2018-2019 ACRP UNIVERSITY DESIGN COMPETITION

Proposal of Mobile Application Design for Aging Travelers in Commercial Airports

(January 2019 - April 2019)

Design Challenge:	Airport Management and Planning
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PURDUE UNIVERSITY | School of Aviation and Transportation Technology POLYTECHNIC INSTITUTE

1 Executive Summary

The Airport Cooperation Research Program (ACRP) University Design Competition has identified that innovative approaches to accommodate the aging passenger demographic at airports and it is necessary to aid airport operators to optimize the use of existing airport resources and plan for future needs (ACRP, 2018). The proposal writing team went over academic papers on the aging passenger needs in the airport and industry reports about improving passenger travel experience in the airport environment, talked to several industry experts whose knowledge and experiences covering airline operation, airport management, and airport consulting, and developed a proposal for mobile app design for aging travelers in commercial airports. Also, the team analyzed the app using the Failure Mode Effect Analysis (FMEA), and Cost/Benefit Analysis.

The background experience of the design team includes Federal Aviation Administration (FAA) airframe and powerplant (A&P) mechanic, aerospace engineer/ European Aviation Safety Agency (EASA) certified private pilot, and mechanical engineer. Industry input from airport consulting professionals, airport management professionals, and airline professionals provided insight and direction for our design. This project began in January 2019 and completed in April 2019.

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3 Background and Problem Statement

According to the United Nations 2017 estimate, the population aged 60 or above is growing at a rate of about 3 per cent per year (United Nations Department of Economic and Social Affairs Population Division, 2017). While the number of older persons in the world is projected to be 1.4 billion in 2030 and 2.1 billion in 2050 (United Nations Department of Economic and Social Affairs Population Division, 2017), the research insinuated an increasing number of aging travelers receiving little attention by the travel industry (van den Berg, Arentze, & Timmermans, 2011). When aging travelers go through the airport, they face multifaceted issues including: wayfinding, fatigue, inadaptation of technology and new equipment, and failure to locate and utilize the amenities (ACRP, 2014). Recently, airport authorities and stakeholders (airlines, the Transportation Security Administration (TSA), and planning & design consultants) have realized those issues, and are now putting the physiological, psychological characteristics of aging travelers into consideration. Some are working on improvements to provisions of direction and best routes in airports, which include communications via visual, verbal, and virtual means, and analysis of existing mobile applications of airport wayfinding (ACRP, 2017).

Concurrently, the smart phone usage across the globe is rising, and has positive correlation with the economic power of the countries, for instance, in U.S. alone 29% of the aging people (65 years old or above) use cell phone (Berenguer, et al., 2017). Few endeavors exist to aid aging travelers to navigate in airports by mobile applications.

Naturally, the team and the ACRP University Design Competition have identified that innovations to accommodate the aging passenger demographic at airports are needed to help airport operators to optimize the use of existing airport resources and plan for future needs

(Airport Cooperative Research Program, 2018). This project proposes a mobile application design for the aging travelers in the airports to cope with the following challenges:

- wayfinding,
- fatigue,
- inadaptation of technology and new equipment,
- also, failure to locate and utilize the amenities.

4 Literature Review

4.1 Aging Travelers and Beyond

In its one of the most recent reports on ACRP (2019) argues that "the United States is experiencing significant and ongoing demographic trends, such as an aging population", and states that "an aging population will move an increasing proportion of the population into age ranges that make fewer air trips per year than those in the age range from 45 to 65 that make the most air trips per year on average" (ACRP, 2019, p. 113). In addition, Aberyatne (1995), Cooper (2006), Chang & Chen (2012), Da Silva et al. (2015) use the term "elderly" for travelers. Cooper argues that getting older and aging are no longer synonyms. As people get older, they do not necessarily become less active, and – as many researchers suggest – they tend to travel even more, which includes air travel. The latter implies they would unavoidably find themselves in airports. Arcidiacono et al. (2015) states that competition in the air transport market in recent years has influenced the companies' view of the products and services making them to choose the most innovative solutions, while less time and resources are being spent on the development of the studies of original technical solutions, and also lists elder people as the essential emerging issue to facilitate air travel for that category of travelers. It is, perhaps, interesting, how Arcidiacono et al. (2015) differentiates between the people with disabilities, elder and dependent

people, putting all of them in the aging passenger groups and arguing that the market share of all three subcategories is growing due to “aging population”. In this report, the beneficiary population is aging travelers and any other potential users regardless of age.

4.2 Policies and Laws regarding Aging Travelers

For all flights within the United States operated by either domestic or foreign carriers, the Department of Transportation have used the Air Carrier Access Act to prohibit any discrimination practices, provide the facilities including aircraft and airport facilities and services that they own, lease or control with accessibilities (U.S. Department of Transportation, 2015).

For airports, FAA uses Airport Disability Compliance Program (ADCP) to ensure that airports comply with the regulations and increase awareness of accessible air travel for people with disabilities (Federal Aviation Administration, 2017). Moreover, travelers with disabilities have access to the activities, programs, and services provided by airports.

14 CFR Part 382- Nondiscrimination on the Basis of Disability in Air Travel have components mandating both airlines and airports with the similar requirements listed above (U.S. Department of Transportation, 2008). Most fundamentally, these laws and regulations in the United States could trace their roots back to Americans with Disabilities Act of 1990, which protects people with disabilities not only in travel but also other aspects of the life (United States Department of Justice Civil Rights Division, 2019).

As for other regions, there are some cases of airlines who show no attention or treat the aging passengers negatively. In China, many low-cost carriers including: Xiamen Air, Spring Airlines, China Express Airlines, Okay Airways ask aging passengers to show the certificates that they are fit for air travel produced by hospitals beforehand. On the other hand, major carriers like Air China, China Eastern, China Southern don’t have such extra requirement for their aging

passengers (Tian, 2017). In Europe, there was also tragic news that legacy airlines such as KLM, Lufthansa, and Delta Air Lines have denied boarding of a 407 pounds passenger who was traveling to seek medical treatment in Bronx, New York and the passenger died in Hungary (Gregorian, 2014).

