COVER PAGE

Title of Design: Utilizing Virtual Queuing Technologies to Improve Passenger Experience at Airports

Design Challenge Addressed: Airport Management and Planning

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Utilizing Virtual Queuing Technologies to Improve Passenger Experience at Airports

Design Challenge: Airport Management and Planning

DragonFly

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Executive Summary

Following a review of FAA goals and issues that airports and travelers are currently facing, our team has proposed a novel solution that will reduce the amount of time passengers spend standing on lines in airports, thereby increasing passenger satisfaction and revenue generation. The application (app) we designed proposes a solution to the Technical Design Challenge of Airport Management and Planning for the 2020-2021 Airport Cooperative Research Program University Design Competition.

In our research, we discovered that travelers expect to spend an average of thirty minutes waiting in lines for domestic flights and an hour waiting in line for international flights [1][2], and even more time at busier airports [3]. Passengers tend to enjoy their airport experience significantly more when they are standing on-line for less time. In order to solve this challenge, our team from Binghamton University – State University of New York, proposed the DragonFly app, which will implement a virtual queuing system within airports enabling passengers to wait on-line while walking around the terminal or sitting down.

In our proposed app, the user will be provided with directions and notifications to help guide them through the airport, ensuring they complete all necessary steps at the correct time to board their flight. The application will help all passengers move through the airport more efficiently while increasing their peace of mind by showing them that they are in the correct location and on time to board their flight.

Currently, virtual queuing technologies are in use at theme parks and other entertainment venues but have not yet been implemented in airport settings. We believe that our proposed solution will provide significant benefits to both airport operators and passengers and will improve the overall travel experience within the United States.

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Problem Statement and Background

Long airport lines continue to be a major factor in delaying flights and preventing people from reaching their destinations. Between the years 2016 and 2020, the Federal Aviation Administration (FAA) set a target for 88% of flights to arrive on time, and every year the goal was achieved, with the exception of 2020 where the number was not yet calculated. However, if 88% of flights arrive on time, there are still over 10% of flights that are delayed. Flights are considered to be on time if they arrive no later than 15 minutes past their scheduled time [4]. In the days following the September 11th terrorist attacks, security has become much tighter, leading to increased wait times at airports. Additionally, Transportation Security Administration (TSA) staffing has also become increasingly problematic. There has been an ongoing shortage of TSA workers since 2013, as officers are leaving at a rate faster than the TSA is able to hire new members [5]. As a result of these factors, there was an 80% increase in wait times at New York's John F. Kennedy International Airport (JFK) in 2015, as mentioned in a hearing before the US Congress [6]. The recent Covid-19 pandemic has also made crowded airport terminals potential hotspots for the spread of the disease. As stated by the FAA, airports must meet an annual percentage of implemented hazard mitigation activities. This percentage is calculated by dividing the number of activities that have been completed by the number of activities identified for the year, then convert it to a percentage by multiplying the resulting decimal by 100. In recent years, excluding 2020 which has not yet been finalized, this percentage has been met [4]. In light of the pandemic, public health has become an important issue that needs to be addressed more effectively than in previous years; the aforementioned percentage will be able to determine whether the cautionary measures implemented by airports are effective.

The original concept of airport lines involved masses of people standing in rope-separated lines, having to patiently wait for their turns to go through airport security or to board their planes.

Due to the higher levels of congestion in today's airports than previously anticipated, the current system simply does not function well.

Attempts have been made in the past to cut down on airport wait times. The implementation of new technology has been an ongoing solution, for example, Computed Tomography, where officers can digitally scan and rotate bags instead of physically emptying it out [7]. The TSA has also made attempts to increase its staff to allow for more lines to be formed at once, and new technology for scanning luggage has been installed to move people through lines quicker. In addition, new conveyor belts with larger bins that allow for more items have been implemented [8]. However, the benefits that these methods have proven to provide are limited.

A virtual queuing system that can be used to notify people when they reach the front of the (virtual) line, will enable the issue to be mitigated by reducing the frequency and length of physical lines throughout the airport. The FAA's Destination 2025's goal is to "enhance the flying experience of the traveling public and other users by improved access to and increased capacity of the nation's aviation system," [9]. One of the largest obstacles on the road to fulfilling this goal is the need to increase the number of passengers the existing airports can serve in an effective and safe manner. This goal can be met by introducing new and innovative technology into airports across the United States. The proposed system would allow passengers to move through the airport more efficiently while enabling them to maintain social distancing during world health crises like the Covid-19 pandemic, or whenever needed. Furthermore, as the customers do not have to stand in a physical line, they are free to move around the airport and visit the concessions, which would also increase airport revenue. Although the standard method of queuing in a physical line has been used for years, it is inefficient and needs to be reinvented.

