Accessible Air Travel Information System (*A²TIS)*

January 2023 - April 2023

Design Challenge: Airport Management and Planning Challenge A- *Innovations to Accommodate the Aging Passenger Demographics at Airports*

Team Members: Gustavo Sanchez, Hans Natakusuma, Hanzi Xie & Tolulope Oluwumi

Graduate Students: 4

Advisor's Name: Mary E. Johnson, Ph.D.

Name of University: Purdue University

Note: Homepage image created using Figma Software.

Executive Summary

Accessibility issues in air travel extend beyond physical barriers; digital communication problems limit aging travelers' ability to access services across U.S. airports. Therefore, a design team of students from different backgrounds proposes the implementation of a comprehensive Accessible Air Travel Information System (*A^{2}TIS*) to improve air travel accessibility, addressing the **ACRP Airport Management and Planning** Design Challenge, Problem A - *Innovations to Accommodate the Aging Passenger Demographic at Airports.*

During the design process, the team conducted field visits and semi-structured interviews with experts from two universities, three government and non-government agencies, and executives from six airports (DFW, IND, LAS, MIA, ORD, SFO) to explore alternatives for removing accessibility barriers and receive feedback about the *A^{2}TIS* requirements. As a result, this proposal includes **digital accessibility guidelines** for airports' websites, an accessible **website prototype,** a **mobile application design**, and novel **virtual assistant** features for improving customer experience and accessibility services' usability.

The *A^{2}TIS* Benefit-Cost Ratio is **2.86:1**. The expected costs are $**174,459,** and the anticipated savings are **$498,432** for ten years of operation for one airport. Furthermore, the *A^{2}TIS* envisions including information from the 30 large U.S. hubs, with an expected Benefit-Cost Ratio of **10.3:1**. Impacting 71% of the commercial enplanements in the U.S. (FAA, 2022). Additionally, a safety risk and sustainability assessment projected the benefits of implementing an information system with the proposed specifications. This design project responds to the call for action from the United Nations' Sustainable Development Goals (SDGs) and aims to *Restore and Improve Urban Infrastructure* - Grand Challenges for Engineering (NAE, 2022). **Overall, the *A^{2}TIS* is a one-*stop-shop* solution for improving air travel accessibility**.

Table of Contents

Problem Statement and Background

Air travel has become the preferred mode of transportation for millions of passengers worldwide. However, despite the continuous improvement in aviation safety and operational efficiency, accessibility barriers affect air transport services for aging travelers and people with disabilities (Government Accountability Office, 2022). The lack of clear, accessible, and standardized communication represents a barrier to improving air transport accessibility. In addition, equitable access to information means that all people, regardless of their physical condition, can access information; an inaccessible website can marginalize people as much as the lack of ramps or elevators in a building (United States Justice Department, 2022).

Physical barriers are not the only problems to solve for improving accessibility, as communication barriers persist within the air travel system. For example, according to the Airport Cooperative Research Program (ACRP) Report 210, *Innovative Solutions to Facilitate Accessibility for Airport Travelers with Special Needs and Disabilities,* there is a lack of standardization of how the information is delivered to older adults and passengers with disabilities, reinforcing communication problems (Van Horn et al., 2020). In the same way, the ACRP Report No. 177, *Enhancing Airport Wayfinding for Aging Travelers and Persons with Disabilities,* describes the benefits of implementing a universal design, making the information perceivable, operable, understandable, and robust for all passengers (Harding et al., 2017).

The freedom to connect and access web information is essential for a member of modern society (Kurt, 2019). Furthermore, passengers with disabilities use airports' websites to access information related to pre-trip planning, ground transportation, and special services (Government Accountability Office, 2021). Additionally, due to the aging population, the air travel industry has experienced significant socioeconomic changes in the last few years.

The growing baby boomer population continues to engage in leisure activities in their lengthening lives (National Institute on Aging, 2018). The number of aging travelers at airports has been increasing due to several factors, including people living longer and participation in social and recreational activities involving travel (Balderas-Cejudo & Patterson, 2023). However, the capacity to do fundamental everyday activities is frequently hampered by functional decline and physical reliance that come with aging (Vaish et al., 2020).

During previous ACRP reports and design competition submissions, focused their attention on the physical dimension of accessibility by understanding the "*Impacts of Aging Travelers on Airports*" (Mein, 2014), improving the "*Planning the intergenerational airport: Making the airport better for everyone*" (Asgarali-Hoffman et al., 2016), improving wayfinding navigation with the "*Proposal of mobile application design for aging travelers in commercial airports*" (Jin et al., 2019) and "*Assessing Airport Programs for Travelers with Disabilities and Older Adults"*(Ryan et al., 2023). However, the digital dimension provides another alternative for improving air travel accessibility. This design aims to eliminate digital communication barriers, explore alternative methods for enhancing websites and mobile user interfaces, increase customer satisfaction, and promotes a beneficial social change.

Furthermore, enhancing information access is vital for passengers that require assistance, and standardizing the terminology, format, website structure, and content improves the user interface. This design offers a novel approach for the **ACRP Airport Management and Planning Challenge A -** *Innovations to Accommodate the Aging Passenger Demographic at Airports***,** by applying a universal design to the accessibility section of airports' websites and proposing the implementation of an integrated Accessible Air Travel Information System (*A^{2}TIS*) for enhancing communication services for aging travelers and people with disabilities.

Literature Review

The global population is aging, and this trend has been accompanied by an increase in overall health, leading to a rise in global life expectancy by five years between 2000 and 2015 (Patridge et al., 2018). According to the U.S. Census Bureau (2020) Population Estimate Program (PEP), the proportion of older adults in the U.S. population has been steadily increasing and is expected to reach a quarter of the population by 2030, with an increase in life expectancy. Most developed countries define 'elderly' or 'older adult' as someone 65 years or older (Kowal & Dowd, 2001), while the United Nations has identified individuals 60 years or older as older adults (United Nations, 2001).

Aging Travelers

Transportation accessibility is crucial for providing a pleasant and secure travel experience for all passengers, especially those with disabilities (U.S. Department of Transportation, 2022). The demand for air travel has substantially risen, with more than 15 million air travelers taking approximately 29.6 million flights per year, resulting in a total expenditure of $11 billion (Ristagno, 2022). This demand includes passengers with disabilities and represents more than 20% of the global population (Stončikaitė, 2022). Furthermore, the number of older adults is expected to increase significantly in the United States and worldwide, making accessibility even more critical (Harding et al., 2017; World Health Organization, 2014).

In the United States, mobility restrictions are the most common disability, followed by conditions such as hearing problems and vision-related disabilities. Older adults are more likely to develop multiple disabilities due to natural aging (Harding et al., 2017). Older adults are vulnerable during air travel and face various travel barriers that impact their travel experiences (Lee & Bowes, 2016). According to a publication by the Airport Cooperative Research Program

(ACRP), aging symptoms can hinder travelers in their 50s, and early-onset limitations can hinder those in their 80s and 90s (Mein et al., 2014). Remillard et al. (2022) emphasized that older adults with mobility disabilities face transportation issues that make it difficult for them to fully participate in society despite federal regulations and programs designed to improve accessibility. Therefore, there is a growing demand to develop a standardized information system that explicitly addresses aging travelers' requirements.

Accessibility Barriers – Information

The United States Census Bureau reported in 2020 that there are more than 49 million people aged 65 and older, a record high, which is expected to continue increasing due to the Baby Boom generation (US Census Bureau, 2020). Therefore, creating a user-friendly and satisfactory for the aging population is imperative. The National Institute on Aging (NIA) and the National Library of Medicine (NLM) published 25 guidelines aimed at encouraging senior-friendly websites, motivating them to explore the Web, and inspiring them to take part in technology (National Aging Institute & National Library of Medicine, 2002). However, due to the lack of design details, strict compliance is not a guarantee of website success or compliance with the preferences of seniors (Hart et al., 2008).

Sayago & Blat (2009) investigated the challenges aging individuals face while accessing the Web and developed strategies to improve accessibility. Stirbens et al. (2010) reported that older adults desired to access the internet independently but encountered obstacles that included trouble with the recall of necessary procedures, comprehending computer and web-based language, and utilizing the mouse. Therefore, providing consistent terminology in web interfaces would assist in their comprehension. According to Olsson et al. (2021), to achieve a socially sustainable transport system, it is crucial to ensure that civil aviation information is easily

accessible to older adults. In this study, the focus is on the accessibility of information as perceived by citizens.

Moreover, the information services provided to older adults can improve mobility and independence (Theodorou, 2022). Despite their health conditions and special needs, many older adults aspire to maintain their independence and access flight information on their own (Bayne et al., 2021). Therefore, it is important to design websites that are free from information barriers and cater to their goals and task, while a user-centered design approach should be adopted that considers the perspectives of older adults regarding airport information service technologies (Wang et al., 2019).

Furthermore, older adults faced technological and physical information barriers, including low technology literacy and unfamiliar terminology. However, they were willing to learn and contribute to co-designing information services and were interested in controlling their data privacy (Wang et al., 2019). In the same way, improving the accessibility of information services for older adults requires increasing their technical knowledge and enhancing human-machine interfaces (Wang et al., 2019).

Technological Applications

In the 21st century, technological advancements have modernized the world and improved the quality of life of many people (Park & Jayamaran, 2003). However, those with complex disabilities, ranging from physical to cognitive impairments, have not been able to benefit from these advances as much as others. Consequently, the Centers for Disease Control (CDC) is committed to enhancing people with disabilities' well-being and their ability to contribute to society by focusing on universal design and minimizing obstacles to accessing technologies and devices (Agree, 2014).

Furthermore, smartphones have emerged as familiar devices to users and can be used to provide an accessible interface for disabled people. They can use features such as voice input technology and text-to-speech capabilities to access daily items such as payment methods and identification cards to access complex services such as transportation, banking, and hospitality services (Mello & Pépece, 2022). Additionally, the smartphone has become an integral part of the roadmap for implementing assistive aid technology. For example, recent research has explored the use of these devices for wayfinding, which helps people navigate indoor spaces (Qing et al., 2020).

According to Birbaumer and Cohen (2007), brain-computer interfaces (BCIs) hold promises for improving the lives of people with disabilities by allowing them to interact with their environment using their thoughts. BCIs operate by detecting and analyzing electrical signals generated by the brain and then converting them into commands to run external devices (Birbaumer & Cohen, 2007). Although still in the early stages, BCIs can significantly improve the lives of people with disabilities (Birbaumer & Cohen, 2007). Therefore, investing in the development of assistive technologies is crucial to create a more inclusive airport environment for passengers with disabilities.

In the future, research is pushing the boundaries of using non-aural or visual cues to aid disabled individuals in navigating through the airport using state-of-the-art technologies such as sensory substitution and augmented reality (Bhowmick & Hazarika, 2017). However, assisting persons with disabilities using this product is still hindered by challenges such as allowing visually impaired individuals to independently find their way inside buildings, retrieve lost or stolen items, locate a specific person, and evacuate without assistance (Bhowmick & Hazarika, 2017).

Regulations

This section will provide an overview of the regulations related to website accessibility and the Americans with Disabilities Act (ADA). Upon reading the regulations, practical recommendations for an accessibility information system include using alt-text for images, providing captions for videos, and ensuring keyboard accessibility. In addition, making websites accessible is not only a legal obligation but also an ethical responsibility to ensure that all users can access information and services online (Laurie & Jefferey, 2021).