4.3 Aging Travelers Needs

Chang and Chen's (2012) research showed the following is the top priority for people aged 64-75: "a) information on direction in the airport terminal, b) transport information to and from the airport, c) announcement of canceled flights and delay, d) announcement of canceled flights and delay, e) special services/meals for elderly, f) information on emergency escape." Da Silva et al. (2015) investigated the difficulties the elderly passengers of 60 years old or more experience using the airport infrastructure, and the following were the most difficult among airport infrastructure: " a) difficulty in using stairs, ramps, and elevators, b) long walking distances in the airport, c) difficulty with way finding signs in airports, d) lack of seating places close to the service desks and to the access corridors. As for the operations waiting lines, lack of inaccurate information, lack of trained customer service staff received the highest negative scores." Indeed, airport environment such as gates, retail outlets, food courts, and bathrooms, resulting signage clutter, and information overload can be even more confounding to not only the regular passengers, but particularly the aging passengers (ACRP, 2014).

4.4 Addressing Aging Passenger Needs

Would aging passenger experience in an airport be any different from those of the people of other generations? And if yes, what are the things to address first to improve that experience?

In terms of the physical design of the airports around the globe, the designers have shown the compassions for the Passengers with Reduced Mobility (PRM) including aging travelers by

linking PRM needs with all the elements and boundaries: infrastructure aspects, limits imposed by security, and the availability of appropriate personnel and equipment (Arcidiacono & Pugliese, 2015). Among many problems aging travelers face is that they tend to fall in airports more than the people of other age groups, including escalator falls (Howland, et al., 2012).

Some of infrastructure improvements entail: use smooth, hard surfaces such as terrazzo are easier for older travelers to use if they are pushing a baggage cart, and are less likely to cause tripping than carpet, adjust lighting condition inside the terminal for the aging travelers to reduce the accident rates and facilitation of signage-reading experience (ACRP, 2014).

Arcidiacono, et al. (2015), Nepal, et al. (2006) advocate for the change of policies, others – like Boeing (2014) – create an automatic wheelchair with a navigation device, which would address most of the issues above but – only for persons who require a wheelchair. Besides, that solution would still face the problem of the existing airport infrastructure.

In the United States, the passenger who is 75 and older may receive the benefit of leaving on their shoes and a light jacket during screening according to the TSA (The Transportation Security Administration, 2019). Multiple research found that the aging passengers receive lower satisfactory score due to inadequate equipment and staff members (ACRP, 2014) (van den Berg, Arentze, & Timmermans, 2011) (Chang & Chen, 2012).

4.5 Electronic Technology Approach

Bogicevic et al.'s (2017) research addresses passenger perception of airport technology, and – as a part of in – self-service technologies (SST) in particular. One of the known SST technologies for airports is tour guide applications. The study confirmed the authors' hypothesis that "self-service technologies at airports have a positive effect on traveler confidence benefits." As long as people of a variety of backgrounds and ages participated in the research, which

includes aging travelers the research is inclusive towards the target population of the project. According to Liu & Law (2013), smartphone and tablet applications became an essential tool for travelers to manage their itinerary when it comes to air travel. While just a few researchers direct their studies towards improving travelers' experiences in airports, there seem to be no solution at all on the market for aging travelers only. In addition, ACRP (2017) suggests that while the market is concentrating on creating accessible way-finding applications for travelers with disabilities, the growing number of aging travelers would need to be specially accommodated as well.

The Information Technology (IT) industry shed some lights on using mobile applications (apps) to help the passengers to travel through the airport. Groove Jones developed an app using Augmented Reality (AR) in collaboration with American Airlines and Locus Labs to aid the travelers in airports, for instance, in the promotional videos, the passenger could use cell phone to find the shortest queue for the security check, the fastest route to the coffee shop, and the boarding gate in the Dallas Fort-Worth International Airport (DFW) (Groove Jones , 2017). Also, American Association of Airport Executives (AAAE) and Aira collaborate together to offer mobile technology to travel to the airports and navigate inside the airport through the interactions between blind or low vision (BLV) passenger and remote-located Aira agent (American Association of Airport Executives, 2017).

5 Problem Solving Approach

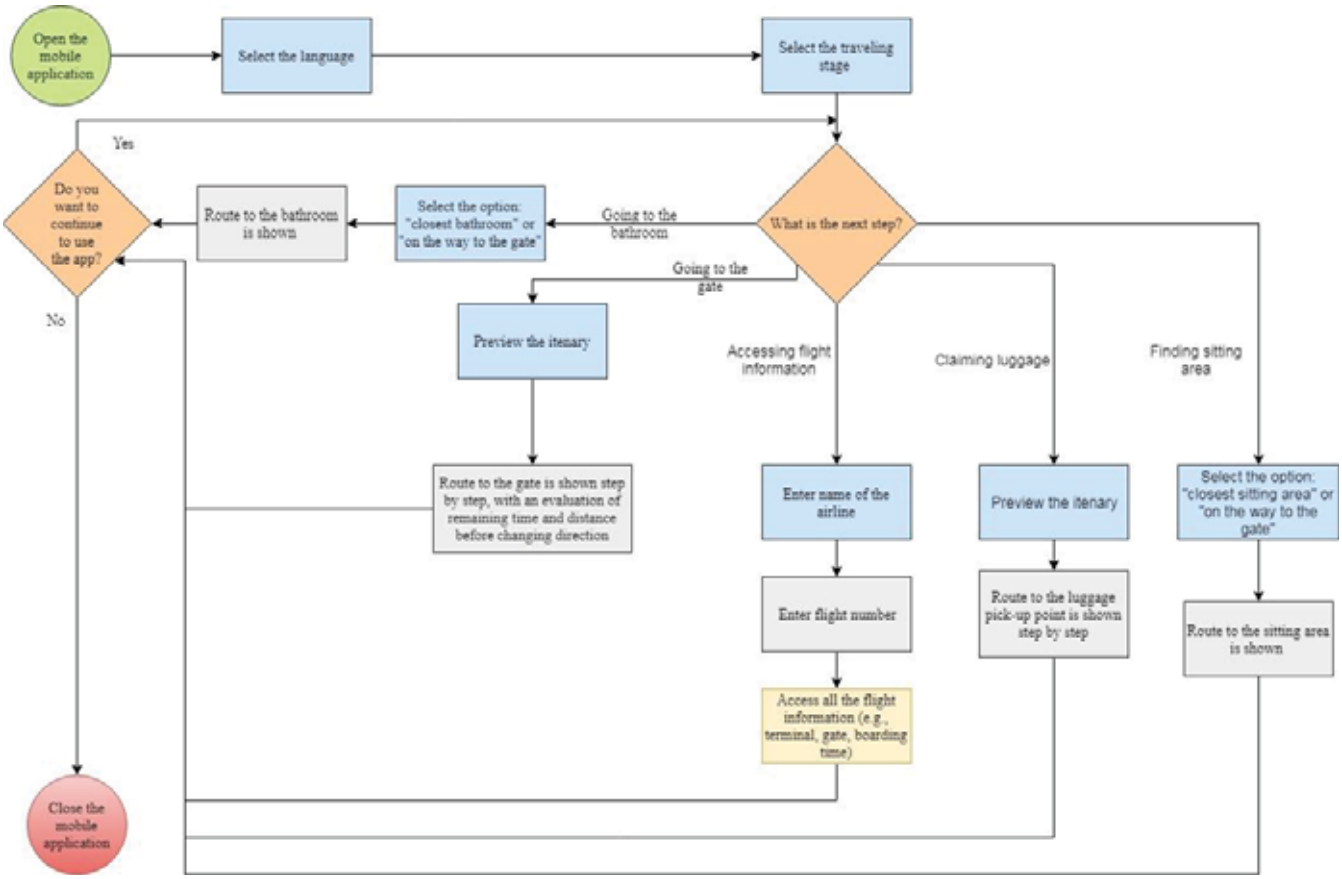
Through the literature review and interaction with industry experts, we identify that there are increasing number of aging people across the globe; more people are using app. Hence, a solution can be a mobile app for aging passengers in airports. Looking at some main stream apps