Summary of Literature Review

i. FAA Goals

Virtual queuing is the next wave of technology that can minimize passenger wait times and improve the passenger satisfaction through streamlining the airport experience starting from entering the airport to boarding the plane. The implementation of this technology highlights many of the FAA's goals to improve the efficiency and customer satisfaction of airports across the United States. As outlined in Destination 2025, the FAA "is committed to ensuring America has the safest, most advanced and efficient… aviation system in the world" [10]. Virtual queuing will allow for new technology to be implemented all across the United States and would create more efficient and technologically advanced airports. Another important goal of the FAA is to improve customer satisfaction and create a better perception of the airport experience [11]. Virtual queuing technology will increase passenger satisfaction due to shorter wait times, increased space, and less confusion about the airport process.

ii. Benefits of Virtual Queuing

The benefits of this technology can be seen in the areas of customer satisfaction, safety, and management. The management benefits will include the following: greater control in crowd movement, increased staff control, information in advance on user movement preferences, and automatic supply of information for customer research [12]. Virtually queuing would make lines a more manageable size for staff to regulate, thus allowing them to more easily communicate and direct those that are in line. A reduction in the size of lines and waiting time will likewise have benefits for customer service. A study by the Atlantic Press found that people experienced lessened wait times and increased satisfaction when using a virtual queuing system [13]. Virtual queuing technology allows for a reduction in crowd size, as previously mentioned, which makes for an overall more efficient experience. People will have a more realistic idea of the time they will have to wait, making it less likely that there will be any changes in wait time that could upset them, and harm customer satisfaction. Virtual queuing technology could also be responsible for improving the safety of customers and employees of businesses that institute it. The spread of viral contagion will be greatly reduced because there will be more room for passengers to space out around the airport instead of waiting in close proximity to others in a traditional queue [14]. By allowing for social distancing guidelines to be met, disease transmission is less likely, promoting the health and safety of those involved. Additionally, it allows companies to avoid reducing the numbers of customers they can service while adhering to social distancing guidelines. In this way, virtual queuing will save companies from lost revenue that would accompany a reduction in customers.

iii. Applications of Virtual Queuing

Companies that have already begun to integrate virtual queuing into their business have started to see the benefits that accompany this technology. Virtual queuing has been implemented by businesses in the fields of retail and produce, seeing a great deal of success. One such company, Tensator, found that their system was able to “increase profitability by up to 96%,” and “increase revenue by 75%,” as well as reducing “waiting times by up to 30%.” [15]. Disney has introduced virtual queuing for some of their more popular rides to regulate lines. In Universal Studios, Disney has begun to use the Universal Orlando Resort app which allows customers to choose a particular time to return to the ride enabling them to do other things in the theme park while waiting for the ride [16]. Disney is also using a different type of virtual queuing technology with their “Star Wars: Galaxy’s Edge” ride. This ride uses the My Disney Experience app which allows riders to join different boarding groups that will enter the rides at different times. Once it is almost time for a boarding group to go on the ride, they receive a push notification reminding them all to start going to the attraction [17]. One of the benefits they have seen so far is that guests can do other activities while waiting instead of losing time in a traditional queue. In Disney, this means going to restaurants and seeing the smaller attractions [18]; in an airport this means shopping and getting food from the various vendors. Furthermore, as found by Lavi Industries, "digital queuing can encourage customers to stay in your store and continue to browse while they wait" [19]. This provides additional income for the airport while also keeping travelers satisfied during their wait time. As well as encouraging passengers to peruse shops, the reduced wait time associated with virtual queuing could translate into profits for airports in other ways too. According to one source, just a seven-second reduction in customer waiting times increases a fast casual restaurant's market share by as much as 1% [20]. To put this into context for the aviation industry. Therefore, the implementation of an virtual queuing system within airports will help the FAA meet their goals on having advanced and efficient airports while improving safety, profitability, and passenger satisfaction.

Problem Solving Approach

The project team was composed of eight undergraduate students from the Binghamton University Scholars Program who worked cohesively to solve the issue of virtual queuing. The team was split into four sub-teams and one project leader who oversaw the entire project. Each student played a different role in reaching the final project.

Figure 1 - The Team Meeting in the Classroom

The project leader worked closely with the rest of the team and non-university officials to prepare the project and ultimately submit the finalized work. They functioned as the Primary Editor of the paper and established deadlines to ensure timely work throughout the process. They worked with each sub-team to discuss their work and act as a bridge between the different groups. One of these groups was the Design Team, which was responsible for the description of technical aspects of the project and wrote their findings in the Technical Aspects Addressed. They also wrote the Projected Impacts, which discusses the effects this project can have on airports and its potential commercial success. The Engineering and Graphics Team collected photos and designed visuals which support the project. Additionally, they created the Problem Statement and Background by addressing the specific problem which the team is working to solve and worked with the Design Team to write the Summary/Conclusion. The Risk Assessment and Research Team evaluated the risks involved with the project by examining FAA materials, in addition to compiling the literature review. They also created Appendix A. List of Complete Contact Information, Appendix E. Evaluation of the Education Experience Provided by the Project, and Appendix F. Reference List with Full Citations as part of the literature review. The Strategy and Approach Team evaluated the steps taken in completing the project to create the Problem Solving Approach and described the interactions with airport operators and industry professionals. Additionally, they researched the airport professionals which the team interacted with for Appendix C, and described Binghamton University in Appendix B.

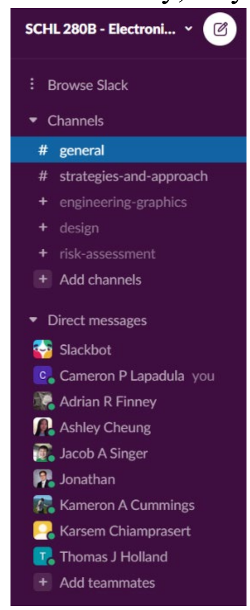

Figure 2 - The Slack Communication App

Overseeing the project was Professor Zachary Staff and Professor Chad Nixon of the Binghamton University Scholars Program. Professor Zachary Staff, who attended Binghamton University, provided his knowledge as an airport planner to give an overview of the processes in which we would be involved and guidance throughout the project. Professor Nixon gave additional guidance through his experience in aviation planning and engineering as well as involvement with national aviation industry organizations.