Under the ADA, all aspects of public life are protected from the discrimination of individuals with disabilities, including employment, education, and access to public employment (U.S. Department of Justice, n.d.). To people with disabilities, the ADA Accessibility Standards (ADAAS) provide technical guidance for making websites accessible (United States Access Board, n.d.). The standards cover a range of accessibility issues, such as keyboard accessibility, alt-text for images, and the use of color contrast. Title III of the ADA prohibits disability-based discrimination where public accommodation exists, including websites that offer goods and services to the public (U.S. Department of Justice, n.d.).

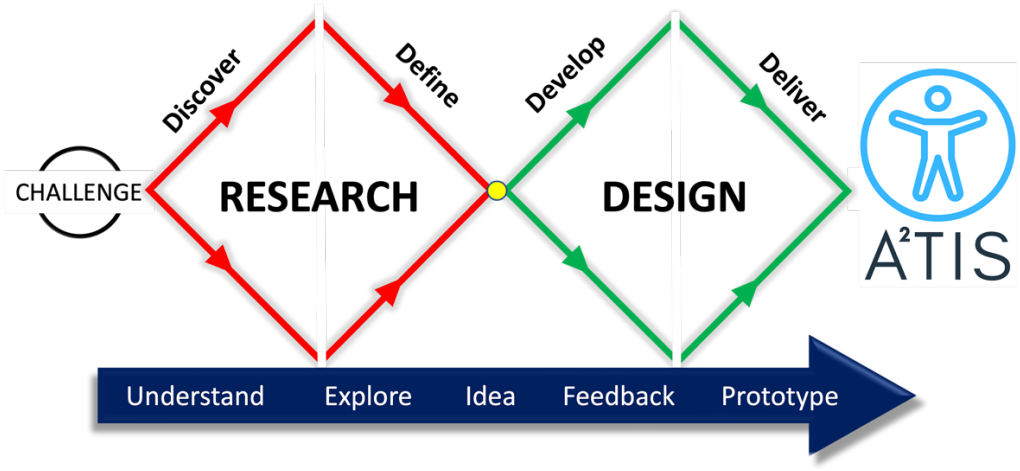
Section 508 establishes the requirements in the information systems for people with disabilities by federal agencies (United States Access Board, n.d.). Furthermore, this regulation provides a useful framework for website accessibility that can be adapted by businesses in the private sector. As for international guidelines, the Web Content Accessibility Guidelines (WCAG) ensures website accessibility to people with disabilities. The guidelines discuss and provide solutions to various accessibility issues, such as inserting alternative text for images, ensuring keyboard accessibility, and providing video captions (W3C, 2021). WCAG is not a legal requirement but is widely recognized as a best practice for website accessibility.

Problem-Solving Approach

Continuing with the design process and after analyzing the regulations and recommendations provided by the available literature for improving digital accessibility. The design team developed a questionnaire and conducted semi-structured interviews with airport operators (IND, LAS, MIA, ORD, SFO & DFW) to understand the main challenges, best practices, and opportunities for improving the accessibility at airports from the digital accessibility perspective. Furthermore, Figure 1 illustrates the Double Diamond methodology used for innovation and problem-solving approach (Design Council, 2015).

Figure 1

Research Design Process



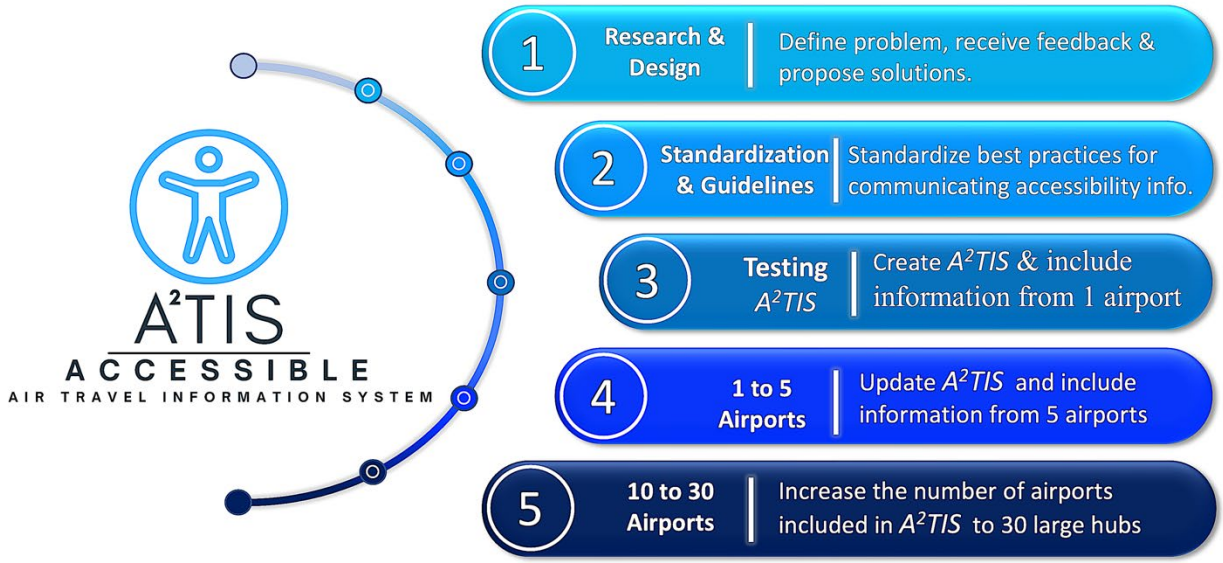
Note: The British Design Council (2015) diagram was adapted by adding the team's general design.

During the early stages of the project, the design team studied technical reports and literature reviews based on the Double Diamond methodology. This initial exploration included defining the problem, creating a conceptual framework, synthesizing the results, and exploring solutions. Additionally, by conducting semi-structured interviews, the design team sought to understand the features, initiatives, and processes developed to communicate information related to accessibility services to passengers at different U.S. airports.

Additionally, the design team analyzed the website accessibility data from 100 airports in the U.S. to identify best practices for presenting information related to accessibility services on airports' websites. This step included identifying information categories, the website's structure, and standard practices across the industry. The following steps involved developing guidelines, identifying standard features, and creating a website prototype using Figma, a web-based tool for designing websites and mobile applications. Figure 2 summarizes the proposed solution steps for improving accessibility services at airports by removing digital information barriers.

Figure 2

Increasing Airports' Websites Standardization Towards A²TIS



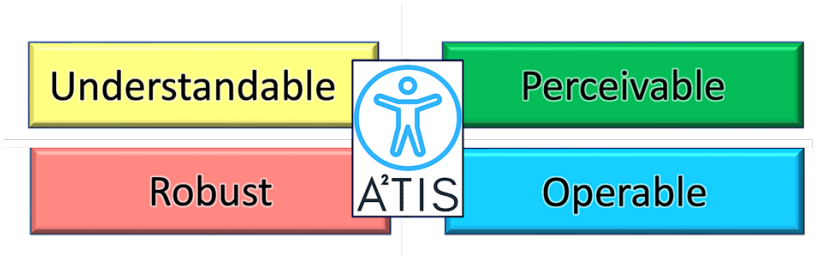
After creating the prototype, the next step requires using a large hub to test the attributes of the *A²TIS* and receive feedback from airport operators to improve the system. The benefits of an integrated information system are scalable, growing as the number of airports included in the *A²TIS* increases. Therefore, the following design phase requires including the information of 5 large hubs in the system to continue gradually increasing the accessibility information from the 30 largest hubs in the U.S. measured by the number of passengers.

Digital Accessibility Guidelines

Building guidelines to enhance digital accessibility in the airports' websites in the U.S. starts with standardization. Web Content Availability Guidelines (WCAG) offer an initial approach to improving digital accessibility. The World Wide Web Consortium (W3C) developed the WCAG to establish a common framework for developers, companies, and organizations to provide an international standard for digital accessibility (Rutter et al., 2006). Additionally, WCAG has resulted in more accessible, usable, and informative websites (Debevc et al., 2007). This design follows the WCAG's principles illustrated in Figure 3, meets the requirements established by WCAG 2.0, and exceeds Section 508 requirements for digital accessibility.

Figure 3

WCAG - Principles



After analyzing the best practices identified during semi-structured interviews, field visits, and reviewing the websites, the design team identified 33 success criteria to improve accessibility information services on the airport's websites. These criteria will enable us to increase standardization across the industry and design an accessible and user-friendly information system. Table 1 summarizes the requirements from three categories for improving the communication of accessibility services on the airports' websites:

1. Web Content Availability (WCAG) 2.0. - Conformance
2. Accessibility Services General Information Guidelines.
3. Special Accommodations and Services Guidelines.

Table 1

Accessibility Services - Digital Communication Guidelines

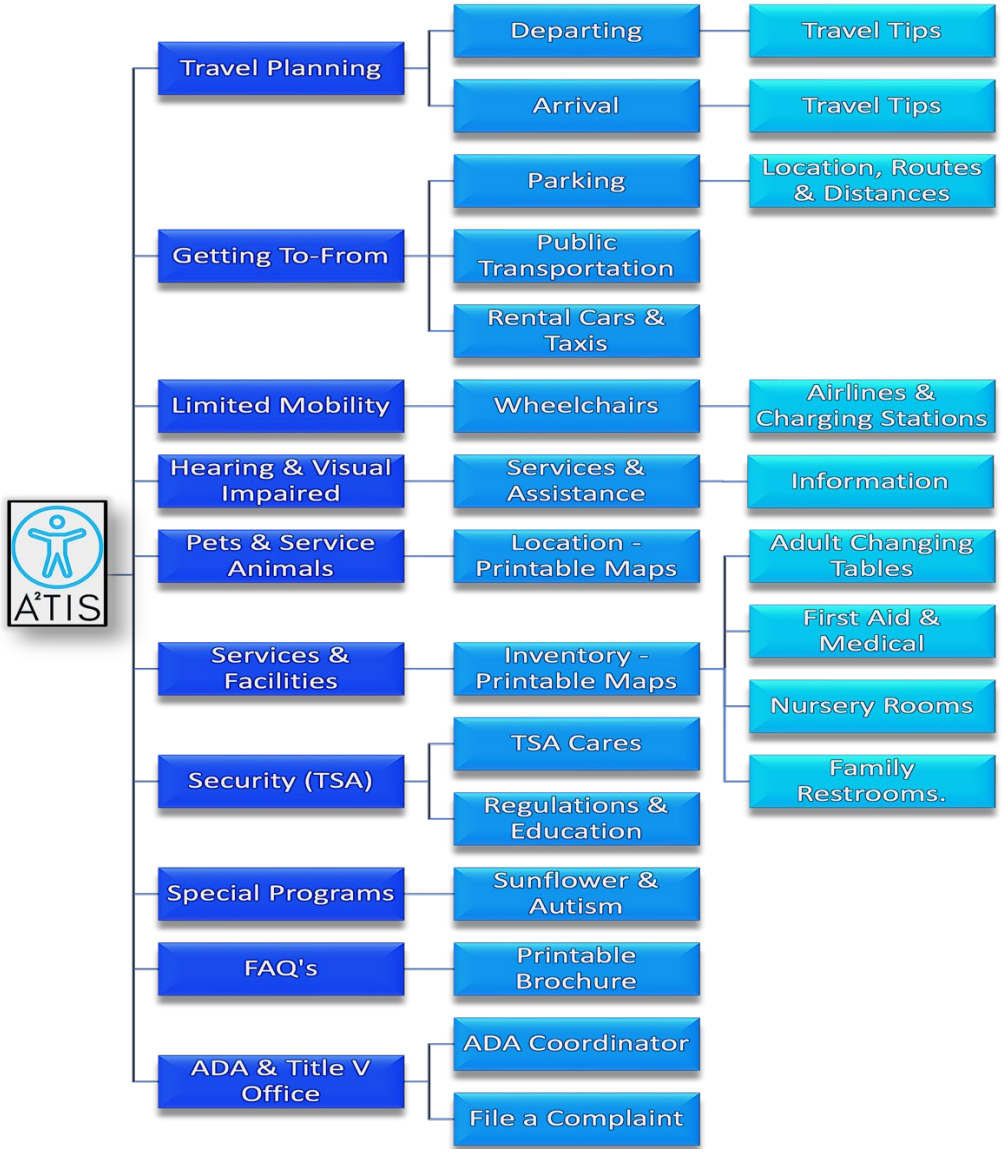
Accessibility Services - General Guidelines			
No.	***Description***	***Yes***	***No***
1	The main homepage includes an international symbol of access		
2	One-click to accessibility information from the airport's homepage		
3	The website includes an accessibility widget		
4	Virtual Assistant to access relevant information for accessibility		
5	The website includes an accessibility brochure for passengers.		
6	The website offers accessible online forms		
7	The website has options for language selection		
8	The website includes an accessibility FAQ section with links included		
9	Includes educational content: Passengers' responsibilities & rights-		
10	Content Accessible on different devices		
11	Provides sign language interpretation for videos		
12	Consistently uses the same format across the website		
Special Accommodations and Services Guidelines			
No.	***Description***	***Yes***	***No***
13	Is there a section with travel tips for passengers with disabilities		
14	Airlines information, links, and phone to request mobility assistance		
15	Includes TSA contact information and educational resources		
16	Includes public transportation options, phone numbers, and schedules		
17	There is a map with accessible parking and routes to the terminal entrance		
18	All Accessibility services are summarized in a self-explanatory video		
19	Includes a printable map with the location of accessibility services		
20	Uses graphic symbols for accessibility services – ISO 7000		
21	Includes distances, walking times, rest areas from parking to the gates		
22	Visual Paging – option to check messages on the website		
23	ADA coordinator information phone and email		
24	Is there an option to file a complaint (ADA)		
25	Include programs developed by airports to improve accessibility		
26	Uses standardized terminology and icons to label accessibility services		
27	Location of Telecommunications Devices for Deaf TDD & TTY on maps		
28	The website includes the location of wheelchair charging stations		
29	Is there a link for tips and training for traveling with disabilities		
30	Does the website include an accessibility services survey?		
31	Includes contact information for parking and ground transportation		
32	Includes accessibility training resources for airport employees		
33	Virtual Assistant addresses FAQs consistently throughout the website		