available in the market the team didn't find a single app that was designed to work in all airports. Aviation industry has two approaches to solving traveler navigation problem at airports.

First, many airlines develop their in-house apps. The limitation travelers face is that such apps only work with certain airports, specific to airlines, and therefore, are not inclusive of all airports by default. Second, airports develop their own apps to address traveler needs. Obviously, the limitation is that such apps only work with individual airports. Both of these approaches might cause inconveniences for travelers. Travelers have to download multiple apps overloading their smart device storage. Another inconvenience is that travelers have to get used to different, and in many cases rather complicated interfaces, which slows them down and prevents them from using such apps in the future. Third, most of all the current applications do not have safety features like panic button to help travelers in danger to contact customer service agents for non-life-threatening emergency. The team proposes a solution that would potentially address all of the above issues for aging travelers in mind as a target population. The proposed system intends to be scalable to all airports in the United States. Scalability is essential as it will make the use of the mobile application easier for aging travelers. Indeed, if aging travelers go to different airports, they would be able to use airport apps with similar features; that will make their travel experience more consistent. Figure 1 shows the process map of the mobile application.

The aging travelers will benefit most from the proposed app, and moreover travelers with disabilities will also enjoy it. The proposed app will cover the four most important issues to aging travelers: wayfinding, failure to locate and utilize the amenities, inadaptation of technology and new equipment, and fatigue. The proposed app will offer different features to address these issues. The features shown in this part are created using the software Axure. The mobile device used for the following figures is an iPhone 6Plus and the scale used is 40% of the original size.

Figure 1. Process Map of the Mobile Application for Aging Travelers



First, wayfinding is important for aging travelers as they may need to navigate from the terminal curbside to the airline counter, the counter to the security check point, and from there to the boarding gate. On the other hand, they may need to find the next connection gates in transition or their luggage on arrival. Figure 2 shows the three options in terms of traveling stages in airports: before screening, after screening, and connecting flight/ Claiming luggage. To facilitate the travel of aging travelers, the proposed app entails the following features: GPS, audio, visual and tactile prompt system. The GPS feature will be activated by the following steps:

1. Passengers enter flight number by voice command or by typing it, Figure 3
2. Preview of the itinerary, Figure 4
3. Passengers choose to accept or not the proposed itinerary
4. Download of the map into the passenger's device in case of Wi-Fi loss
5. App shows the directions (e.g., turn left, turn right, go straight forward) to take
6. App evaluate the time and distance before change of direction, Figure 5

Figure 2. Status Selection

Figure 3. Flight Number Input

Figure 4. Itinerary

Figure 5. Navigation

Second, there are plenty of amenities in the airport such as gourmet restaurant, souvenir stores, and currency exchange. Based on the physiological conditions of the aging passenger, the most urgent amenity for them is the bathroom. In the app, the bathroom is integrated to the priority list as shown in Figure 6. The bathroom feature includes two options, as shown in Figure 7:

1. Closest bathroom
2. On the way to the gate

Figure 6. Service

Figure 7. Bathroom

Third, there are also a number of technologies in the airport. The technologies such as airline apps, flight information display system (FIDS) tailors for the young and middle-aged demographic group. Those technologies appear a bit user-unfriendly to the aging travelers. In fact, the proposed app has the philosophy of "Weniger, aber besser: Less but better! (Rams, 1995)" The proposed app has a maximum of five buttons per screen. The font size used for the app is minimum 36 pt. Furthermore, the color combination black/white and yellow/black makes the app more comfortable to read for the aging travelers. Finally, the use of audio for the GPS and voice command to enter the flight number simplify the use of the app for travelers with hearing disability.

Fourth, fatigue is a common issue when addressing aging travelers, especially as the distance become longer. Indeed, in airports the distance between the security checkpoint and the boarding gate can be very long. Moreover, other factors such as noise and essential traffic in the airport can increase the fatigue of aging travelers. To reduce fatigue, the mobile application

includes a feature similar to the bathroom feature that allows aging travelers to find the closest sitting area to their location, as shown in Figure 8. Furthermore, an icon is present on the screen next to the “home icon” to help aging travelers find a seat quickly, without using several buttons.