Arriving in class on the first day through a Zoom meeting, we were introduced to the responsibilities which the teams would take on throughout the process. The next week, the class met in person for the first time and began by learning the processes involved in airport planning, maintenance, and operation. Building on this, the class began brainstorming ideas for the project and discussing their potential for our future work. After class, we did continued research into the ideas stated in class and worked to find additional ideas. After going around the class and discussing the many ideas which were researched, Professor Staff and Professor Nixon specified the ideas which stood out to them and helped to provide thoughts for the group to consider as they researched. The class was then split into groups which did in-depth research of these ideas to find the pros and cons of each pathway. The initial set of ideas included virtual queuing, the use of basalt fibers to strengthen asphalt, using drones to sanitize airport terminals, and a potential treatment option for water contamination from Perfluorooctanoic acid (PFAS). After further research into these concepts, the options were narrowed down to virtual queuing and the basalt fibers via a class vote. Professor Staff informed the class that there were enough students to occupy two research teams for the ACRP Design Competition. The students indicated which team they preferred to participate in, and the class was split into two teams of eight students before further splitting into the various sub-groups.

Figure 3 - The Team Discussing the Project over Zoom

With the research topic established, our team began to work on an initial literature review to gather knowledge on the topic. These individual literature reviews would eventually be compiled by the Risk Assessment and Research Team for the final literature review. With the basis of knowledge established, the various teams set off on their respective work. The Design Team began to create the Technical Aspects Addressed by assessing the process by which people navigate the airport queuing system in the typical physical queuing method. By cross-referencing with systems like Disney's virtual queuing, which was an inspiration for this project, the team was able to work out a system that would be applicable to airports. The team decided to utilize an application system for the virtual queuing, and through discussion came to the name "DragonFly" for the app. The app name was chosen because dragonflies are the fastest travelling insect, and we wanted the app name to represent the quick speed in which you would be able to travel through the airport and be ready to fly. The Engineering Graphics team worked to create a visual experience for the user centered around the app theme and name. They accomplished this by creating potential color palettes for the application, which the team then voted on and came to a final decision for a red, white and blue concept. Throughout the process of discussion and design, the class was often separated from one another due to the effects of the Covid-19 pandemic. The team met every other week on Zoom, with the other weeks being in a traditional classroom setting while remaining socially distanced. Within Zoom meetings, breakout rooms were used to facilitate discussion within teams; when in class the group gathered in a large circle of desks to work alongside each other and meld our respective parts of the project.

To further the design and gather feedback on the work done, the class met with industry professionals and airport operators to discuss airports through the lens of their knowledge and experience. The first meeting took place over Zoom with Richard Strickland, who is the Senior Director of Airports at Key West International Airport and is responsible for the airport's operation and management. Mr. Strickland discussed the implementation of virtual queues and the people who would find it the most beneficial. He said the application would have to account for dramatic variations in design between airports and the differences in checkpoints. This provided a new direction for the team to work. In the next class, the team met with Jonathan McCredie, who is the co-founder and managing principal of Fennick McCredie Architecture, which specializes in aviation architecture. Mr. McCredie talked about concessions and the effect of human behavior on the system. This showed the team that the application would require a significant amount of real-time data to be transmitted to the user for an efficient experience; with this there would have to be a forecasting model for the transmitted data. Additionally, the placement of concessions would be a component which they would address further. These meetings gave insight into the workings of airports and gave continued points on which the project could develop.

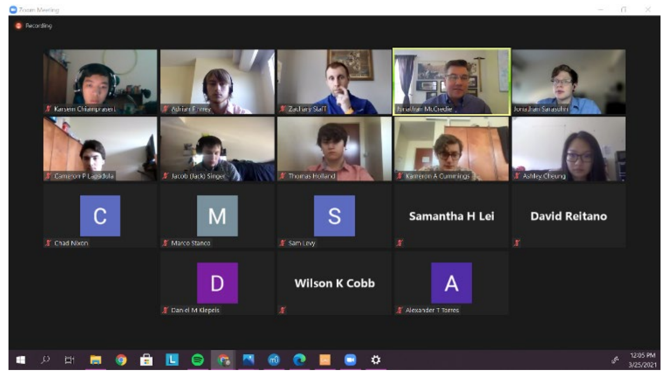

Figure 4 - The Team Meeting with Jonathan McCredie over Zoom

Looking past the initial implementation of a virtual queuing system in airports, there are several maintenance components that need to be addressed. The application will necessitate dedicated server space for the increasing data flow, as well as the expansion of physical baggage kiosks for the service as the system reaches more users. Additionally, new staff may have to be hired within airports to maintain both the functionality of the application and to provide assistance to passengers.

While the process for the project was made difficult by Covid-19, the team worked cohesively throughout the entire process. With meetings alternating between Zoom and in-person, the class continued to find ways to innovate the work and adapt with what they learned. Through the guidance of Professors Staff and Nixon, the team worked together to find a design solution that could be implemented through the contributions of every class member.

Technical Aspects

i. User Interaction

The virtual queuing system will interact with users as follows. New users will create an account on the app (DragonFly). Upon creating this account, the user will be assigned a unique user ID that is recognizable by TSA and all airlines. When purchasing a ticket through an airline, the account will automatically link the purchase to the app, allowing the user to check in before the flight through the app. The app will also draw data from a database on flights and times of different flights to provide the user with necessary information about their flight. The application will further alert the user with notifications regarding flight status, boarding times, and other relevant information so that the user has ample time to travel to their location at their designated time slot.