Website Sitemap Structure

After identifying the best practices and requirements to communicate to customers the information related to accessibility services on the airport's websites. This design proposes the website structure illustrated in Figure 4 to increase standardization in the accessibility section among airports' websites. Increasing standardization across the airports' websites is the initial step for reducing digital communication barriers.

Figure 4

Proposed Website Structure to Increase Standardization Across Industry



Additionally, despite the differences in airport layout, size, or number of enplanements per year across the air travel network, standardizing across the industry the path to access the same type of information (i.e., pet relief areas and adult changing tables) will reduce communication inefficiencies and will increase accessibility services' usability, which at the end, will result in higher customer satisfaction. Furthermore, the *A^{2}TIS* helps to reduce the probability of errors when conveying accessibility information to passengers; standardizing accessibility terminology or categories will also contribute to this reduction.

Additionally, a shared website structure in the accessibility section across U.S. airport websites promotes best practices for communicating accessibility services to customers in the air travel industry. Furthermore, from meetings with airport operators, it was common to hear that most of the complaints from travelers with some disabilities were related to arriving at or leaving the airport. Therefore, including information related to accessible parking spaces, curbside assistance procedures, and special public transport accommodations to avoid communication problems and delays during arrival and departure procedures. It is also essential to include a list of telephone numbers to contact them for detailed information on alternative ground transportation to improve airport access efficiency.

In the same way, providing contact information for airlines and companies that assist passengers with limited mobility is essential to improving the travel experience for passengers who require assistance during their journeys at the airport. Consequently, along with the telephone numbers in this section, it is recommended to include a link to each airline's website and the contact information for the subcontractors who provide wheelchair services to the airlines. Furthermore, the accessibility of airport routes within the airport and the availability of wheelchair charging stations is essential information that must be described on the website.

A²TIS Website and Mobile App Prototype

Implementing *A²TIS* impacts 71% of the commercial enplanements in the U.S. (FAA, 2022) and provides a standard for the industry to communicate accessibility services to passengers. Therefore, the design team used *Figma* to create the information system prototype, which allowed team members to collaborate to design the web page and mobile application. In addition, the *A²TIS* prototype allowed the design team to apply the recommendations in the literature to eliminate digital communication barriers at airports' websites and receive feedback regarding the features included in the *A²TIS* from the experts interviewed during the design phase. Figure 5 illustrates the information system layout and features.

Figure 5

Accessible Air Travel Information System, A²TIS – Homepage

Note: Homepage created using Figma Software.

The *A²TIS* homepage follows the same structure recommended for airport websites. In addition, it includes an accessibility widget to adjust the contrast, increase the size of the letters, and increase the space between characters. The *widgets* illustrated in Figure 6 include a screen reader and language selection to provide options for each user's needs.

After reaching an optimal level of maturity, the *A²TIS* will include information from the accessibility services of the 30 large hubs in the U.S., removing communication by using a universal design, turning this information system into a one-stop shop for aging travelers and people with disabilities. Therefore, the *A²TIS* has a high capacity to improve information services for air travel accessibility.

Figure 6

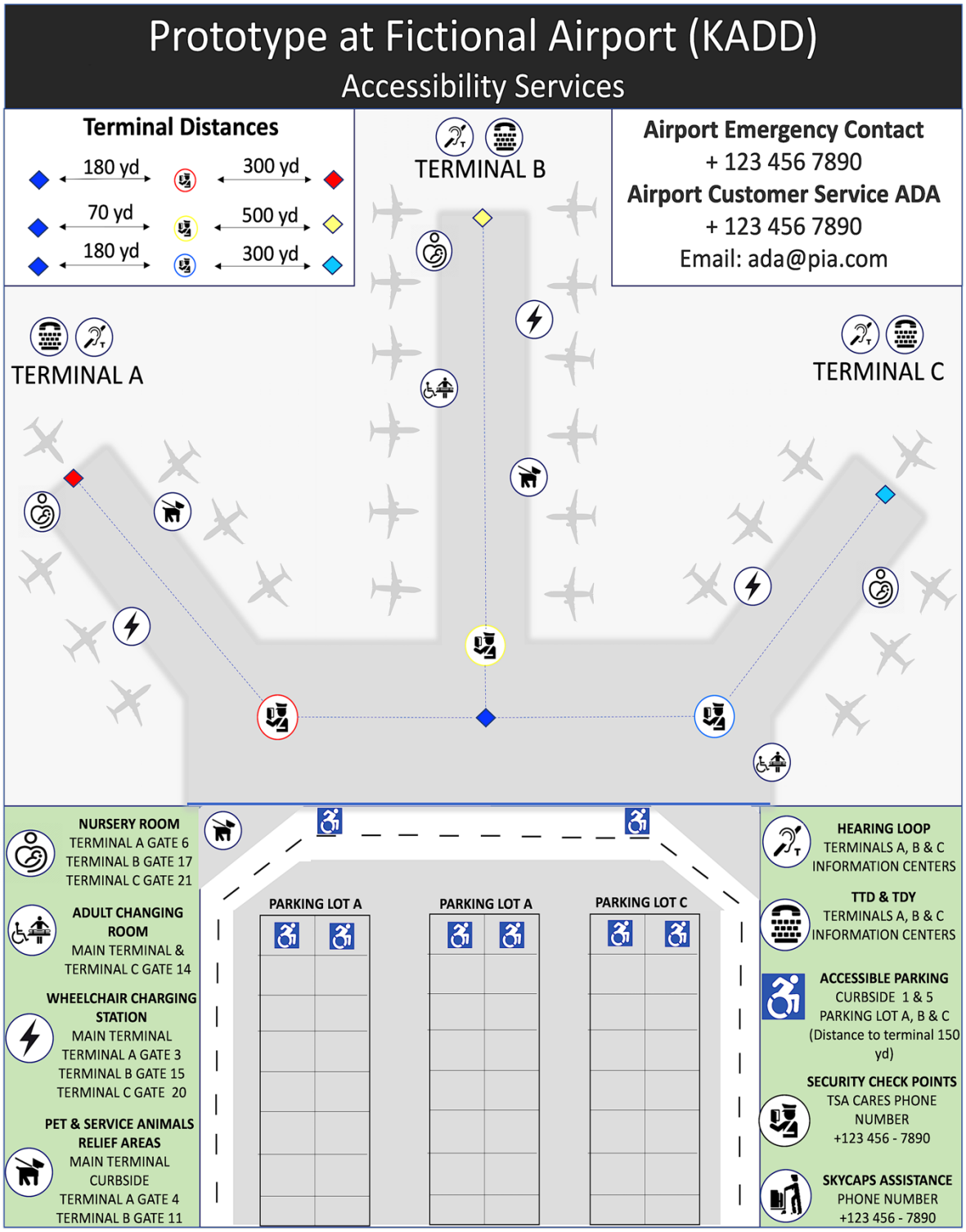
Accessibility Widget Services

Note: Virtual assistant page created using from Figma Software.

Additionally, the *A²TIS* contains in the Frequently Asked Questions (FAQs) section - a summary of the most frequent questions that passengers with some disability have while using airport services - reducing the labor hours required to assist passengers during their trips as well as the costs associated with these services. Furthermore, printable maps of location, distances, and contact information are also included in this information system to facilitate navigation and improve access to services for people who require assistance during their travels**.** Figure 7 illustrates a printable map developed by the design team for a fictional airport.

Figure 7

Accessibility Services Printable Map at Fictional Airport



Virtual Assistant

The virtual assistant is a promising and developing technology that capitalizes on mobile applications. Consumers would be familiar with these services from the likes of Amazon's Alexa, Google Assistant, Apple's Siri, and a host of other developers that have created similar devices. Virtual assistants are software programs that can be activated and addressed by voice commands and respond to the user's input. In addition, the virtual assistant is capable of "conversing" with the user based on specific information, questions, or prompts, like a chatbot. Although these virtual assistants cannot fully replace the emotional and human touch, they are beneficial in reducing labor and workload demands.

Several studies show that virtual assistant devices can support technology interaction with senior citizens to fulfill their needs and improve their quality of life. Examples are studies on virtual assistant applications in the healthcare industry by Bolaños et al. (2020), speech recognition to perform commands, preparing presentations and documents by Garg et al. (2020), and smart home "intelligent butlers" to make older adults living at home seamless (Fiol-Roig, 2009).

Although contactless technologies at airports, such as touchless check-in and baggage drop, touchless shopping, and touchless immigration and customs procedures, were created to curb physical contact, there was minimal progress in developing touchless methods of air travel for disabled individuals. During the industry interaction with San Francisco International Airport, they shared their utilization of an information system for air travelers to easily access the ever-changing COVID-19 travel policies during the pandemic, further solidifying that information systems could benefit the mass public.

Today, virtual assistants are no longer a luxury but a must-have to improve response times and customer satisfaction while reducing workforce demand for assistance services. Airports continue to become hotspots for traveling and a new generation of computer-literate individuals will become senior citizens traveling independently, demanding technological advancements to accommodate a new era of aging air travelers by implementing virtual assistants.