Figure 8. Sitting

Additional features include:

1. Choosing among the main spoken languages, when opening the app for the first time, as shown in Figure 9
2. Gaining access to the flight information, as shown in Figure 10, 11 and 12
3. Panic button, if the passengers need any assistance under non-life-threatening emergency situation. The assistance covers travelers suffering from anxiety or lost in the terminal.
4. 911 button, if the passengers require any life-threatening situation

Figure 9. Language Selection

Figure 10. Flight-On Time

Figure 11. Flight-Delay

Figure 12. Flight-Cancelled

6 Risk Assessment

The FAA advises each airport authority in United States to do a safety risk analysis before any new equipment or procedure is added to the airport. FAA describes safety management systems (SMS) for an airport and explains how to do a safety assessment; Safety Management System (SMS) is: "The formal, top-down business-like approach to managing safety risk. It includes systematic procedures, practices, and policies for the management of safety (including safety risk management, safety policy, safety assurance, and safety promotion) (Federal Aviation Administration, 2007)."

The FAA uses the predictive risk matrix chart, as shown in Table 1 and 2 below, to analyze how much risk is associated with a specific outcome and whether it is acceptable or not in the FAA Advisor Circular 150/520-37.

Table 1. Legend of Risks Classifications

High Risk
Medium Risk
Low Risk

Table 2. Risks Classification

Severity \ Likelihood	No Safety Effect (1)	Minor (2)	Major (3)	Hazardous (4)	Catastrophic (5)
Frequent (5)	5	10	15	20	25
Probable (4)	4	8	12	16	20
Remote (3)	3	6	9	12	15
Extremely (2)	2	4	6	8	10
Extremely Improbable (1)	1	2	3	4	5

Each outcome of the potential risk is the product of the likelihood and severity. From a perfectionist safety management perspective, the person shall keep every potential outcome risk in the green zone low risk range. But in the reality, nobody can guarantee that, so the person has to be content with the coexistence of yellow zone medium risk range and green zone. High risk red zone is not an option for the airport authority (Federal Aviation Administration, 2007). The proposed app should be in the green region.

In terms of safety risk identification and mitigation for the app, the team decides to use the Failure Modes & Effects Analysis (FMEA). FMEA is a technique to assess the nature and impact of a failure event, including the severity of the failure effect, the expected frequency of occurrence, and the likelihood that the current process will prevent or detect the failure (Rubin & Dahlberg, 2017). The team conjectures that the app user may face the following risks: the loss of situation awareness, no power, the signal loss, and app malfunction. The research indicated that the walking and texting will result in the loss of situation awareness and the concurrent task performance (Lim, Amado, Sheehan, & Van Emmerik, 2015). The risk priority number (RPN) is the product of the severity of potential failure effect timing occurrence timing detection. The higher RPN is, the worse the situation is. The most four common failure modes were analyzed in Table 3.

Table 3. Failure Modes and Effects Analysis of Proposed Mobile Application (Limited)

Process Step/Input	Potential Failure Mode	Potential Failure Effects	SEVERITY (1 - 10)	Potential Causes	OCCURRENCE (1 - 10)	Current Controls	DETECTION (1 - 10)	RPN (Risk Priority Number)	Action Recommended	Resp.	Actions Taken	SEVERITY (1 - 10)	OCCURRENCE (1 - 10)	DETECTION (1 - 10)	RPN
What is the process step, change or feature under investigation?	In what ways could the step, change or feature go wrong?	What is the impact on the customer if this failure is not prevented or corrected?		What causes the step, change or feature to go wrong? (how could it occur?)		What controls exist that either prevent or detect the failure?			What are the recommended actions for reducing the occurrence of the cause or improving detection?	Who is responsible for making sure the actions are completed?	What actions were completed (and when) with respect to the RPN?				
Using the app while walking	Loss of Situation Awareness	Bump, Trip Hazard	10	Too much attention to the app	8	Nothing	10	800	Motion sensing cutoff	Programmer	Added motion sensing/cut off	10	7	1	70
App INOP	Mobile Phone Power Loss	Service Disruption	9	Weak Battery	6	Nothing	10	540	Add battery charging stations in the airport	Airport	More battery charging stations	9	3	10	270
App INOP	Wifi/data Signal loss	Service Disruption	9	Poor reception	8	Nothing	10	720	Add a phone number in case of any signal loss	Programmer	Staffing need for call center	5	6	1	30
App INOP	App malfunction	Service Disruption	9	Poor design	5	Test Run	5	225	Improvement of app design	Programmer	Better user experience	9	4	3	108

7 Cost benefit analysis

The cost-benefit analysis of the proposed system is critical to evaluate its practicability and feasibility. The cost-benefit analysis is based on O'Hare International Airport (ORD) in Chicago, Illinois. All the labor costs (2018 data) used in the cost-benefit analysis are from the Bureau of Labor Statistics (BLS, 2018).

7.1 Cost assessment

The cost analysis is divided in four parts as shown in Tables 4-7. Those four parts are:

- Research and Development Cost (alpha)
- Research and Development Cost (beta)
- Marketing, Distribution, Testing, & Training
- Operation, Training, & Maintenance (per year)

We consider the direct materials (e.g., computers, software), the labor (e.g., engineers, programmers), and the other expenses (e.g., marketing) involved in each part of the cost-benefit analysis. The Research and Development Costs (alpha and beta) are a one-time cost, those costs are only necessary for the development of the first initial mobile application. However, the other costs are estimated to be present for each new airport mobile application developed.

Research and Development Cost (alpha)

The Table 4 lists the costs related to the first step of the research and development (alpha) of the proposed system. Those costs include the labor costs (students and advisors) for the first part of the project at Purdue University.

Table 4
Research and Development Cost (alpha) for the Initial App

Item	Rate	Quantity	Subtotal	Remarks
Labor - University Design Competition				
Students	$25/hr	120	$3,000	3 Students - 40hrs each
Faculty Advisor	$100/hr	80	$8,000	2 advisors - 40hrs each
Subtotal			$11,000	

Note.
This table was inspired by Guidance for Preparing Benefit/Cost Analysis (Byers,2016)

Research and development Cost (beta)

The Table 5 presents the costs related to the development (beta) of the proposed system. In this step, the system is fully developed and tested by an engineer and a programmer. The costs involved in this step are labor costs (software engineer and software programmer) and materials costs (computers). In the materials costs, we only consider the price of a computer as the software needed to develop a mobile application are free.