Figure 5 – App Flight Information Display. Mockup Designed in JustInMind Prototyping Tool

The queuing system itself will create a line from a list of groups of people. It will form this virtual line based on several factors, with the primary focus being on the number of groups and the number of people within each group. To prevent users from reserving a place on the line when they are nowhere near the airport, the queue will only be joinable once they are within a certain distance of the airport or a designated checkpoint within the airport, registered by geofencing. This will prevent people from joining the virtual queue when they have very little chance of being able to reach their checkpoint during their designated time. This will help to reduce backups in the queue, as well as reducing the number of missed time slots. The queuing system will use an algorithm based on Little's Law which asserts that the time average number of customers in a queueing system, l, is equal to the rate at which customers arrive and enter the system, λ, the average sojourn time of a customer, w [21]. This equation, $l = \lambda w$, will be used to predict the time it will take for a user to be called. The time will dynamically change as it adjusts to different conditions.

Upon joining the queue, the user will be assigned a specific shape and color group. The user will be alerted by a phone notification when their five-minute window is open for them to arrive at the checkpoint. The number of people designated to arrive at each time interval will be calculated from data concerning the passenger traffic flow of each airport to suit their individual needs.

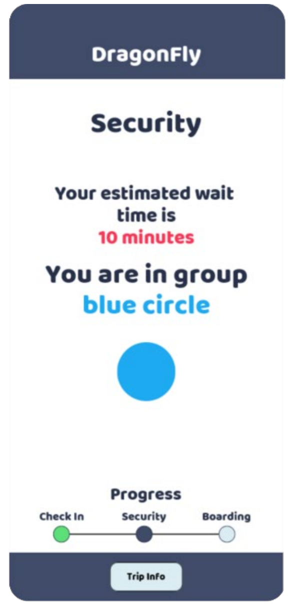

Figure 6 - App Mockup Showing Group Assignment

A server will be maintained by the airport that utilizes randomized server-sided application programming interface (API) tokens to help protect the server from outside cyber threats and hacking attempts [22]. Upon creating and using the account, two-factor authentication will be required to help ensure the security of user accounts. Two-factor authentication requires a user to use both a password and a randomly generated token to access their account. In case of a power or server outage, physical queuing methods will still be available if it is necessary to revert to a traditional queuing system. An alert will also be sent out via app notification, email, or other forms of communication to inform users the virtual queuing system is temporarily inoperable.

Virtual queuing would be best implemented with a reliable forecasting model, widespread participation amongst passengers, and a passenger arrival pattern with spikes in capacity. In this way, virtual queuing could effectively reduce both cost and operational times for the airport.

ii. Airport Management Interface

The following describes how airport management will interact with the queuing system to allow it to function at optimal performance. The queuing system will be regulated by airport operators who can manually control the queue itself or move passengers if necessary. The airport queue managers will be able to view the current group on their computer displays. Passengers will know which queue group is currently being called up through a variety of methods. These would include in app notifications, as well as announcing the boarding groups through the speakers and pre-existing displays at each gate.

iii. Changes Within the Airport

If there are to be changes to the passenger experience in the airport, there needs to be some changes made to the airport itself. Currently, in this new system of virtual queues, there is no longer a need for the entire entrance of an airport to be webbed with countless retractable barriers to withstand the substantial amount of people entering at all times of the day. There would only be a need for short retractable barriers located at the service station for the limited group of passengers called up with their queuing group. This space can be repurposed and used to greatly benefit the airport. One thing that can be done is to add chairs and outlet towers that are socially distanced for users to wait at in order to provide a safe and comfortable environment for all passengers. Another element that could be added to this entrance of the airport are concessions. These concessions can contain various dining establishments, stores, or even city-centric souvenir shops. These additions would result in less unoccupied time for the passengers and a greater revenue stream for the airport.

To continue focusing on the passenger experience, free Wi-Fi and TV entertainment systems could be added to the seating areas. Again, occupied passengers virtually waiting in line are happy passengers waiting in line. These entertainment systems can double as informational displays showing current queue information such as what group is currently being called up and which group will be next on a small section of the display. This will ensure that even if passengers are not looking at their phone, they will receive the notification almost instantly through another method.

iv. Queuing Process and Methods

Four places in every airport can benefit greatly from virtual queuing. These locations are Baggage check-in, TSA security, and Flight boarding, as well as customs and immigration for international airports which would function in the same manner as the TSA security queue. Adding virtual queuing into all four of these locations can greatly increase airport efficiency, lower waiting times, and as a result, raise passenger satisfaction.

Four or more places in many airports can benefit greatly from virtual queuing. These locations are baggage check-in, TSA security checkpoint, the boarding gate, and customs and immigration for international airports, which would function in the same manner as the TSA security queue. Adding virtual queuing into all four of these locations can greatly increase airport efficiency, lower waiting times, and as a result, raise passenger satisfaction.