The St. Louis Lambert International Airport demonstrates one contemporary example of virtual assistant applications' success. After implementing a virtual assistant for commercial travelers, the utilization rate is remarkable, reaching a 35% increase in knowledge base growth and receiving over 100,000 messages in 2018 to support air traveler queries, emphasizing the benefit and positive aspects of this technology (Satisfi Labs, n.d.).

Additionally, implementing the *A^{2}TIS* virtual assistant on these 30 large hubs create a significant impact on the aging travelers and encourage other airports to follow the standards provided by *A^{2}TIS* to communicate services. The design team prototyped a functional webpage to demonstrate our primal vision of *A^{2}TIS.* A link is included on this report to explore the widgets and features of the prototype.

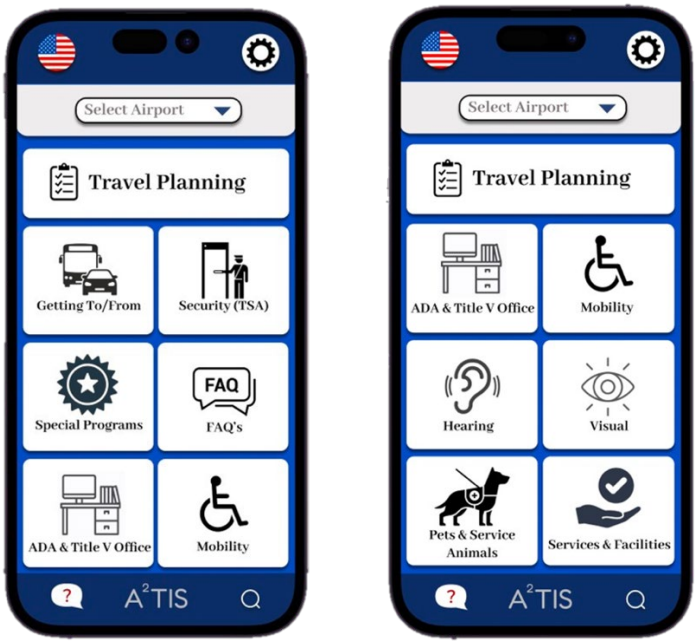
Features such as the virtual assistant at the bottom right corner, the language and font selection at the website's top bar and the contrast control are conceived to meet the WCAG standards to meet the needs of our target audience, the aging travelers and the people with disabilities. Figure 8 illustrates the A^{2}TIS features and the following link (Figma, 2023) provides access to the *A^{2}TIS* website and mobile application prototype created using the Figma online software:

https://www.figma.com/proto/39k6dcSbfTLkNbAHlpF8X8/A2TIS?node-id=2-3914&scaling=scale-down&page-id=0%3A1&starting-point-node-id=1%3A2

Figure 8

Virtual Assistant and Mobile App Interfaces

Note: Virtual assistant created using from Figma Software.



Note: Mobile app created using from Figma Software.

Safety Risk Assessment

This chapter evaluates the possible risks associated with the proposed design. Implementing an Accessible Air Travel Information System has its own potential risk for older adults and people with disabilities. According to the International Civil Aviation Organization (ICAO), a hazard is defined as a condition or object that may cause injury, damage, or reduce the ability to perform prescribed activities safely and effectively (ICAO, 2014). Although hazards and risks are misused as similar terminologies, this project will support Neubauer et al. (2015) view that risk is the combination of the likelihood of occurrence and affectation produced by the hazard in the organization (Neubauer et al. 2015).

Additionally, the Federal Aviation Administration (FAA) Advisory Circular 150/5200-37 defines the Safety Risk Assessment (SRA) as one element of Safety Risk Management (SRM), which includes the identification of hazards and implementation of barriers (e.g., technology, training, and regulation) that reduce their impact on the system. (FAA, 2007). Additionally, risk management involves monitoring and continuously verifying the effectiveness of protection measures against the materialization of the risk. Figure 9 illustrates the FAA recommended 5-step SRM process for airports.

Figure 9

Risk Management Process, FAA AC 150/5200-37

Note: The diagram illustrates the 5-step SRM process as adapted from FAA AC 150/5200-37.

The airport information system consists of interconnected hardware, software, and communication components that collect, store, and display flight, passenger, and operational data to improve safety and efficiency. Therefore, the Accessible Air Travel Information System is designed to support aging travelers with standard information regarding accessibility services integrated into the existing system. The team used the Risk Matrix Chart on the FAA Order 5200.11A, illustrated in Table 2, to quantify the impact and probability of occurrence of hazards associated with the accessible air travel information system (FAA, 2021).

Table 2

Risk Matrix Chart using FAA 5200.11A (FAA 2021)

Severity / Likelihood	Minimal (1)	Minor (2)	Major (3)	Hazardous (4)	Catastrophic (5)
Frequently (5)	5	10	15	20	25
Probable (4)	4	8	12	16	20
Remote (3)	3	6	9	12	15
Extremely Remote (2)	2	4	6	8	10
Extremely Improbable (1)	1	2	3	4	5*

Low	Medium	High
No Action Required	Monitor, determine if Risk can be mitigated to a Low Risk	Must be mitigated to a Medium Risk

Furthermore, to identify the potential hazards associated with the *A²TIS*, a risk analysis of the airport information system was conveyed while exploring the potential hazards that may exist in the proposed system through semi-structured interviews with industry experts, airport managers, and airport information system managers. Consequently, the design team determined the hazards associated with the *A²TIS*, their effects on airport operations, and the risk of materialization in terms of probability of occurrence and impact on the airport.

After the initial risk assessment, this design proposes implementing mitigation strategies for each identified hazard using tools provided by the technology, training, and regulations to reduce the initial risk valuations, mitigating the impact on airport operations. Table 3 shows a list of hazards identified, effects, and mitigation strategies to reduce the initial risk values using the Risk Assessment Worksheet in the FAA - AC 150/5200-37A (FAA, 2023).

Table 3

Potential Risks and Mitigation Strategies, FAA AC 150/5200-37A.

Accessible Air Travel Information System Risk Assessment Worksheet of the Proposed Information System						
Hazards	**Effects**	**Severity**	**Likelihood**	**Initial Risk**	**Mitigation**	**Residual Risk**
Cyber Attack	Delays and data breaches	5	4	High 20	Control *A²TIS* access Cybersecurity Measures. Training Program	Medium 10
Technology Failures	Delays and cancellations for passengers.	4	4	High 16	Alternate communication channels Incorporate Redundant systems.	Medium 8
Human Error	Inaccurate information. System Failures. Language or cultural barriers.	3	4	High 12	Training Program SOPs, including control points. Regular auditing.	Medium 6
Outdated Information - Website	Inconvenience to passengers. Legal and Financial issues	4	2	Medium 8	Regular auditing. Designated coordinator - Responsibilities Updates Protocols	Low 4
Failure to meet WCAG Standards.	Confusion, Delays, and Missed flights	2	2	Low 4	Regular WCAG Audits. Customer Survey Results - KPIs Training Program	Low 2

Industry Interaction

During the design project, our team held virtual and face-to-face meetings with personnel from the following international airports: Chicago, O'Hare International Airport (ORD), Indianapolis, IN (IND), Las Vegas, NV (LAS), Miami, FL International (MIA), San Francisco, CA (SFO); meeting participants included: Airport Managers, Information Technology Officers, and airport's Americans with Disabilities Act (ADA) coordinators. Additionally, meetings with experts from Purdue University and Kent University and government and non-government organizations such as the Federal Aviation Administration (FAA), Government Accountability Office (GAO), Airports Council International (ACI), and Open Doors Organization (ODO); provided fruitful recommendations that shaped the construction of this report. Table 4 provides a summary of the interactions held by the design team.

Table 4

Experts Interviewed During the Design Process

Academia

Name	*Title*	*Organization*
Dr. Richmond Nettey	Professor School of Aeronautics	Kent State University
Adam Baxmeyer	Instructor & KLAF Airport Manager	Purdue University

Airport Operators

Name	*Title*	*Airport*
Mario Rodriguez	Executive Director	Indianapolis (IND)
Reid Goldsmith	Director of Information Technology	Indianapolis (IND)
Maria Wiley	Audit & Compliance, Procurement	Indianapolis (IND)
Jessica Marin	Chief of Innovation and Transformation	Miami (MIA)
Denisse Ridge	Assistant Director of Operations	Miami (MIA)
Kantrice Ogletree	Director of Commission Affairs	San Francisco (SFO)
Christopher Birch	Guest Experience Director	San Francisco (SFO)
Danielle Mose	ADA Coordinator	Las Vegas (LAS)
Alan Gonzalez	Landside Manager	Dallas Fort Worth (DFW)

Government and Non-Government Organizations

Name	*Title*	*Organization*
Jamie Rhee	Commissioner Department of Aviation	Chicago Department of Aviation
Maria Wallace	Senior Analyst	Government Accountability Office
Jonathan Carver	Assistant Director - Infrastructure	Government Accountability Office
Marcus England	Office of Civil Rights	Federal Aviation Authority
Nathalie Herbelles	Director of Security and Facilitation	Airports Council International
Jean-Sebastien Pard	Manager Facilitation Passenger Services	Airports Council International
Katie O'Reilly	Program Manager	Open Doors Organization

In advance, the design team prepared a questionnaire to explore topics regarding aging travelers, information system design, communication barriers, and technological applications for the semi-structured interview. During the meeting with professors and instructors from Purdue University and Kent University, the design team discussed universal design, standardization, and literature for understanding the challenges faced by aging travelers and people with disabilities. As a result, the team received ideas to reduce communication problems in airports and especially understood the importance of talking to airports located in different geographical areas and of different sizes to understand the situation from multiple angles.

During the meeting with the airport operators, our team learned first-hand about the initiatives developed by the DFW, IND, LAS, MIA, ORD, and SFO airports to improve accessibility in air travel; a comprehensive explanation also included the responsibilities of the ADA coordinators. From the meetings, we understood the importance of using the proper terms to describe the services for people with disabilities. Furthermore, the design team received feedback about aging travelers' challenges and the digital accessibility regulatory frameworks and costs associated with the airports' websites.

The design team visited Indianapolis International Airport to understand better the daily operations, the airport's information system characteristics, and aging travelers' challenges. A short presentation from the design team included the following:

- The proposed design and goals.
- The project deliverables.
- Q & A section – Customer service and air travel accessibility.

During the meeting, it was clear that it was vital to design the *A^{2}TIS* by considering how to satisfy the needs of passengers who require assistance while traveling without losing sight of the importance of human interaction in providing customer service to passengers. Additionally, at the meeting, our team received feedback regarding the information system requirements, digital accessibility tools, and the underlying costs and benefits of the proposed design.

Figure 10

Design Team Visit to Indianapolis International Airport (IND)

Additionally, from the meetings with the airport operators, the design team understood that there is a high degree of cooperation and communication between airports to improve the accessibility of air transport. Proof of this was the joint information system used by airports to communicate and support passengers during the COVID-19 pandemic. In addition, during the meetings with the experts, it was clear that implementing a single information system to share information about accessibility services available at airports is a realistic solution that would reduce communication problems in air travel and increase passenger satisfaction across the U.S. airports.

Continuing the semi-structured interviews, our team held a Zoom conference with the FAA Office of Civil Rights. During the interview, our team received first-hand information about the regulations governing the transportation of passengers with disabilities and the responsibilities of airports and airlines during air travel. In addition, our team received feedback about the proposed information system and the importance of asking for the opinion of air travel advocacy groups to include their opinion about the communication problems within air travel on the proposed information system.