Table 5
Research and Development Cost (beta) for the Initial App

Item	Rate	Quantity	Subtotal	Remarks
Labor - Academic R&D (5 months)				
Software programmer	$90/hr	800	$72,000	1 worker
Software engineer	$105/hr	100	$10,500	1 worker
Expenses				
Material (computers)	$2,000	2	$4,000	
Subtotal			$86,500	

Note.
This table was inspired by Guidance for Preparing Benefit/Cost Analysis (Byers,2016)

Marketing, Distribution, Testing, & Training

The Table 6 shows the costs related to the marketing, distribution, testing and training of the proposed system. The cost of marketing includes advertisements on selected websites (e.g., American Association of Retired Persons) that represents the best audience of the system developed: aging population. Advertisements at the airport are the other part of the marketing costs. The distribution and testing costs are mostly covered by the labor costs and the membership to the two platforms (IOS and Android) where the system will be launched. The training costs cover the design of the training program that will need to be taken by the airport customer service employees to master the use of the proposed system.

Table 6
Marketing, Distribution, Testing, & Training for One Airport

Item	Rate	Quantity	Subtotal	Remarks
Labor - Distribution & Testing (5 weeks)				
Software programmer	$75/hr	600	$45,000	3 workers - 200hrs each
Software engineer	$90/hr	100	$9,000	1 worker
Cartographer	$60/hr	40	$2,400	1 worker
Training				
Design of the Training Program	$50,000	1	$50,000	one-time fee
Expenses				
Marketing	$50,000	1	$50,000	Advertising
Android membership for developer	$25 each	1	$25	one-time fee
Material (computers)	$2,000	4	$8,000	
Subtotal			$164,425	

Note.
This table was inspired by Guidance for Preparing Benefit/Cost Analysis (Byers,2016)

Operation, Training, & Maintenance (per year)

The Table 7 lists the costs of operation, training, and maintenance for one year of the system proposed. In this step, the operation and maintenance costs are evaluated to be the technical support and the servers for the system proposed. The technical support is delegated to a contractor to reduce the expenses, as the mobile application is not part of the domain of expertise of an airport. The training costs cover expenses due to the update of the training program every year and the costs of a three hours training program taken by all customer service employees four times per year.

Table 7
Operation, Training, & Maintenance for one Airport (per year)

Item	Rate	Quantity	Subtotal	Remarks
Labor - Operators' Personnel + Technical Support Representative				
Technical Support	$1,000/month	12	$12,000	1 contractor
Training				
Upgrade Training program	$5,000	1	$5,000	Update of the training program due to mobile app update
Customer service employees	$23/hr	720	$16,560	60 employees - 3 hours per session - 4 sessions per year
Expenses				
IOS membership for developer	$299	1	$299	
Server (computing)	$1,200 each	2	$2,400	
Subtotal			$36,259	

Note.
This table was inspired by Guidance for Preparing Benefit/Cost Analysis (Byers,2016)

The research and development steps of the proposed will cost $97,500. The Marketing, Distribution, Testing, and Training will cost $164,425. The Operation, Training, and

Maintenance will cost $362,590 for a 10-year period. The total cost of the proposed system is evaluated to be $624,515 over a 10-year period. The major challenge for the proposed system is the testing part as a sample of aging travelers will be required to determine its efficiency.

7.2 Benefits assessment

The proposed system offers both qualitative and quantitative benefits.

Quantitative benefits

The proposed system offers two significant benefits to the airport. Every year, several accidents leading to severe injuries happen in large airports like ORD. The proposed system will reduce the number of severe injuries among the aging population at those airports. The system is considered to prevent at least 2 severe accident over a 10-year periods. According to the U.S. Department of Transportation (2016), the value of statistical life (VSL) in 2016 is evaluated at $9.6 million. The value of severe injury is 10% of the VSL which means that the value of severe injury is evaluated at $960,000. By preventing 2 accidents in 10 years the benefit is estimated at $1.92 million.

The other benefit comes from the operational efficiency. The operational efficiency is the amount of money saved every year in term of labor. The system proposed will be able to decrease the number of requests to customer service employees. In an airport like ORD, 15 customer service employees are estimated to work in each terminal. ORD consists of four terminals, which means that 60 customer service employees work for the airport. The proposed service is estimated to save 15 jobs. However, the jobs will be saved only after five years, the period required for the airport to master the use of the proposed system. The Table 8 shows in detail the total benefits in term of operational efficiency over a one-year period.

Table 8
Benefits for Airport per year (value of labor saved)

Item	Rate	Quantity	Subtotal	Remarks
Customer service employees	$23/hr	20,800	$478,400	10 Customer service employees - 40hrs each per weeks - working 52 weeks per year

The total benefits over a 10-year period are evaluated to be $4.312 million.

Qualitative benefits

The proposed system will facilitate aging travelers' journey at the airport. Indeed, the system will help to reduce traveler's fatigue and wayfinding by showing them the shortest route to reach the gate. This will also improve the comfort of the travelers by helping them quickly finding amenities such as bathrooms. It will improve the safety of the travelers thanks to the emergency button integrated to the system. This will improve the efficiency of the emergency response as the position of the travelers will be known due to the GPS in their smartphones.

The Table 9 shows in detail the cost-benefit analysis. The total costs of the proposed system are $624,515 and the total benefits are $4.312 million over a 10-year period. The ratio benefits/costs is 6.90 which means that the benefits overweigh the costs of the proposed system for an airport of the size of ORD.

Table 9
Benefits vs Costs Analysis

Item	Subtotal	Quantity	Total	Remarks
Costs				
Research & Development	$97,500	1	$97,500	
Marketing, Distribution, Testing, & Training	$164,425	1	$164,425	
Operation, Training, & Maintenance	$36,259 /year	10	$362,590	
Total Costs (10 years)			$624,515	

Benefits				
Operational efficiency	$478,400/year	5	$2,392,000	Benefits of the app in term of operational efficiency will be seen after 5 years
Value of severe injury	$960,000	2	$1,920,000	
Total Benefits (10 years)			$4,312,000	
Subtotal			$3,687,485	
Ratio benefits/costs			6.90	
Note. This table was inspired by Guidance for Preparing Benefit/Cost Analysis (Byers,2016)				

8 Industry Interaction

The team contacted two airport management professionals, one airline professional, and five aviation industry experts with airport consulting experiences. The information the team understands from our conversations with these eight experts are our understandings and may not reflect their viewpoints. In this project to improve service quality at airports, this team report summarizes our interactions in three groups.

