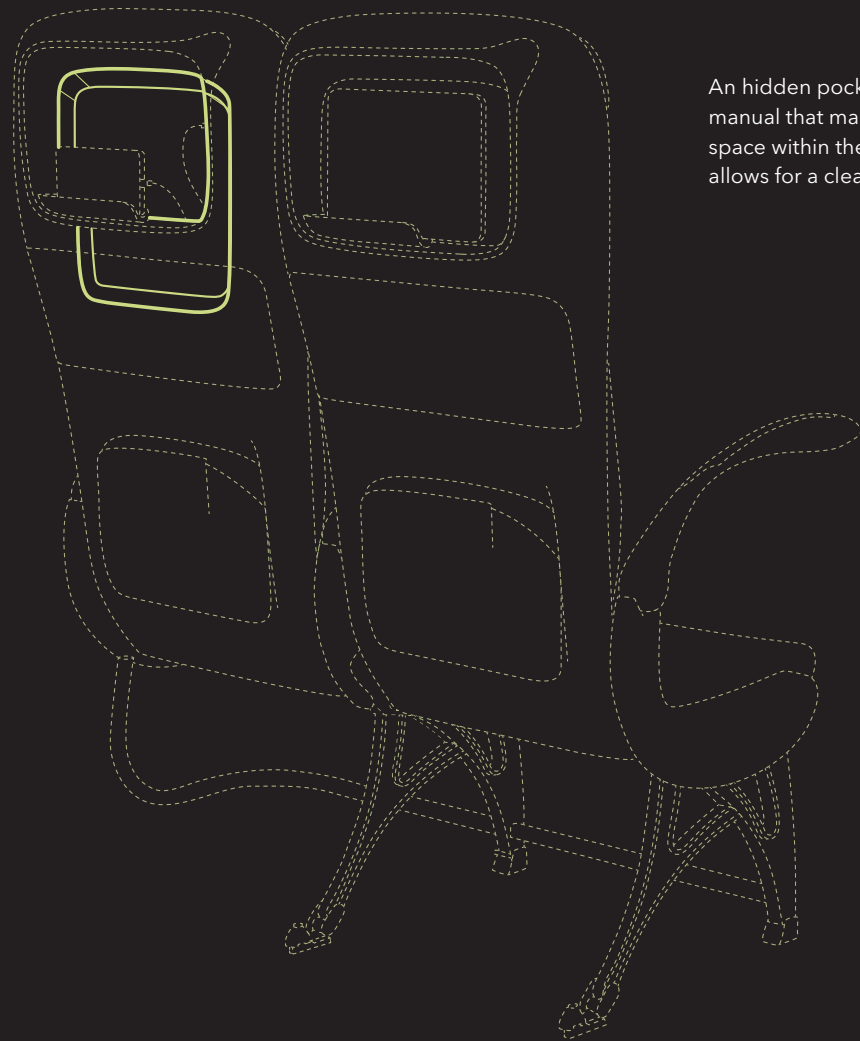


Ergonomic arm rests
prevent elbow wrestling.



A built-in sensor system provides ambient alert that remind you to do some in-seat movement.





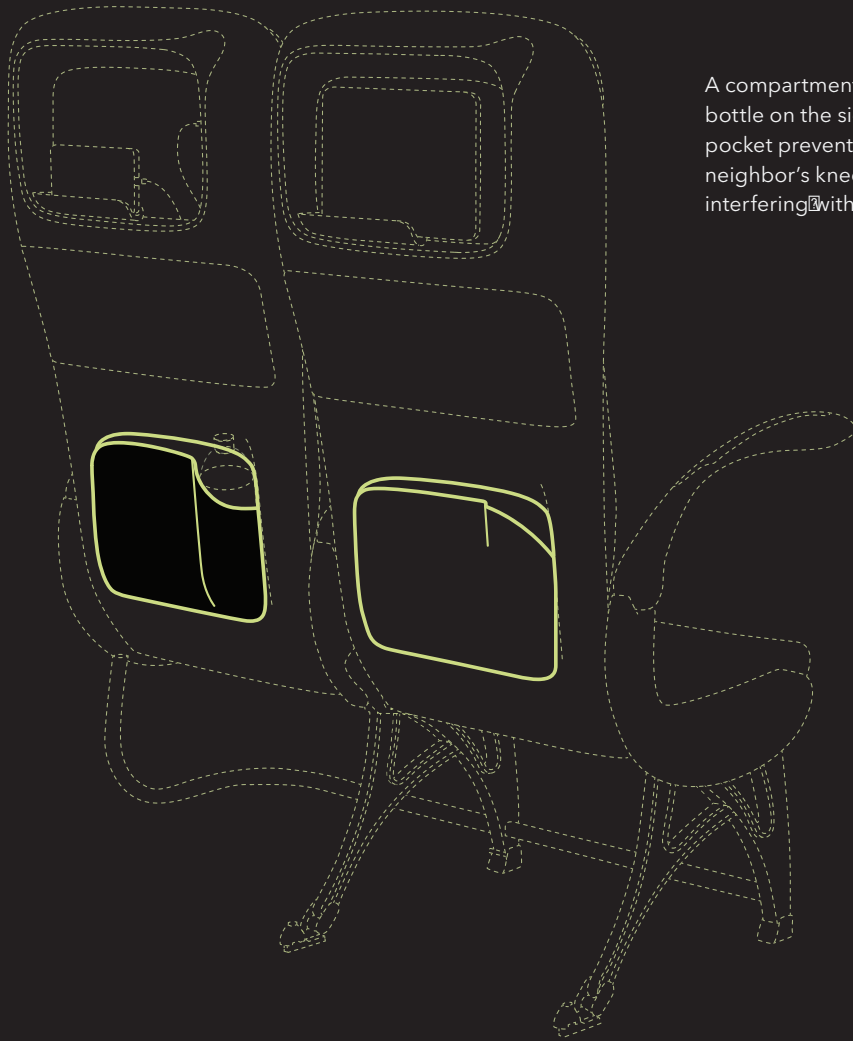
An hidden pocket for safety manual that makes use of space within the seat and allows for a cleaner look.



An adjustable channel for
your tablet / phone with an
adjacent usb outlet.



A snap-in, fold-out tray provides a smoother surface for a safer and more comfortable headrest.



A compartment for a water bottle on the side of the pocket prevents your neighbor's knee from interfering with your space.