During the meetings with non-government organizations, such as ACI-World and Open Doors Organization, the team understood the scope of initiatives developed by ACI-World, such as the Accessibility Enhancement Accreditation program for airports and the regulatory framework differences for accessibility between countries. Finally, to obtain feedback from advocating groups for improving accessibility, the team interviewed staff from the Open Doors Organization. During the interview, the team understood the importance of including on the *A^{2}TIS* an education module where passengers can understand their rights and responsibilities while using airport services.

Projected Impacts of Design

The implementation of the proposed *A^{2}TIS* aims to improve air travel accessibility for aging travelers and people with disabilities. The integrated air travel information system design, website standardization, and use of virtual assistant features will significantly improve the accessibility services for people that require assistance during air travel. Furthermore, improving information services removes accessibility barriers in air travel and enhances customer satisfaction through its effortless, efficient, and robust design. The *A^{2}TIS* offers a novel approach for the **ACRP Airport Management and Planning Challenge** - Innovations to Accommodate the Aging Passenger Demographic at Airports, improving access and standardizing the airports' website information services for passengers with different types of disabilities.

ACRP Goals

Connecting to the internet and obtaining information on the internet is a crucial part of modern society. This design offers an innovative solution for improving air travel accessibility by removing communication barriers in air travel. Furthermore, the proposed design explores, updates, and expands the issues found in Research Report 177, related to airport services for aging travelers (Harding et al., 2017), focusing on the digital dimension of accessibility and presenting new solutions provided by emerging technologies such as artificial intelligence applications to improve accessibility at airports.

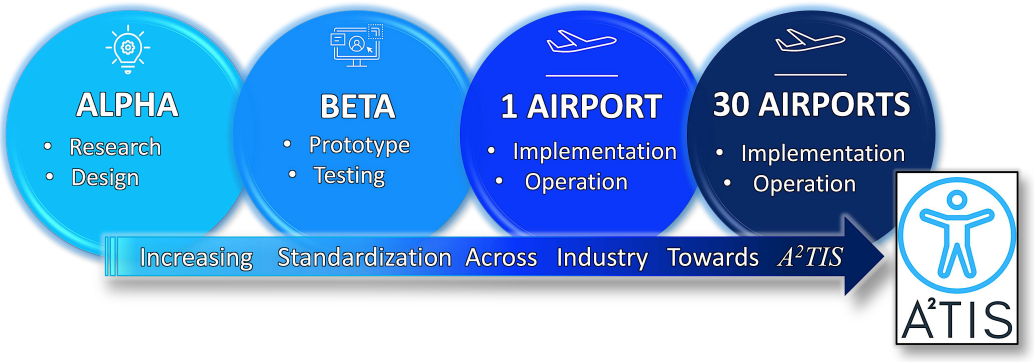
Additionally, enhancing accessibility in air travel requires raising awareness of digital accessibility issues among the academic community. This design fosters the engagement of Scholars and Students in the U.S. by evidencing the importance of equitable access to information in air travel and emphasizing the importance of standardization to avoid communication and operational inefficiencies.

Benefits – Costs Analysis

The viability of the proposed design must be assessed through a benefits-cost analysis. A summary of the benefit-cost analysis comprising two stages, phase Alpha (Concept development) and Beta (Prototype and Testing). Once the prototype has been tested, the *A²TIS* can be integrated into the airports' websites. Figure 9 shows the cycle used for assessing the costs for the *A²TIS* design, implementation, operation, and maintenance at one airport. Additionally, the integrated information system is designed to be scalable; an overview of the costs and benefits of implementing the *A²TIS* in 30 airports is presented in this section.

Figure 11

A²TIS Benefits and Costs Allocation from Design to Implementation



Benefits Assessment

Following the recommendations available in the literature for improving digital accessibility, *A²TIS* provides a standardized user-friendly, accessible information system for passengers that require assistance while traveling. The information system provides valuable resources across all airports in the U.S. network. After using the website for the first time, travelers may become more familiarized with the information and format. As a result, they will require less assistance when traveling again at airports, which translates into fewer human hours required from airports to provide the same service.

Additionally, implementing the *A²TIS* improves the information and assistance for people with disabilities, resulting in a reduction in the number of complaints and accidents related to accessibility services at airports. Across several sources, like the National Transportation Safety Board (NTSB) and the Department of Transportation (DOT), the amount of compensation for injuries or losses that occur at the airports varies. However, FAA statistics for 2020 show that all aviation accidents, including those at airports, caused 0.97 serious injuries per 100,000 flight hours. (FAA, 2021b).

Besides equipping the airport with complete and standardized accessibility information, *A²TIS* may bring confidence to travelers with special needs. At the same time, attracting more travelers and boosting the traveling demand, the revenue from an increasing number of enplanements. *A²TIS* may include advertising space for traveling-related products, representing an additional income source for airports. Overall, *A²TIS* projected benefits amounts to **$498,432** per annum, resulting in **$4,984,320** over ten years.

Table 5

A²TIS Benefits to Airports

Item	Rate	Multiplier	Quantity	Subtotal	Notes
Labor Hours	$20	40 hours/day	365 days	$292,000	Calculated for 1 large hub
Serious Injury Reduction	$2,292,950	Divided by 30 large hubs	/	$76,432	Reduces the probability of serious injury rate by 1%
Traveling Demand Increase	$10,000	1 airport	1 year	$10,000	Revenue in terms of landing & gate fees
Advertisement fees	$10,000	1 airport	1 year	$120,000	12 months
Benefits for 1 Airport Per Year Subtotal				**$ 498,432**	*10 years $4,984,320

Note: Inspired by the ACRP Cost-Benefit Analysis Resource Video (Byers, 2021***).***

Intangible Benefits

Intangible benefits from *A^{2}TIS* should also be considered. For example, U.S. law defines the requirements for assisting persons with disabilities through the Americans with Disabilities Act (ADA) and the Air Carrier Access Act (ACA). Failure to comply with legal requirements may result in penalties and negative publicity. Furthermore, improving the travel experience increases customer satisfaction and loyalty, leading to higher travel demand.

The virtual assistance and Frequent Asked Questions (FAQs) integrated into *A^{2}TIS* will reduce labor hours for in-person service staff, as passenger demand for assistance services will decrease due to easy access to information. Then, airports may redeploy staff to other responsibilities, improving the efficiency of their operations. In addition, providing accessible travel options for people with special needs promotes social justice; It is important to ensure that everyone has an opportunity to travel and experience the world regardless of age or mobility.

Cost Assessment

In phase Alpha, the design team aims to understand the targeted user's needs through research, subject matter expert inputs and interviews, and brainstorming concepts to address the problem statement. The main goal is understanding consumers' challenges and creating an efficient, effective, and sustainable user-friendly designed product. Part of phase Alpha is applying universal design to website and mobile app mock-ups as the users interact with the A^{2}TIS. Feedback from industry experts allowed for continuous improvement of the user interface and innovation on both web and mobile platforms, intending to design a working prototype at the end of the Alpha phase.

In the Beta phase, the design becomes a prototype ready for user testing. The development and testing of the prototype are necessary to ensure that it is compatible with multiple devices and operating systems and follows health and safety regulations. Additionally,

Table 6 illustrates the costs for phase Alpha at $39,690, and the Beta phase has a projected cost of $105,800.

Table 6

A²TIS Prototype Costs for Alpha and Beta Phases

Design and Research – Alpha phase (3 months)

Item	***Rates***	***Operators***	***Work Hours***	***Subtotal***	***Remarks***
Graduate Student[1]	$23	4 students	300 hours	$27,600	12 weeks, 25 hrs./week
Design Concept[2]	$0	1 prototyping	3 months	$0	Figma
Faculty Advisor[3]	$60	1 advisor	30 hours	$1800	Project advisor
			Subtotal	$29,400	
		Materials & Supplies' costs		$10,290	35% of the project
		Subtotal (Alpha phase)		**$39,690**	

Prototype and Testing – Beta phase (4 months)

Item	***Rates***	***Operators***	***Work Hours***	***Subtotal***	***Remarks***
Graduate Student[1]	$23	4 students	400 hours	$36,800	16 weeks, 25 hrs./week
UI/UX Developer	$44	1 designer	200 hours	$8,800	Website & Mobile App
Airport Expert/Manager	$31	1 expert	40 hours	$1,240	Pilot testing and support
A.D.A. Expert[4]	$34	1 advisor	45 hours	$1,530	Safety & Compliance
Travel & Accommodation	$1000	/	/	$1000	Field survey + testing
Faculty Advisor[3]	$60	1 advisor	400 hours	$24,000	Project advisor
I. Property Protection[5]	$5000	/	/	$5000	Intent to patent and license
Subtotal				$78,370	
Material & Supplies costs				$27,430	35% of the project
Subtotal (Beta phase)				**$105,800**	

Note:

1. Graduate student stipend is $23, as of 2022-2023
2. Figma Professional for design and prototyping.
3. Faculty advisor
4. ADA compliance and compliance
5. Patents and licenses

Following the Beta Phase, the next step is to develop a mobile app compatible with Android and iOS users and achieve product realization at the end of the Beta Phase for desktop and mobile platforms. Table 7 summarizes the costs for the web and mobile platforms (fixed costs), A*irport-Specific items* (variable costs), and mobile and web platforms, resulting in a benefit ratio of 2.86 for one airport).

Table 7

A²TIS costs (one pilot airport)

A²TIS Web Platform (fixed cost per year)

Item	***Rate***	***Subtotal***	***Remarks***
Domain name	$15/ year	$15	Unique web address
Website functionalities	$200/year	$200	API, Augmented Reality, etc.
Website functionalities	$30,000/year	$30,000	Indoor Wayfinding
Maintenance	$60,000/year	$60,000	Bi-weekly maintenance
Hosting, SSL, and Support	$5600/year	$5600	
	Subtotal	**$95,815**	

A²TIS Mobile Platform (fixed cost per year)

Server	$600/year	$600	
Push Notifications	$120/year	$120	
Payment Gateways	$1,800/year	$1,800	Apple Pay, PayPal, etc.
App Developer	$25+$99/year	$124	Google & Apple Store
Hosting[1]	$2,400/year	$2,400	
Tech support	$2,400/year	$2,400	
Maintenance	$60,000/year	$60,000	Bi-weekly maintenance
	Subtotal	**$67,444**	

Airport-Specific items (variable cost per year)

Airport visits & training	$1,200/year	$1,200	Monthly visits
Advertisement	$10,000/year	$10,000	
	Subtotal	**$11,200**	
	Total Cost for 1 Airport Per Year	**$174,459**	*10 years = $1,744,590
	Benefit for 1 Airport Per Year	**$ 498,432**	*10 years = $4,984,320
	Benefit-Cost ratio for 1 Airport	**2.86**	

Note: Inspired by the ACRP Cost-Benefit Analysis Resource Video (Byers, 2021***).***

Benefit-cost ratio

Comparing the benefit and cost analysis in Tables 6 and 7, the projected benefit-cost ratio is 2.86 for the pilot airport. As the project targets implementing *A²TIS* in 30 large hub airports in the United States, Table 7 illustrates the benefit-cost analysis for one pilot airport and the remaining 29 airports. This proposal considers that the web and mobile platform O&M costs are fixed, as these costs are essential to running *A²TIS,* regardless of how many airports will utilize it. The design team understands that the fixed costs to operate and maintain the web and mobile platforms will increase as more airports implement the information system.

Additionally, the fixed costs will increase by 20% for each additional airport operating *A²TIS* in addition to the pilot airport. On the contrary, the variable cost of airport-specific items will increase linearly for every additional airport. This amounts to $1,446,162 annually to implement *A²TIS* in 30 large hub airports and $14,461,620 in 10 years, broken down in Table 8, resulting in a benefit-cost ratio of **10.3**.