1) Airport Manager at Purdue University:

   Adam Baxmeyer, C.M.

2) Ground Transportation Supervisor at Dallas/Fort Worth International Airport (DFW):

   Alan Gonzalez

3) Special Service, Planning, and UAS program Manager at Delta Airport Consultants, Inc.:

   Bill Kelly, C.M.

4) Analyst at Landrum & Brown (LB):

Ting Xu,

5) Managing Principal at TransSolutions

   Gloria Bender

6) Senior Planner / Consultant at Woolpert

   Maria Muia, Ph.D.

7) Manager - Airport Improvement at an airline

   Airline One

8) Principal at Gresham, Smith and Partners

   Jim Harding

Adam Baxmeyer, C.M.

From our conversation with Mr. Adam Baxmeyer, C.M., we learned that in America, asserting that passenger age be considered a disability is not appropriate but may likely be viewed as an infraction of 14 CFR Part 382- Nondiscrimination on the Basis of Disability in Air Travel. Mr. Baxmeyer reminded us that age is not a disability and should not be substituted with the important issues of: mobility challenges, limited English proficiency, use of a service animal, and the like. Also, Mr. Adam Baxmeyer suggested we focus on the distinction of responsibilities between airlines and airports.

Alan Gonzalez

From the phone call with Mr. Alan Gonzalez, we learned that he has a great experience of working in the Dallas Fort Worth International Airport (DFW). The Americans with Disabilities

Act (ADA) has a great convergence with the potential needs from the aging travelers. Each customer service employee in DFW has ADA training. One thing shares the close relationship with our aging passenger mobile app is that there are 24/7 DFW employees with iPads walking around to assist the passengers in general; the iPad could serve not only information desk from the passenger perspective, but also it works as a translator in case there is a language barrier between employees and passengers. There are kiosks around the DFW which are operated by touch screen to find quickest routes between points in the airport, and conspicuous color-coded buses to different destinations. Outside the hardware, the DFW works hard to care for the emotional needs of the passengers such as distinctive uniformed volunteers with abundant information, stress relief of puppies petting.

Ting Xu

We learned from the Mr. Ting Xu in the email. For L&B, the design of accessibility facilities in any airport construction, expansion or renovation project is mainly imbedded in steps of designing terminal exterior architecture and interior floor plan, optimization and revision of the plan, engineering drawings drafting. While L&B is forecasting future operation volumes and optimizing aircraft or passenger flows, making sure that sufficient accessibility facilities are included is mostly the task of the partnered interior design team. Depending on the nature of the project, having a detailed and thorough design of accessibility facilities may not always be the key task. However, the designed accessibility facilities should always satisfy the requirements of Chinese accessibility standards that are similar to the ADA (Americans with Disabilities Act) standards in the United States.

In real-world operations, any people can use the accessibility facilities. Aging, disabled, or young passengers can also request the escort service from either the airline or the airport via

phone call, mobile app, website or airport service counter at many airports. In the early design stage, however, the goal is to reserve enough accessibility facilities without assuming any additional services.

It is also worth mentioning that in rare cases, accessibility facilities or services may be abused by some passengers, resulting in unpredictable design requirement, higher operational cost and interrupted passenger flow. This is actually a potential challenge in designing accessibility facilities.

Bill Kelly, C.M.

In a telephone interview Mr. Kelly, we learned his general thoughts on aging and airport wayfinding, and he suggested that he put the study group in contact with someone with more direct expertise. He was subsequently able to put the group in touch with Mr. Jim Harding.

Gloria Bender

Ms. Bender took our phone even when she was on sick leave at home. After having heard our targeted demographic: the aging passengers, we understood from her that the converging needs of aging passengers and disabled passengers, and more importantly, unlike the disabled passengers in the airports, the aging passengers tend to deny their problems and refused to seek the help from the airport.

As a private business owner, she wanted us to have our project scalable to both large commercial airport technologies and small-medium size airports' needs and technologies, and she also talked about the potential business partnership between our project and airport customer service provider. It would be even better if our app could be maintained and distributed by the wheel chair service.

She also gave us a name Mr. Steve Wareham who has written a great deal on accessible features when he was working at Minneapolis-St. Paul International Airport (MSP).

Maria Muia, Ph.D.

From the phone call, we understood that few aging people know how to use smart phone, and technologies like smart phone, tablets would be an obstacle for the aging passengers. We also told Dr. Muia that we might provide a second option for the aging passengers: smart devices (e.g., tablets, clickers). We learned that the anxiety of losing smart devices will be another stress during the travel. The Global Positioning System (GPS) should be simple and include audio/visual/tactile functions. Geofencing could be integrated with the app or smart devices to remind the passengers that they need to return the tablet.

Airline One

From the phone call with Airline One, we learned the following things. Different airports have different approach to utilize technologies. Some airlines are trying to truncate the passenger experiences into different stages including pre-travel, at departure airport, inflight, at arrival airport. For the airline customer service agent (CSA), they have self-service iPad, hand-held phone to assist the passengers to check in. These devices have proximity tracking sensors to help dispatch center to know the precise locations of CSAs and passengers.

Future projects may include the radio-frequency identification (RFID) wrist band issuing to the passengers who have no smart phones. And 14 CFR Part 382 states that there is no need for the disabled passengers to expose their disability to the airlines beforehand. And the airlines take measures like designating the disabled passengers boarding area, improvement of the signage in the airport.

Jim Harding

We had a phone call with Mr. Jim Harding who is a recognized aviation industry expert in the field of wayfinding and he has written quite a lot correlated with our project proposal. In the phone call, we learned some of his company's research experience with testing an alpha mobile app in the field at an airport in Texas and in the CATEA lab at the Georgia Institute of Technology as part of ACRP Report 177: Enhancing wayfinding for aging travelers and persons with disabilities. We are reminded to read chapter 8 of the ACRP Report 177 dealing with wayfinding using mobile phone that used the results from the usability and utility testing of the mobile app to create a list of do's and don'ts for airports and or developers to follow. Having a single mobile app that customers can use as they travel from one airport to another across the states be an excellent way to promote the goal of independent travel for aging travelers and persons with disabilities without them having to download a different app for each airport. Currently, the airline apps are more popular with the customers compared with the airport apps. We learned a cost for alpha testing stage of a mobile app for a medium size airport was approximately $80,000. From the testing that used Wi-Fi triangulation, there was lag time of several seconds that resulted in the test subjects not being able to make the correct decision in time to avoid navigational issues.