Upon arriving at the airport, the passenger will be prompted to check in and then will be asked if they have any baggage they wish to check-in. Passengers who select yes will receive a quick response (QR) code within the app and will be prompted to bring their bag to a kiosk where they can print their luggage tags and complete the check-in process. After applying the luggage tags, they will drop their tagged baggage off for security screening and to be loaded on the aircraft in a manner similar to how it is completed today. The baggage check-in kiosks will all be connected to a centralized system for all airlines thereby

Figure 7 - App Baggage Check-in Screen

enabling the most efficient use of the kiosks. These interconnected smart kiosks will enable a reduction of check-in lines and allow check-in counters to be almost completely eliminated, freeing up precious space in the airport entrance. Since the kiosks will all be connected to the airport systems, the virtual queuing system will know which kiosks are unused and sanitized and will be able to direct passengers who need to check a bag to the closest open kiosk. This will provide a safe and efficient way for passengers to move through the baggage check-in process at the airport.

For the TSA security checkpoint, the queue system would work the same way it does currently. There can be unique separate virtual queues for passengers of various status such as TSA PreCheck and CLEAR, as well as other groups that TSA or the airport operations staff deems fit. These unique groups can direct the individuals in them to unique lines or into the general lines. As the passengers do not know who is in the virtual queue ahead of them, the airport operations staff could move small groups of passengers to the font of the line without the rest of the passengers noticing. Beyond these exceptions, the line will work on a first-come first-serve basis as it does currently.

Lastly, boarding should work like it currently does with different priority groups set by the individual airlines. The application will notify the user when they should arrive at the gate and when it is their turn to board. In speaking with our industry experts, they let us know that passengers often congregate around the boarding door as they are worried that they will miss their flight if they do not. To combat this mentality, the app will notify the passenger that they are in the correct place to board their flight and will again notify the passengers when it is their turn to board. In addition to the app,

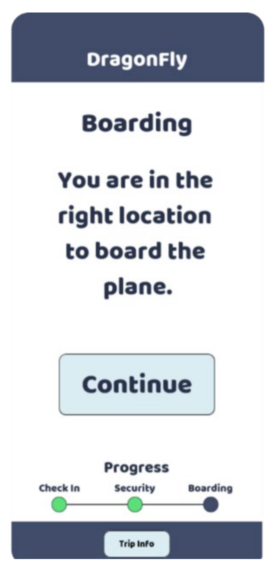

Figure 8 - App Boarding Location Screen

there will still be displays and speakers in the gate lounge that will provide flight information updates and display the boarding queue.

v. Pre-existing Technology

The app will use a variety of different pre-existing technologies. One of the most critical to the success of the app will be geofencing. Geofencing works using the global positioning system (GPS) and satellites to track how close a connected device is to a certain location. Most smartphones have geolocation technology pre-installed in the device, and this will allow the app to utilize geofencing. If the device is tracked to be within a certain distance of a set boundary, then they will be registered as within that geofence [23]. This system will be aided by the airport-wide Wi-Fi, a networking technology that connects devices to a wireless network, in order to both provide a free internet connection to all passenger devices, as well as to improve the location accuracy of the geofencing technology. Using Wi-Fi, the app will rely on servers to send and receive information about the queuing times for each person. Quick response codes are another pre-existing technology that will also be utilized. A quick response (QR) code is a type of barcode that can be read by a digital device and which stores information as a series of pixels in a square-shaped grid [24]. These codes will be used to print luggage tags at the kiosks and complete the check-in process. Kiosks are touchscreen devices that allow passengers to self-check-in and print baggage tags or even boarding passes, helping to save time at busy airports [25]. An essential pre-existing technology that will be used is smartphones. Smartphones provide mobile access to the internet which is necessary to use the app. Smartphones come with an app library that allows users to download applications that they wish to use.

vi. How to Make a Mobile Application

The application will be developed in order to run on both Apple (iOS) and Android (Google) devices. The first part of making the application will be to choose the appropriate programming languages. For an iOS application, the use of Swift is required. For an Android application, the use of Java is required. For both applications multiple software developers will need to be hired. The iOS application is developed in Xcode while the Android application is developed in Android Studio. Both ports of the app will be connected to the same API or an application programming interface which will allow the app to send and receive data from the backend servers. Once the application development is complete, it would need to be tested rigorously through a combination of simulations and stress tests. These stress tests would involve hundreds of instances of the app running at the same time in the same airport to test if the servers could handle the load. Following that there would be a testing phase where passengers could opt-in to use the app when they travel. The airport would provide a dedicated check-in and security line for just these passengers. This would help jump-start the transition to the new system [26].

vii. App Operation Flowchart

The flowchart below shows how the users would be guided through the airport utilizing our application. The user would begin by confirming their trip, and then choosing where to check a bag or not. After check-in and bag drop off, the user would proceed to security and automatically be added to then correct queue based on their account status. The user would be assigned a group and a wait time and would receive a push notification before it is their turn to go through security. After going through security, the user would be directed to find their gate and join the virtual boarding queue at their gate. Each user would be placed in a queue corresponding to their status in the app or airline servers. The user will then again be presented with a boarding group and wait time, after which they are free to walk around until they are notified that it is almost time for them to begin boarding. For users who are not as comfortable travelling, a screen will appear when they are seated in the boarding area letting them know that they are in the correct place to board the plane. The app will then notify the user that it is time to board and wish them a safe flight.

Figure 9 - App Operations Flowchart Page 1

Figure 10 - App Operations Flowchart Page 2

Risk Assessment & Safety

i. FAA Risk Assessment & Safety

When implementing a new system, it is important to ensure that it is safe for everyone who uses it. In order to ensure the safety of a new system the FAA, as outlined in the Safety Management System Manual, has provided metrics and explanations on how to accurately assess any and all risks involved with the system. In the case of virtual queuing, the first step in this process is to identify the range of risks associated with the use of this technology. After identifying the risks, they need to be characterized into different risk levels depending on the frequency of the risk and the consequences that come from it as shown below.