Table 8

A²TIS Web + Mobile Platform costs (30 airports)

Item	***Cost***	***Remarks***
Subtotal for Web Platform	$95,815	From Table 7
Subtotal for Mobile Platform	$67,444	From Table 7
Subtotal (one pilot airport)	**$163,259**	
Fixed cost Subtotal (30 airports)	**$1,110,162**	$163,259 + 29*(20% of $163,259)
Airport-Specific items (variable cost)		
Variable cost Subtotal (30 airports)	$336,000	$11,200 * 30 airports
Costs for 30 airports Per Year	$1,446,162	* 10 years = $14,461,620
Benefit for 30 airports Per Year	**$14,952,960**	*10 years = $149,529,600
Benefit-cost ratio for 30 Airports	**10.3**	

Sustainability Assessment

The growing awareness of the consequences of our actions on the environment has led to an ever-increasing interest in sustainability. Although it has long been a topic framing discussion around "social, ecological and economic challenges" (Mulvihill & Milan, 2007. p. 2). The concept of sustainability is broad and extends to all aspects of human life, including communities, organizations, companies, and individuals. The United Nations (U.N.) report on sustainability in 1987 outlined two principles for defining sustainability: incorporating the needs of the world's poor and limiting the technological progress of societies (Brundtland, 1987).

Consequently, the aviation industry actively integrates sustainable practices to enhance the economic and social benefits and reduce the impact of its operations. Current innovations include but are not limited to Sustainable Aviation Fuel (SAF) to reduce the carbon footprint emitted by jet fuel, airframe improvements to improve aerodynamic performance, reduce weight and strengthen aircraft systems (ICAO, 2021). Additionally, the FAA *AC 150/5360-13A Airport Terminal Planning* adopted the *Economic vitality, Operational efficiency, Natural resources, and social responsibility (EONS) Model* to measure sustainability at airports across the country (FAA, 2018).

Furthermore, the Sustainability Aviation Guidance Association (SAGA) promotes the use of the "EONS" model to assess the impact of airport operations and measure the operational efficiency of passenger and cargo transportation in the U.S. (SAGA, n.d.). Therefore, a sustainability analysis of ***A^{2}TIS*** was conducted to assess its positive and negative impacts based on the EONS model. After the analysis, the ***A^{2}TIS*** showed verifiable benefits in all variables considered in the "EONS" model. Table 9 provides a summary of the effects on airports' sustainability for the implementation of the information system.

Table 9

EONS Sustainability Impacts Analysis

EONS	Sustainability Impacts	Effect on Airports' Sustainability
Economic Vitality	Savings from reduced complaints for accessibility services and accessibility services usability.	(+)
	Innovation increases demand, revenue, and services.	(+)
	Cost savings from fewer lawsuits due to injured and/or lost individuals.	(+)
	Piloting airport may aid product implementation at other airports for a price.	(+)
Operational Efficiency	Less tech-savvy individuals may find it more challenging to interact with the system.	(-)
	Accessibility services provided utilized at a higher rate.	(+)
	More efficient passenger movement within the airport terminal.	(+)
	Reduces communication barriers with primary needs and FAQs in fingertip reach.	(+)
	Reduces communication barriers, increasing workforce efficiency and reduces costs.	(+)
Natural Resources	Periodical visits to audit and inspect the platforms will require more traveling and CO2 emissions.	(-)
	Digital innovations reduce carbon footprint in the product development.	(+)
	Minimal material use and waste for product development and usage.	(+)
	Reduced workforce required to assist individuals around the airport terminal.	(+)
Social Responsibility	Encourages shift toward more independent air travel.	(+)
	Reduces injury and deaths due to self-navigating ability and pre-planning features.	(+)
	Reduces inequalities and travel stigma around aging travelers and people with disabilities.	(+)
	Increased usability and familiarization with accessibility services and their locations.	(+)

United Nations Sustainable Development Goals (SDGs)

The 2030 Sustainable Development Agenda, developed by the United Nations, includes 17 key Sustainable Development Goals (SDGs) to promote a peaceful and prosperous world for future generations (UN Development Program, 2022). After considering the SDGs and targets established by the U.N., the *A²TIS* contributes directly to reaching the following goals: SDG9 -

Industry, Innovation, and Infrastructure, SDG10 - Reduced Inequalities, and SDG11 - Sustainable Cities. Table 10 elaborates further on how our proposal supports these goals and meets their objectives throughout the *A²TIS* Implementation, beginning with increasing standardization and homogenization of the websites' structures towards the information system.

Table 10

Sustainability Development Goals - A²TIS Implementation

Sustainable Development Goals (SDGs)	***Target***	***How***
	*"Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in the least developed countries by 2020"* (*United Nations, n.d.)*	***A²TIS*** reduces information and communication barriers using the virtual assistant and our web and mobile application features.
	*By 2030, empower and promote the social, economic, and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion, or economic status.* (*United Nations, n.d.)*	Passengers using accessibility services will become more independent travelers and reduce the stigma and the exclusionary to special services and needs for assistance while traveling.
	*By 2030, provide universal access to safe, inclusive, and accessible, green and public spaces, in particular for women and children, older persons, and persons with disabilities.* (*United Nations, n.d.)*	Standardizing information and enabling access to information in a "one-stop-shop" will make the airport much more comfortable, efficient, and sustainable.

Note: UN SDG logos and targets from the United Nations (n.d.)

Conclusion

Air travel accessibility remains a challenge for aging travelers and people with disabilities despite continuous improvements in airport physical environments. Therefore, implementing a comprehensive information system to communicate to customers the information related to accessibility services at airports represents an opportunity for increasing standardization and removing communication barriers across the U.S. airport network.

The Accessible Air Travel Information System (*A^{2}TIS)* offers an innovative solution *"to Accommodate the Aging Passenger Demographic at Airports,"* providing a **one-*stop-shop*** for air travel accessibility, increasing accessibility services usability, improving customer satisfaction, increasing air travel demand, and reducing the number of workforce hours required to assist passengers at airports. Furthermore, the *A^{2}TIS* envisions including information from the 30 large U.S. hubs, with an expected Benefit-Cost Ratio of **10.3,** impacting more than two-thirds of the commercial enplanements in the U.S. and provides a standard for communicating accessibility services for all airports.

Overall, the *A^{2}TIS* offers an innovative and sustainable solution to address the accessibility challenges faced by the air travel industry, leading to significant improvements in the air travel experience for older adults and people with disabilities, enhancing their quality of life, and promoting social inclusion.

Appendix A: Contact Information

Faculty Advisor:

Mary E. Johnson, Ph.D. Professor
Associate Head for Graduate Education and Research & Professor School of Aviation & Transportation Technology.
Purdue University
mejohnson@purdue.edu

Student Information:

Gustavo Sanchez
sancheg@purdue.edu

Hans Natakusuma
hnatakus@purdue.edu

Hanzi Xie
xie414@purdue.edu

Tolulope Oluwumi
toluwumi@purdue.edu

Appendix B: Description of the University

Purdue University

Purdue University is a public university in West Lafayette, Indiana. Founded in 1869, the University is now the largest in the country and is well known for its strong engineering, technology, and scientific programs and is listed high in the national and international lists. The University offers more than 200 undergraduate courses and 70 master's degrees in 10 universities and schools, with state-of-the-art research facilities, laboratories, and classrooms. The University's rich tradition and slogan reflect the University's mission to provide excellent education, research, and community service through outreach and involvement. The University has several major research centers and institutes, such as the University of Purdue Research Park, the Institute for Integrative Neuroscience, and the University of Purdue Cancer Research Center. In addition, Purdue has a vibrant campus life, more than 1,000 student organizations, and a general slogan called "boiler up!" to support the University's athletic teams on campus (Purdue Polytechnic, n.d.)

School of Aviation and Transportation Technology (SATT)

Purdue University's School of Aviation and Transportation Technology (SATT) is a leading aviation and transportation education institution founded in 1930. It is one of the largest aviation schools in the United States, offering a wide range of universities and colleges, such as aviation management, aerospace engineering technology, professional flight, and unmanned air systems. The program aims to prepare students for careers in aviation and transportation and to provide practical training and experience using the latest equipment and facilities. In general, the University of Purdue is a highly respected institution known for its excellence in the academic world, excellent research, and its commitment to innovation (Purdue Polytechnic, n.d.).

Appendix C. Description of non-university partners

Industry Experts Biography

Dr. Richmond Netty is a tenured and former Associate Dean of the College of Aeronautics and Engineering at Kent State University. He has also served as president and treasurer of the University Aviation Association and as a trustee of the Aviation Accreditation Board International. In addition, Dr. Netty has worked with numerous governmental and non-governmental organizations and trade associations to promote aviation education. He has received several awards for his contributions to the field of aeronautics and aviation, such as UAA's recognition of "Outstanding Contribution to Aviation Education, and he serves on various committees and editorial boards. In addition to his academic work, Dr. Netty is involved in recreational aviation and is a member of the Kiwanis Club and his local church.

Mario Rodriguez is the Indianapolis Airport Authority's Executive Director and a nationally recognized senior leader. He has received numerous awards and recognition for his leadership in the aviation industry, including the Biden-Harris Presidential Transition Team and being appointed to the United States Department of Transportation's Consumer Protection Committee by President Obama and President Trump. Under his leadership, the Authority has experienced record growth and has been recognized by prestigious organizations as the best airport in North America and the United States. He is also an active community leader and board member of many philanthropic and business organizations, including the Indiana Latino Institute. He graduated from the University of Miami and held leadership positions for more than 30 years in locations ranging from Hong Kong to Indianapolis.

Reid Goldsmith is the Senior Director of Information Technology for the Indianapolis Airport Authority. He first joined the Authority as an intern in 2005 and later joined the information technology department as a business analyst. After serving as a technology consultant in the private sector, he returned to the Authority in 2012 as a technology consultant and information technology applications engineer. Mr. Goldsmith currently focuses on strategic projects for the successful operation of the airport. He studied aviation technology at Vincennes University and holds FAA-issued Private Pilot, Airframe, and Powerplant mechanic certificates.

Maria D. Wiley is the senior director of audit & compliance and procurement at the Indianapolis Airport Authority, responsible for internal audit, compliance, safety, risk management, and procurement. She also serves as the airport's ADA Coordinator and created Sensory Rooms for passengers with challenges on the Neurodiversity Spectrum. In addition, Ms. Wiley serves on several civic and not-for-profit boards, is a Certified Fraud Examiner, and holds a Bachelor of Science degree in accounting from the University of Illinois and an MBA from Indiana Wesleyan University.

Adam Baxmeyer is currently the Airport Manager at Purdue University Airport. He has held this position since October 2016. Previously, he served as Deputy Director of Operations and Facilities for the Bloomington Normal Airport Authority for ten years and as Airport O Operations Supervisor at Cherry Capital Airport for four years. In these roles, he was responsible for directing various departments, such as operations, maintenance, custodial, and shuttle departments, and directing staff in these departments. Mr. Adam Baxmeyer holds a master's degree in public administration from the University of California and completed his degree from August 2020 to December 2022. He also holds a bachelor's degree in aviation administration from Purdue University, focusing on airport and airline management.

Jamie Rhee is the commissioner of the Chicago Department of Aviation (CDA), which manages O'Hare and Midway International Airports and serves more than 100 million passengers annually. Ms. Rhee has worked for nearly 24 years in various roles in the City of Chicago, including Chief Procurement Officer, where she supervised the purchase of $2 billion in goods and services for several city departments. She also served as General Counsel for the O'Hare Modernization Program and has received numerous awards for her contributions to public service. Rhee has a Bachelor of Arts degree from Michigan State University and a Juris Doctorate from DePaul University School of Law.