For the design part, we learned that the mobile app design should consider not only the needs of direct flight passengers, but also connecting flight passengers (like "Opening a book in the middle.") who may not be familiar with the connecting airport. For international connection flights, the app may remind the passengers of potential unfamiliar requirements in the U.S. such as having to claim luggage, recheck their luggage and then having to go through security check again before they can transfer flights.

9 Projected Impacts of Design

9.1 Project Meets ACRP Goals

Airports serve as a connection area between air space and ground space. Many people spending their precious time in airport. Throughout the years, many improvements have been made to promote traveling experience while they are in airports; however, few endeavors have been made for them by IT. Thanks to this proposed mobile application design for aging travelers, they would have a straightforward tool to deal with the four most important issues to them: wayfinding, failure to locate and utilize the amenities, inadaptation of technology and new equipment, and fatigue.

9.2 Impacts on Sustainability

ACRP, FAA, and many airports around the United States have adopted "EONS" (economic vitality, operational efficiency, natural resources, and social responsibility) to approach sustainability (ACRP, 2015). The proposed mobile application design will benefit the aging travelers and airports in terms of economic vitality, operational efficiency, natural resources, and social responsibility.

From economic vitality perspective, the proposed app design will attain the benefits/costs is 6.90 for a single airport like ORD. Furthermore, the spread of airports choosing the app will have enormous economic benefits for themselves.

From an operational efficiency perspective, the aging travelers who use the app would lower the chance of getting lost and serious injury significantly by introducing the features of panic button and emergency call. The airport/airline would decrease the workload of the employees in the long run as well.

The application would assume significant social responsibilities to care for needs including: wayfinding, fatigue management, inadaptation of technology and new equipment, and failure to locate and utilize the amenities of not only aging travelers but also other travelers who share the similar pain regardless of age, which is the initiative for the team.

From a natural resource perspective, loading maps into the application is an excellent way to reduce publications of airport maps.

10 Conclusion

The team reviewed academic papers on the aging traveler needs in the airport and industry reports about improving their traveling experience in the airport environment, talked to several industry experts whose knowledge and experiences covering airline operation, airport management, and airport consulting, and developed a proposal for mobile application design for aging travelers and other travelers with disabilities in commercial airports. In addition, the team analyzed the design using the Failure Mode Effect Analysis (FMEA), and Cost/Benefit Analysis. It has been found that the proposed application design is both safe and economically viable. Moreover, the proposed application design has positive impacts on sustainability using EONS model and could definitely be implemented into airports in the future.

Appendix A: Contact Information

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Appendix B: Description of the University

About Purdue University (from the www.purdue.edu)

Purdue University is a vast laboratory for discovery. The university is known not only for science, technology, engineering, and math programs, but also for our imagination, ingenuity, and innovation. It's a place where those who seek an education come to make their ideas real — especially when those transformative discoveries lead to scientific, technological, social, or humanitarian impact.

Founded in 1869 in West Lafayette, Indiana, the university proudly serves its state as well as the nation and the world. Academically, Purdue's role as a major research institution is supported by top-ranking disciplines in pharmacy, business, engineering, and agriculture. More than 39,000 students are enrolled here. All 50 states and 130 countries are represented. Add about 950 student organizations and Big Ten Boilermaker athletics, and you get a college atmosphere that's without rival.

About Purdue University's School of Aviation and Transportation Technology (from web)

Purdue University's School of Aviation and Transportation Technology, one of six departments and schools in the Purdue Polytechnic Institute, is recognized worldwide as a leader in aviation education. All seven of Purdue's Aviation and Transportation Technology undergraduate majors are world-class educational programs. Take a virtual tour of the school, including Flight Operations, the Simulator Building, Terminal Building, Laboratories and Research Centers, and the Niswonger Building of Aviation Technology.

Aviation and Transportation Technology Mission Statement

The mission of the School of Aviation and Transportation Technology is to prepare the next generation of leaders and change agents for the transportation sector.

Vision Statement

The School of Aviation and Transportation Technology will be the recognized global leader in aviation technology education through excellence in faculty, students, curricula, laboratories, and mutually beneficial partnerships.

Appendix C. Description of non-university partners

Not Applicable.

Appendix E: Evaluation of Educational Experience Provided by the Project

Students

1. Did the Airport Cooperative Research Program (ACRP) University Design Competition for addressing Airports Needs provide a meaningful learning experience for you? Why or why not?

Yes, this competition was a meaningful learning experience for our group. Through the semester long project, we have been developing many skills, and most importantly, team relationship, time management and industry interaction (addressed in question 4 and 5).

Our team is as diverse as it could be; Linfeng is from China with an aircraft mechanic certificate, Yury is from Russia with a mechanical engineering background, and Victor is from France with an aeronautical engineering background and private pilot certificate. During the project work, there were plenty of times share our own cultural identity; however, we managed to reach agreements. In short, we all see the world through different lenses. We are different; we are the same.

Besides this project, we are busy doing our own work. Linfeng was responsible for total four aircraft maintenance labs of total sixty undergraduate students, Victor was taking three graduate level class in the semester, and Yury has a boy that is six months old. We had a phone call with one industry contact and Yury was taking care of the baby in the same room. Looking back, we all overcame our difficulties and succeeded.

2. What challenges did you and/or your team encounter in undertaking the competition? How did you overcome them?

During the competition, we encountered several challenges. One of them is that there are limited academic papers on aging travelers in airports and service products for aging passengers

in airports. After having talked to several industry people, we realized that currently most of the service providers and academic researchers are working on the travelers with disabilities due to the ADA law. So we adjusted the strategies, found many useful papers and commercial products addressing people with disabilities. While aging and disabilities are not the same thing, there may be overlaps between the aging travelers and people with disabilities. The second challenge is that we could not find labor cost estimations for this specific project easily. We looked into the Glassdoor, LinkedIn, Bureau of Labor Statistics websites, and bulletin board systems. Finally and luckily, one of our industry contacts reminded us that money is not important for our team because the project is more about the ideas instead of accounting. So we spent more time on other parts of the project like features and innovation.