Depending on the level of risk identified using the matrix, different modifications and considerations will need to be made. If a risk is determined to fall into a green category this means it has low risk and no countermeasures need to be developed. If a risk falls into a yellow category, it will not cause disastrous consequences but there are still issues that need to be accounted for to the best of the airport’s ability. Finally, if a risk falls into the red category, this is

Severity / Likelihood	Minimal 5	Minor 4	Major 3	Hazardous 2	Catastrophic 1
Frequent A	Low	Medium	High	High	High
Probable B	Low	Medium	High	High	High
Remote C	Low	Medium	Medium	High	High
Extremely Remote D	Low	Low	Medium	Medium	High
Extremely Improbable E	Low	Low	Low	Medium	High* / Medium

Figure 11 - FAA Safety Matrix [27]

a worst-case scenario. Risks in the red category are the most important, and therefore need to be addressed and mitigated as much as possible.

ii. Risk factors of Virtual Queuing

When looking at the implementation of virtual queuing, there are three main risk factors that will need to be accounted for in the development of this project. The first major risk identified is the danger of cybersecurity and potential system-wide hacking that can result from handling passenger-airport interactions mainly through the use of one centralized app. Another important risk that has been identified is the possibility that the app or the system responsible for running the app crashes and pauses airport operations within the terminal. Finally, the third risk identified has to do with changing the layout of the airport to accommodate for virtual queuing. By placing stores and concessions before the TSA checkpoint in the airport, it allows potentially dangerous people to have access to large crowds before they can get checked for weapons at security which is a major security and safety risk.

Looking at these three risks we can initially plot their levels of projected severity and likelihood. The risk of hacking is an important one to consider since it can lead to harmful consequences such as malware attacks and data breaches [28]. Currently, airports use LAN (Local Area Network) and VPNs (Virtual Private Networks) in order to reduce the threat of cybersecurity hacking [29]. Without the introduction of any additional security measures within the app, the current threat of cybersecurity hacking is minimal but is still a threat that the DragonFly app will aim to mitigate as much as possible.

Prior to our solution, a system-wide failure of the DragonFly app would lead to the inability of passengers to move through the airport effectively and may cause people to miss their flights or lead to major delays which can become a compounding issue across the country. This is a major risk for airports as it will lead to significant revenue loss and will waste many resources of the airport as well as decreasing customer satisfaction and trust with the app. Currently, airports use many systems which fail very infrequently, so while failure of airline software does occur it is not common [30]. Therefore, the frequency of the system crashing is minimal, but if it happens there needs to be systems in place to minimize the damage this can cause on passengers and the airport.

Moving the concessions to before security raises concerns surrounding the increased opportunity for people with violent intent to have access to a large population of people, because they will not be checked at security for weapons until later in the boarding process. However, while this concern is understandable, it is not inevitable. Terrorism in the airline industry as a whole in the United States has been on the decline in recent decades, with only two reported cases according to the RAND Worldwide Terrorism Database [31]. Furthermore, attacks in the airline industry have always disproportionately occurred on airplanes themselves, and not in physical airports, both before and after the 9/11 attacks [32]. This means that historically, the biggest safety risk to passengers has been posed on airplanes not in airports, even before the restructuring and safety modifications that followed the 9/11 attacks. Building on this, it would be logical to assume that simply having concessions before security is unlikely to make concessions a more popular target for terrorist activity. Another factor that would indicate that relocating concessions would have minimal effect on airport safety, is the example of other institutions and businesses. People frequently attend malls, grocery stores, and restaurants, that all have little to no security, or means of preventing armed violence from occurring. Extending this principle, people would be at no greater risk at concessions in the airport than they are at any other public space.

When analyzing these risks in regard to the FAA safety matrix it is necessary to think about the frequency of these risks alongside the consequences that may occur from any of these problems. The risks discussed above have been categorized based on their likelihood of occurring and the severity in the event that they do happen. The distinction between the characterization of a risk as major versus catastrophic arises from the potential for fatalities when risks are of catastrophic severity. The distinction between remote and extremely remote is more straightforward.

Risk	Severity	Likelihood	Color
Cybersecurity Threats/Hacking	Major	Remote	Medium Threat
Software Failure	Major	Remote	Medium Threat
Terrorist Attack	Catastrophic	Extremely Remote	High Threat

Table 1 - Initial Likelihood and Severity of Risks with the DragonFly App

iii. Proposed Solutions

In order to lower these levels of risks, our team proposes the following strategies and implementations for use either within or alongside the DragonFly app. In regard to the threat of cybersecurity or hacking events, the DragonFly app will include high levels of authentication in order to make the sensitive information it contains protected from hackers. There are many different ways this can be implemented within the DragonFly app. Similar to Apple’s face recognition technology, the DragonFly app could use a facial scan or a fingerprint scan in order to authenticate the user [33]. These biometric authentications would be the most effective way to protect people’s phones locally from others in the airport in the case that someone else gets possession of their phone. In addition to this, two-factor authentication would be used supplementarily to increase the security of the app. With multi-factor authentication, passengers will put in their regular password which will prompt the app to send a one-time password that can only be used for a short amount of time in order to authenticate the user. This will protect the user from cyber-attacks on a global scale [34]. Both of these techniques will be effective in reducing the ability of hackers to steal or access people's personal information and will create a lower risk overall for the passenger in using the app.