Jessica Marin is the Innovation Chief at Miami International Airport. She previously held roles such as Operations Special Projects Administrator and Sr. Public Relations & Digital Marketing Specialist at the airport. She has a Master of Professional Studies in Integrated Marketing Communications from Georgetown University and a Bachelor of Arts in International Relations and Political Science from Florida International University. Ms. Marin has also completed the Airport Executive Leadership Program and the Global ACI-ICAO Airport Management Professional Accreditation Program. She was awarded the 2021 Future Leader IAP (International Airport Professional) CoP Award in 2021.

Denise Ridge is the Assistant Director of Operations at Miami International Airport, overseeing the Terminal, Landside, and Airside divisions and a workforce of over 450 Miami – Dade Aviation Department employees. She manages a four-runway airfield and seven million square feet of terminal space. She also works closely with U.S. Customs and Border Protection (CBP) and the Transportation Security Administration (TSA) to manage the airport's security checkpoints and federal inspection facilities. Before this, she worked at the Massachusetts Port

Authority, American Airlines, and LAX, holding various management positions in customer service and operations.

Christopher Birch has over 25 years of experience in customer experience management in the aviation industry. He is currently the Director of Guest Experience at San Francisco International Airport, where he has worked since 2008. Before that, he worked as a Customer Service Manager at Cathay Pacific Airways and an Airline Customer Service Manager at Alaska Airlines. Mr. Birch studied Aviation and Transportation Management and Aviation/Airway Management and Operations at Bridgewater State University.

Alan Gonzalez is currently the Landside Manager at Dallas Fort Worth International Airport (DFW). Before this, he worked as the Guest Transportation Assistant Manager and Ground Transportation Supervisor at DFW. He also worked at Purdue University as a Research Assistant and Student Worker. Gonzalez holds a Master of Science degree in Aviation and Aerospace Management from Purdue University and a Bachelor of Business Administration in Finance and Management from The University of Texas at El Paso.

Marcus England is the Team Lead of the National Airport Civil Rights Policy and Compliance Team at the FAA Office of Civil Rights. He is responsible for the federal policy and compliance on civil rights at airports that receive federal funding for the Americans with Disabilities Act, Title VI of the Civil Rights Act, and the Disabled Business Enterprise Program. He has over 20 years of experience in financial, budgetary, resource management, and procurement in the private and federal sectors. In addition, Mr. England has completed various leadership training programs, is a writer of inspirational books, and likes to mentor others. He graduated from Virginia Commonwealth University and is an active Phi Beta Sigma Fraternity, Inc member.

Nathalie Herbelles is the Senior Director of Security and Facilitation at the Airports Council International (ACI) in Montreal, Canada. She represents the world's airports and helps deliver ACI's priorities as their point of contact for global airport security and facilitation issues. Ms. Herbelles has a legal background and holds a master's degree in Air Transport Law and Management from Aix-Marseille University, France. She was previously a member of the International Air Transport Association (IATA), the Association of European Airlines, Air France, the European Commission, and the Spanish Airport Authority AENA.

Jean-Sébastien Pard is the Senior Manager of Facilitation, Passenger Services, and Operations at Airports Council International (ACI) World. His role includes providing guidance and support to the airport community, representing airport interests with stakeholders, and leading the development of best practices and initiatives to improve passenger experience and facilitate travel. He has extensive experience in airport terminal operations, passenger facilitation, supply chain, project management, and continuous improvement. Mr. Pard has also been involved in several passenger facilitation and innovation projects. In addition, he is an advisor to the Facilitation Panel and the Traveler Identification Program (TRIP) at the International Civil Aviation Organization (ICAO).

Katy O'Reilly is a Program Manager at Open Doors Organization and a certified therapeutic recreation specialist with over seven years of experience. She is responsible for coordinating programs, conducting disability awareness and CRO training, planning events, and participating in research projects. She has a Bachelor of Science in Therapeutic Recreation/Recreational Therapy from Western Illinois University and is a member of the Katy previously worked at Fox Valley Special Recreation Association and Helping Hand Rehabilitation Center.

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?

The competition provided the team with a significant educational experience. The various stages of the project proposal design served as a valuable learning opportunity for each team member. With team members from diverse cultural backgrounds, we identified an airport need that had been overlooked for years. Our analytical and critical thinking skills improved drastically, especially during the safety and cost-benefit analysis phase. As we progressed, we interacted with various industry stakeholders and partners through written and verbal communication, which gave us the confidence and exposure needed to develop a proposal that would improve the travel experience of aging passengers and those with disabilities.

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

The team encountered significant difficulty in building a prototype of the website due to our lack of technical expertise in UX design. However, we overcame this obstacle by acquiring knowledge of new technological tools such as Figma to design the prototype. In addition, we sought the assistance of a UX design expert to help the team in the design process. The project design also faced the challenge of meeting strict deadlines, but the team managed to overcome it by supporting and motivating each other despite busy schedules.

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

To begin with, the team investigated the issues that aging travelers and passengers with disabilities face at airports due to the absence of standardized accessibility information. We identified several challenges that could arise due to the absence of such standards. Consequently, we examined various resources on accessibility support services for aging travelers and passengers with disabilities, including research on possible technological solutions. This helped the team to build a logical analysis of what information should be standardized to improve accessibility. Finally, with the aid of industry experts and knowledge acquired, we designed a website prototype for a standardized accessible air travel information system.

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

The team received assistance from industry experts through semi-structured interviews, which enabled us to acquire new information about accessibility issues at the airport. The industry experts included individuals from academic institutions, airports, and regulatory bodies, and they provided useful input and suggestions for the design proposal and its implementation. The team gained valuable information on technological features, cost benefits, and risk assessment associated with the project proposal, which was useful for the design. The interactions with industry experts also provided clarity on the centralization and decentralization of the information system for future implementation, as well as insights into accessibility issues faced by airlines and airports globally. Overall, the team gained genuine insights from these interactions.

5. What did you learn? Did this project help you with the skills and knowledge you need to be successful in entry into the workforce or to pursue further study?

As a group, we gained valuable experience in the arduous task of presenting an airport proposal project. Our appreciation of the experts in the field who identify issues and offer solutions beyond academia grew. As we conducted our research, we gained transferable skills such as critical thinking, leadership, communication, and problem-solving, which are highly applicable in the industry.

Faculty

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

Because the teams choose their challenge areas, they are more invested in the outcome and dedicate a great deal of time to the projects. Many of these students make contacts that will be a resource throughout their careers. The students gain more value when they can apply newly learned design skills and sustainability skills to a project that is based on real airport needs. While they learn theoretical information, the learning that occurs through team interaction and expert interactions cannot be easily replaced.

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

This competition package is one of the choices for a project in a graduate level course in Aviation and Aerospace Sustainability. The course level and context are appropriate and a popular choice of project types.

3. What challenges did the students face and overcome?

The team formed quickly and began searching for experts to contact. The team dove into the world of websites, user experience design, and accessibility. No previous coursework had prepared them for this. They began working with each other and contacting airport experts. This design is in a spring semester course. I am so proud of the way that this team met deadlines.

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

I definitely will continue to use this competition as an educational vehicle. The knowledge the team gains in 12 weeks is irreplaceable through readings and shorter projects.

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

I would add sustainability as an aspect of the project that should be addressed because this issue is challenging and is becoming requested by more communities and other stakeholders.

Appendix F: List of References

Agree, E. M. (2014). The potential for technology to enhance independence for those aging with a disability. *Disability and health journal*, *7*(1), S33-S39. https://doi.org/10.1016/j.dhjo.2013.09.004

Airport Cooperative Research Program. (2022*).* Design Competition Guidelines. University Design Competition for Addressing Airport Needs. (2022). Retrieved March 29, 2023, from https://vsgc.odu.edu/acrpdesigncompetition/wp-content/uploads/sites/3/2022/08/2022-2023-ACRPDesignGuidelines_v5.pdf

Asgarali-Hoffman, A., Bailey, C., Berrier, R., Combs, A., Day-Woodruff, S., Fleischer, R., Gentles, C., Lake-Smith, A., Long, A., Moore, M., Peris, K., Stone, N., Vazquez-Mejia, S., & Yoon, T. (2016). Planning the intergenerational airport: Making the airport better for everyone. ACRP University Design Competition. https://vsgc.odu.edu/acrpdesigncompetition/wp-content/uploads/sites/3/2018/11/Management_2nd-place_Tie_2_Rosenbloom.pdf

Balderas-Cejudo, A., & Patterson, I. (2023). Tourism as a Means of Happiness and Subjective Well-Being for Senior Travelers. *Anduli : Revista Andaluza de Ciencias Sociales*, 19–33. https://doi.org/10.12795/anduli.2023.i23.02

Bayne, A., Siegfried, A., Beck, L. F., & Freund, K. (2021). Barriers and facilitators of older adults' use of rideshare services. *Journal of Transport & Health*, *21*, *101055–*. https://doi.org/10.1016/j.jth.2021.101055

Bhowmick, A., & Hazarika, S. M. (2017). An insight into assistive technology for the visually impaired and blind people: State-of-the-art and future trends. *Journal on Multimodal User Interfaces, 11(2), 149–172*. https://doi.org/10.1007/s12193-016-0235-6

Birbaumer, N., & Cohen, L. G. (2007). Brain-Computer interfaces: Communication and restoration of movement in paralysis. *The Journal of Physiology*, *579*(3), 621–636. https://doi.org/10.1113/jphysiol.2006.125633

Bolaños, M., Collazos, C., & Gutiérrez, F. (2020). Adapting a virtual assistant device to support the interaction with elderly people. *Proceedings of the 6th International Conference on Information and Communication Technologies for Ageing Well and e-Health*. https://doi.org/10.5220/0009840102910298

Brundtland, H. (1987). Our Common Future : Call for Action. *Environmental Conservation*, *14*(4), 291–294. https://doi.org/10.1017/S0376892900016805

Byers, D. (2021). ACRP design Competition- Dave Byers - Guidance for preparing benefit/cost analyses [Video]. YouTube. https://www.youtube.com/watch?v=J1yRM1uPpcc&ab_channel=VirginiaSpaceGrantConsortium

Debevc, M., Kožuh, I., Hauptman, S., Klembas, A., Lapuh, J. B., & Holzinger, A. (2015). Using WCAG 2.0 and Heuristic Evaluation to Evaluate Accessibility in Educational Web Based Pages. *Communications in Computer and Information Science*, *533*, 197–207. https://doi.org/10.1007/978-3-319-22629-3_16

Design Council (2015), Design methods for developing services. London: Design Council. https://www.designcouncil.org.uk/fileadmin/uploads/dc/Documents/DesignCouncil_Design%2520methods%2520for%2520developing%2520services.pdf

Federal Aviation Administration. (2007). *Introduction to safety management systems (sms) for airport operators (AC 150/5200-37)*. https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_150_5200-37.pdf

Federal Aviation Administration. (2018). *Airport Terminal Planning (AC 150/5360-13A).* https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC-150-5360-13A-Airport-Terminal-Planning.pdf

Federal Aviation Administration. (2021). *FAA airports (ARP) Safety Management System (SMS) (Order 5200.11A).* https://www.faa.gov/documentLibrary/media/Order/order-5200-11a-sms.pdf

Federal Aviation Administration. (2021b). *Aviation Safety Workforce Plan 2021-2030.* https://www.faa.gov/about/plans_reports/media/wfp_2021.pdf