3. Describe the process you or your team used for developing your hypothesis.

Our project proposed a mobile app for aging travelers in airports. The first step was to identify the problem in the current system. Through the literature review, we found the increasing proportion of aging people in every country, increasing smart phone usage across the globe, and no fully-developed airport app for aging traveler in airports. Consequently, we decided to propose an app for aging traveler in airports.

Secondly, what should be in the app? We answered this question by using airline apps, doing literature review, and talking to industry experts. Through the literature review, we understood the needs for the aging travelers and travelers with disabilities, and industry efforts for satisfying their needs. After trying to use several airline apps, we also recognized the complexity of these apps might not suit for the aging travelers. In the same time, we were contacting the industry experts which will be elaborated on the next answer. Based on these inputs, we narrowed our app features so that it would be suitable for aging travelers in airports.

Finally, we conducted safety analysis and cost/benefit analysis of our project. One part of the safety analysis named Failure Modes and Effects Analysis is new knowledge for the team. And by doing cost/benefit analysis, we gained knowledge and basic skills of accounting and budgeting.

4. Was participation by industry in the project appropriate, meaningful and useful? Why or why not?

The industry participation in the project was appropriate, meaningful, and useful. We talked to nine experts whose job functions have covered airline operations, airport operation, and airport consulting. Overall, these interactions gave us a better understanding of our project from an outside perspective and talking with experts was really a delightful experience. Several things touched us deeply in our hearts. An expert was willing to give us her feedback even she was on sick leave at home, another expert showed candidacy that he might not be able to help us, but gave us contact information of renowned industry expert that totally changed the direction of our team workflow.

5. What did you learn? Did this project help you with skills and knowledge you need to be successful for entry in the workforce or to pursue further study? Why or why not?

Besides the knowledge specific to the project, we have sharpened the team cooperation skills, time management skills, and networking with industry experts. We believe people skills are the most important skills for our further study and career. We had the opportunity to apply our technical skills to potentially improve the airport experience for aging passengers, and we are excited to work on that project. This was a completely different type of project any of the team

member ever experienced. We have spent our “blood, toil, tears and sweat” on the project to borrow a piece of speech from Sir Churchill in 1940.

Faculty – Dr. Johnson

l. Describe the value of the educational experience for your student(s) participating in this competition submission.

This competition is valuable for students in my aviation sustainability course primarily due to the challenges and topics coming from real airports, the interactions with industry experts, and the structure of the project report being a proposal in response to the competition guidelines (much like a request for proposals). This competition encourages my students to do deep dives into not only what to do to improve airports, but also to quantify the risks, costs, benefits, and for my students, to describe the impact that these projects may have on airport sustainability. One key to the educational value of the experience is the interactions with industry experts from airports, airlines, and consultants. While the written portion in the report may be brief, what is doesn’t say is the overwhelmingly positive response these experts provide the students. Every one of these experts took at least 30 minutes from their day, most of them took an hour or so. Some experts also interacted with the team via email and follow-up phone calls. This team interacted with 8 experts – this is invaluable education that is not available via typical textbook-based courses. These interactions energized the team as they realized that these airport challenges are truly important and that with some tweaking or changes, their proposed solution may become to a better solution.

2. Was the learning experience appropriate to the course level or context in which the competition was undertaken?

Yes. This is a graduate level applied aviation sustainability course where the airport improvement projects are also evaluated in a sustainability analysis. The required literature review was enlightening for this team as they found information on the similarities and differences between aging passengers and differently abled passengers, and the studies done to understand and improve the airport experiences for aging passengers. They spoke with airline personnel, airport personnel, and consultants to better understand what the airport does versus what the airline does. They learned a great deal about regulations from airport managers, and from ACRP literature addressing these issues. To my knowledge, this is the only course in our graduate curriculum where the students respond to an RFP. This is a valuable skill.

3. What challenges did the students face and overcome?

Learning about this expansive subject was the biggest challenge for this team. Aging passengers is not a topic that the students typically spend much time on in other classes, and certainly not 10 weeks. This team had to learn deeply about the differences between aging and disabled, and the regulations covering these passengers in the airport. Seemingly simple services such as wheelchair service are really not so simple. The team learned more about the specific roles of the airport, the airlines, and the support services and concessionaires, and how these entities interact to serve passengers. Talking with experts is always a challenge but this team had to learn a great deal about aging passengers before speaking to the first expert. Papers and ACRP reports helped the team learn about aging passengers.

4. Would you use this competition as an educational vehicle in the future? Why or why not?

Yes. This competition inspires students to learn more deeply, to seek out regulations and guidance, and to read the available literature. All of this leads to a greater understanding of airports and the aviation industry.

5. Are there changes to the competition that you would suggest for future years?

Yes, consider including a sustainability analysis as a required section of the report.

Faculty – Dr. Lucietto

l. Describe the value of the educational experience for your student(s) participating in this competition submission.

The students in this group found value in determining the best way to work with one another. Each represented a different ethic group and culture. They also worked hard to learn from experts in industry and found the experience invaluable. Discussing the value of the group work, intense cooperation between different cultures, and learning from experts in the various areas encountered was a pleasure for me as one of the mentoring faculty members.

2. Was the learning experience appropriate to the course level or context in which the competition was undertaken?

While students may encounter similar experiences in earlier work, at the doctoral level integrating new knowledge, experiencing the relevance of all aspects of the project, and having a true appreciation while developing a solution to a real problem is appropriate for this level of study.

3. What challenges did the students face and overcome?

The students were resistant to interaction with experts, but became energized as they found that the experts were excited by talking about their areas of expertise. This further motivated the

students as they found much of this material. Integrating and providing sound solutions to the work they were doing in meeting the objective of this project. The cultural differences were overcome by discussing their experience and leveraging it in the completion of the project.

4. Would you use this competition as an educational vehicle in the future? Why or why not?

It's a great tool that allows students to solve an authentic problem. Continuing it's use allows students to have "real life" experiences and to understand the area in which they are studying.

5. Are there changes to the competition that you would suggest for future years?

The competition appears to be well designed.

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