Using virtual queuing means relying on technology to work perfectly, which is widely recognized as impossible. Systems fail and apps crash, so there needs to be measures in place for when these happen to mitigate the effects they can have on people and airlines. One obvious failsafe in the event that DragonFly is not working is to have a physical queuing backup. Therefore, if passengers can no longer check their place in line on the virtual queue via the app, they will simply get on a physical line and wait. While this is not ideal, because many of the problems of physical queuing come into play once again, such as long wait times and customer irritation, the effects won't be nearly as bad as they would be if there were no back up and people missed their flights as a result. People will resort back to the "default" as in they will wait in lines for security as they do now, and they will remain very close to their gate the entire time before their departure, which is also commonplace now. The use of physical queuing in emergency cases will therefore reduce the severity of the effects associated with the app crashing.

Terrorism is always a consideration when operating in the aviation industry, so it must be accounted for when considering changes. In the case of virtual queuing, which would move concessions to before security, there are steps to take to help minimize the chances of a successful terrorist attack. One simple way of doing this could be to hire more security and law enforcement officers in and around the concession areas who can act if they observe dangerous activity. To further augment the effectiveness of these officers, systems would be put in place that allow them to observe a potential threat before they cause harm. This could be accomplished with the various forms of technology aimed at detecting explosives and firearms before they have the chance to harm or kill people. Companies like "Omnilert" are working on a device that can detect guns before they are fired, and can send alerts to officers, notifying them of the location and appearance of the person with the firearm [35]. Other companies promote technology for sensing explosives before they go off, and use methods centered around X-rays, infrared, terahertz and microwaves [36]. Similar to the firearms detection technology, these technologies would enable law enforcement and security to react quicker to potential threats to passenger safety and would be better equipped at quelling terrorist attempts. In addition, at least one Law Enforcement Officer is present inside the airport terminal whenever a flight is arriving or departing, although this number would be much higher for many larger airports.

Risk	Severity	Likelihood	Color
Cybersecurity Threats/Hacking	Major	Minimal	Low Threat
Software Failure	Minimal	Extremely Remote	Low Threat
Terrorist Attack	Catastrophic	Extremely Improbable	Medium Threat

Table 2 - Likelihood and Severity of Risks after Proposed Solutions

After the implementation of the proposed solutions the threat levels of the risks addressed in this section can all move down one level. Further than this, these risks will need to be consistently addressed and evaluated throughout every step of the implementation of the DragonFly app and during the entirety of its use within the airport. By consistently addressing these risks and improving the mitigation strategies employed for them it can be ensured that the DragonFly app will be beneficial to airports all across the country.

Interactions with Airport Operators and Industry Experts

Our team met with two aviation experts, one Airport Operator and one Airport Architect. Richard Strickland is the Senior Director of Airports at Key West International Airport and has over 20 years of experience in airport operations and management. The team met with Mr. Strickland via Zoom on March 23, 2021 to discuss the possible applications of virtual queuing systems in airports. On March 25, 2021, the class met with Jonathan McCredie on Zoom to discuss the implementation of virtual queuing in airports. Jonathan McCredie is the co-founder and managing principal of Fennick McCredie Architecture, which specializes in aviation architecture. With his 25 years of experience, Mr. McCredie has worked on projects with over two dozen airports across ten states. After introducing Mr. McCredie to the class, Professor Staff turned to Project Leader Jonathan Sarasohn to ask questions regarding virtual queuing. Mr. McCredie provided useful information on where virtual queuing can be used and possible issues that could arise which could be addressed. Regarding where virtual queuing could be implemented, Mr. McCredie said gates and hold areas would be a good place to start, but checkpoints or baggage would be more difficult due to required data from the Transportation Security Administration (TSA). Additionally, there would need to be concessions before checkpoints, but this could be difficult to implement post-9/11 because airports

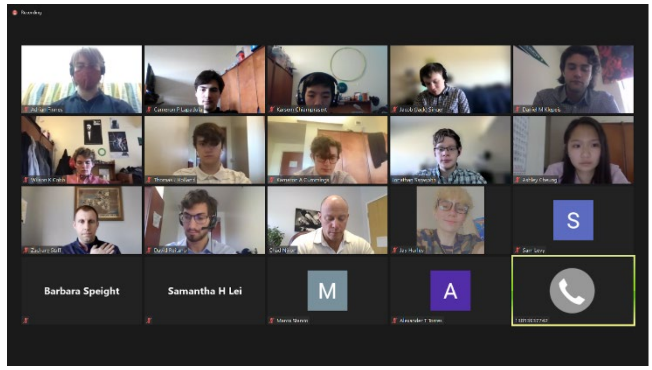

Figure 13 - The Team Discussing Virtual Queueing with Richard Strickland over Zoom

Figure 12 - The Team Meeting with Jonathan McCredie via Zoom to Discuss the Project

generally have concessions after checkpoints. Prior to 9/11, airports were designed to have concessions before checkpoints, but they were moved past checkpoints after the security changes post-9/11. Mr. McCredie said virtual queuing for aircraft boarding could be immediately implemented; however, the only issue arises with human behavior. People could arrive early or late to the flight and affect queue overflow, and flight delays could cause issues in the system. The application would have to be sufficient to deal with these changes to be fully beneficial. In general, virtual queuing would be useful in airports but would require the adaptation to irregular behavior.