Federal Aviation Administration. (2022). *Enplanements at All Commercial Service Airports in the year 2021.* *https://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/cy21_commercial_service_enplanements*

Federal Aviation Administration. (2023). *Safety Management Systems for Airports (AC 150/5200-37A).* https://www.faa.gov/documentLibrary/media/Advisory_Circular/150_5200_37A_Part_139_SMS.pdf

Fiol-Roig, G., Arellano, D., Perales, F. J., Bassa, P., & Zanlongo, M. (2009). The intelligent Butler: A virtual agent for disabled and elderly people assistance. *Advances in Soft Computing*, 375–384. https://doi.org/10.1007/978-3-540-85863-8_44

Figma. (2023). Figma Incorporated. Version 3.2. Proprietary Sofware. https://www.figma.com/

Garg, I., Solanki, H., & Verma, S. (2020). Automation and presentation of word document using speech recognition. *2020 International Conference for Emerging Technology (INCET).* https://doi.org/10.1109/incet49848.2020.9154078

Government Accountability Office (2022), *PASSENGER WITH DISABILITIES: Barriers to Accessible Air Travel Remain.* Testimony Before the Subcommittee on Aviation, Committee on Transportation and Infrastructure, House of Representatives. Retrieved March 29, 2023, from https://www.gao.gov/assets/gao-23-106358.pdf

Government Accountability Office. (2021). *PASSENGERS WITH DISABILITIES Airport Accessibility Barriers and Practices and D.O.T.'s Oversight of Airlines' Disability Related Training*. Report to Congressional Committees. Retrieved January 26, 2023, from https://www.gao.gov/assets/gao-21-354.pdf

Harding, J. R., Bosch, S. J., Rayfield, W. P., & Florie, J. (2017). Enhancing Airport Wayfinding for Aging Travelers and persons with disabilities. *Enhancing Airport Wayfinding for Aging Travelers and Persons with Disabilities (2017)*. https://doi.org/10.17226/24930

Hart, T. A., Chaparro, B. S., & Halcomb, C. G. (2008). Evaluating websites for older adults: adherence to "senior-friendly" guidelines and end-user performance. *Behavior & Information Technology*, *27*(3), 191–199. https://doi.org/10.1080/01449290600802031

ICAO. (2014). Hazard definitions and usage notes - ICAO. Retrieved April 27, 2023, from https://www.icao.int/SAM/Documents/2017-SSP%20BOL/CICTT%20Hazard%20Taxonomy.pdf

ICAO. (2021). Innovation Driving Sustainable Aviation. Retrieved March 29, 2023, from https://www.icao.int/environmental-protection/SAC/Documents/Innovation%20Driving%20Sustainable%20Aviation%20-%20November%202021.pdf

Iqbal, M. Z., & Campbell, A. G. (2021). From luxury to necessity: Progress of touchless interaction technology. *Technology in Society, 67, 101796*. https://doi.org/10.1016/j.techsoc.2021.101796

Jin, L., Kuleshov, Y. A., & Pertel, V. (2019). Proposal of mobile application design for aging travelers in commercial airports. ACRP University Design Competition. https://vsgc.odu.edu/acrpdesigncompetition/wp-content/uploads/sites/3/2019/06/2019-ACRP-Design-Competition_1st_Tie2_Management.pdf

Kowal, P., & Dowd, E. (2001). Definition of an older person. Proposed working definition of an older person in Africa for the MDS Project. https://doi.org/10.13140/2.1.5188.9286

Kurt, S. (2019). Moving toward a universally accessible web: Web accessibility and education. *Assistive Technology*, 31(4), 199–208. https://doi.org/10.1080/10400435.2017.1414086

Laurie, S. J., & Jefferey, B. (2021). ADA website accessibility: What businesses need to know. *Journal of Management Policy and Practice, 22*(1), 1-10.

Lee, B., & Bowes, S. (2016). A Study of Older Adults' Travel Barriers by Examining Age Segmentation. *Journal of Tourism and Hospitality Management*, *4*(2). https://doi.org/10.15640/jthm.v4n2a1

Mein, P., Kirchoff, A., & Fangen, P. (2014). ACRP synthesis 51: Impacts of aging travelers on airports. Transportation Research Board. https://doi.org/10.17226/22417

Mello, V. G., & Pépece, O. M. (2022). Reconfigurations of shopping practices for consumers with disabilities: A mobile shopping view. *S R.N. Electronic Journal*. https://doi.org/10.2139/ssrn.4103086

Mulvihill, P. R., & Milan, M. J. (2007). Subtle world: Beyond sustainability, beyond information. *Futures*, *39*(6), 657–668. https://doi.org/10.1016/j.futures.2006.11.006

National Academy of Engineering. (2022). *Restore and improve urban infrastructure*. Grand Challenges - Restore and Improve Urban Infrastructure. Retrieved April 26, 2023, from http://www.engineeringchallenges.org/challenges/infrastructure.aspx

National Institute on Aging (2018). Participating in Activities You Enjoy. Retrieved from: https://www.nia.nih.gov/health/participating-activities-you-enjoy

National Library of Medicine, U. S. (2002). Making Your Web Site Senior Friendly: A Checklist. *Repository.arizona.edu*. https://repository.arizona.edu/handle/10150/106378

Neubauer, K., Fleet, D., & Ayres, M. (2015). National Research Council (U.S.). Transportation Research Board, Airport Cooperative Research Program, & United States. Federal Aviation Administration. *A guidebook for safety risk management for airports*. https://www.trb.org/Publications/Blurbs/172635.aspx

Olsson, L. E., Friman, M., & Lättman, K. (2021). Accessibility Barriers and Perceived Accessibility: Implications for Public Transport. *Urban Science*, *5*(3), 63–. https://doi.org/10.3390/urbansci5030063

Park, S., & Jayaraman, S. (2003). Enhancing the quality of Life Through Wearable Technology. *IIEE Engineering in Medicine and Biology Magazine*, 22(3), 41–48. https://doi.org/10.1109/memb.2003.1213625

Partridge, L., Deelen, J., & Slagboom, P. E. (2018). Facing up to the global challenges of aging. *Nature*, *561*(7721), 45–56. https://doi.org/10.1038/s41586-018-0457-8

Purdue Polytechnic Institute. (n.d.). About. https://polytechnic.purdue.edu/schools/aviation-and- transportation-technology/about

Qing, Z., Sun, C., & Reneker, J. (2020). Evaluation of airport wayfinding accessibility with the use of a wheelchair simulator. *Journal of the Transportation Research Board*, 2675(4), 52–60. https://doi.org/10.1177/0361198120980445

Remillard, E. T., Campbell, M. L., Koon, L. M., & Rogers, W. A. (2022). Transportation challenges for persons aging with mobility disability: Qualitative insights and policy implications. *Disability and Health Journal*, *15*(1). https://doi.org/10.1016/j.dhjo.2021.101209

Ristagno, L. (2022). *Good day everyone from Geneva Taking Accessibility to the Next Level*.

Rutter, R., Lauke, P. H., Waddell, C., Thatcher, J., Lawton Henry, S., Lawson, B., Kirkpatrick, A., Heilmann, C., Burks, M. R., Regan, B., & Urban, M. (2006). *Web Accessibility Web Standards and Regulatory Compliance* (1st ed. 2006.). A-press. https://doi.org/10.1007/978-1-4302-0188-5

Ryan, P., Sood, K., Metreveli, K., & Paternoster, J. (2023). Assessing Airport Programs for Travelers with Disabilities and Older Adults. *National Academies Science, Engineering, Medicine*. https://doi.org/10.17226/27012

Sayago, S., & Blat, J. (2009). About the relevance of accessibility barriers in the everyday interactions of older people with the web. *Proceedings of the 2009 International Cross-Disciplinary Conference on Web Accessibililty (w4a)*, 104–113. https://doi.org/10.1145/1535654.1535682

Satisfi Labs. (n.d.). *St. Louis Lambert Int Airport Virtual assistant: Case study*. St. Louis Lambert International Airport Provides Visitors with Reliable, Accurate Travel Information in One Place. Retrieved April 26, 2023, from https://satisfilabs.com/case-studies/stl-airport/

Stirbens, K. A., Guercio, A., Haiber, C., & Williams, J. (2010). *Barriers to Distance Learning in Web Accessibility for Persons with Blindness and Visual Impairment*. http://www.apple.com/accessibility/voiceover/

Stončikaitė, I. (2022). Baby-boomers hitting the road: the paradoxes of the senior leisure tourism. *Journal of Tourism and Cultural Change*, *20*(3), 335–347. https://doi.org/10.1080/14766825.2021.1943419

Sustainable Aviation Guidance Alliance. (n.d.). *What is Sustainability?* Saga learn. Retrieved March 29, 2023, from http://www.airportsustainability.org/learn

Theodorou, P. (2022). Design, Development and Technology Acceptance Modeling of Accessibility Systems for People with Sensory Impairments. *University of Piraeus.* https://doi.org/10.12681/eadd/53040

United States Access Board. (n.d.). Americans with Disabilities Act (ADA) homepage. Retrieved April 17, 2023, from https://www.access-board.gov/ada/

United States Access Board. (n.d.). Rehabilitation Act: Section 508 & Electronic and Information Technology. Retrieved April 17, 2023, from https://www.access-board.gov/law/ra.html#section-508-federal-electronic-and-information-technology

United States Census Bureau. (2020). Supplemental Tables for Living Longer: Historical and Projected Life Expectancy in the United States, 1960 to 2060. Retrieved from https://www.census.gov/content/dam/Census/library/publications/2020/demo/p25-1145.pdf

United States Department of Justice. (n.d.). Americans with Disabilities Act (ADA) home page. Retrieved April 17, 2023, from https://www.ada.gov/

United States Department of Justice. (2022). Guidance on Web Accessibility and the A.D.A. Civil Rights Division. Retrieved from https://www.ada.gov/resources/web-guidance/

United States Department of Justice. (n.d.). Title III regulations. Americans with Disabilities Act (ADA) home page. Retrieved April 17, 2023, from https://www.ada.gov/law-and-regs/title-iii-regulations/

United States Department of Transportation. (2022). *Passengers with disabilities*. U.S. Department of Transportation. Retrieved April 20, 2023, from https://www.transportation.gov/airconsumer/passengers-disabilities

United Nations (2022). Development Programme - The SDGs in action. SUSTAINABLE DEVELOPMENT GOALS. https://www.undp.org/sustainable-development-goals

United Nations. (n.d.). *The 17 goals | sustainable development*. United Nations. Retrieved March 29, 2023, from https://sdgs.un.org/goals

Vaish, K., Patra, S., & Chhabra, P. (2020). Functional disability among elderly: A community-based cross-sectional study. *Journal of family medicine and primary care*, *9*(1), 253. https://doi.org10.4103/jfmpc.jfmpc_728_19

Van Horn, L., Lipp, E., O'Reilly, K., Pound, P., Vange, J., Wirth, S. & Cole, S. (2020). *Innovative Solutions to Facilitate Accessibility for Airport Travelers with Disabilities* (No. Project 01-31). ACRP Research Report 210. https://doi.org/10.17226/25728

W3C. (2021). Web Content Accessibility Guidelines (WCAG) 3.0. World Wide Web Consortium. https://www.w3.org/TR/2021/WD-wcag-3.0-20211207/

Wang, S., Bolling, K., Mao, W., Reichstadt, J., Jeste, D., Kim, H.-C., & Nebeker, C. (2019). Technology to Support Aging in Place: Older Adults' Perspectives. *Healthcare*. https://doi.org/10.3390/healthcare7020060