Projected Impacts

i. FAA Goals

The use of virtual queuing through a mobile application in airport settings helps “enhance the flying experience of the traveling public and other users by improved access to and increased capacity of the nation’s aviation system”, one of the goals in the FAA’s Destination 2025 [37]. Our proposed solution meets that goal by decreasing the average wait time of passengers, occupying travelers during waiting periods, decreasing the risk of spreading contagious viruses and diseases such as Covid-19, decreasing the risk of theft due to the reduction of physical density in the queue, and improving the comfort and peace of mind of travelers by guiding them through the airport system.

ii. Commercial Potential and Processes for Implementation

In the current age, there is a near ubiquitous prevalence of smartphones in our society as well as increased global connectivity, and public knowledge on the use of technology. According to a Pew Research study, about 81% of Americans currently have smartphones, and the number rises each year that passes [38]. The proposed solution will be easy to implement because there is no need for initial major airport renovations or changes to an airport’s main infrastructure.

However, a change this large should be approached in a cautious manner regardless. This system can be implemented in airports of all sizes, but initial tests should be conducted in smaller airports. This makes these tests easier to control and has less risk if a flaw is detected. Like all systems, this will require a closed beta period as well as a public beta period for those who wish to opt-in and test the new system before a more refined system is released to airports nationally or even worldwide. During these beta periods, bug fixed will constantly be deployed as user and airport feedback is received. Once the system is ready for the public and has been tested in multiple smaller airports, it will be ready to be applied to larger airports. In order to spread awareness of the new technology, an advertising campaign would ideally take place in airports in which the technology will be implemented, as well as on the airport and airline websites. In addition to the advertising campaign, customer service agents would be hired to staff both a call center and airport information booths to help passengers with any difficulties they may experience joining the new system. There can also be an incentive at specific airports to join the new system such as a coupon to use at a concession in the airport.

iii. Affordability and Utility

The app will be available free of charge to the travelling public. There will also likely be no in-app purchases, meaning that there are no costs associated for using any part or features within the app. The app will have a simple design that will enable users to be guided through the airport process, making it a great utility for passengers. For example, it will guide them step by step through the different locations they need to pass through, such as baggage check-in and security, and at what times they should be at each location.

iv. Financial Analysis

It is anticipated that the project will be funded by the Federal Government. Development of the app and other background technology would be funded at a larger scale, while improvements at specific airports would be reimbursed through grants provided by the Airport Improvement Program. The primary costs would be the cost of hiring a development team to develop the app as well as the construction and hiring to staff a call center for those with questions regarding the application, especially during the rollout phase.

In order to calculate the salary of the app development team, we first determined the size of the team that would be needed. Since we would be building a large app on both the Apple iOS and Google Android platforms, we would need a large development staff [39]. This staff would be led by one technical project manager who will earn $85,000 per year [40]. The app development work will be split amongst four mobile developers, each earning $105,000 per year [41]. Two of the mobile developers will work on the iOS application while two will work on the Android application. In addition to the mobile developers, we would need two backend developers who would each earn $100,000 per year [42]. Finally, we would hire both a part time app designer for 45,000 per year [43] and a part time quality assurance engineer for $42,000 per year [44]. Therefore, the total salary for the app development team would be $792,000 per year. At the end of year 1 after testing and implementation is complete, we would reduce the development team to a technical project manager, two mobile developers and one backend developer for a total yearly salary of $395,000 per year. The app development team would then continue working on updating and improving the system and application.

For the call center, we determined by the TSA checkpoint numbers that approximately 2.9 Million passengers travel each day in the US [45]. We assumed, due to the easy-to-use nature of the app and the availability of staff within the airport to assist travelers that only 0.1 percent would reach out to the call center for assistance. From this, we used the Erlang calculator to determine that an average of 41.5 call center agents would be needed to answer 80% of calls within 20 seconds and assist all customers within 240 seconds [46]. Therefore, for the first two years we plan to staff the call center with an extra ten employees to help handle a potential increase in calls as the new system begins operations. It costs $5000 to build each call center station [47], which for fifty stations will give an initial cost of $250,000, The average salary for a call center worker is $30,000 [48], so the total yearly salary would be 1.5 million for the first two years, and $900,000 for the proceeding years.

The app would be hosted in the existing government data centers, so minimal, if any cost would be associated with running the applications servers.

The benefits of our poised solution would be substantial, as implementing virtual queuing would enable the airport to process more passengers with less staff while increasing the revenue it generates. The passengers will also see a substantial improvement in their airport experience as they will be able to expedite their travel through the airport.

The airport will be able to process more passengers while simultaneously reducing staff by reducing or eliminating the presence of workers in the check-in area, as all of the functions of that area of the airport could be accomplished on the application. These concepts can be extended further through the airport, especially large ones where some positions may no longer be needed as the application enables more efficient methods for the passengers to move. With the average salary of an airport worker being $28,000 per year [49], some airports will save significant money. For our case study of Key West International Airport, we estimated that six less employees would be needed. In addition, for areas like baggage drop-off automated kiosks connected to the application would be utilized, further reducing staffing requirements.

According to an earlier source [15] regarding the use of virtual queuing in the fields of retail and produce, companies that properly implement the technology can see an increase in revenue of up to 75%. In our case study below, we applied this percentage to the revenue from concession and retail sales in Key West International Airport in 2015. The total increase in revenue from these sales resulted in a profit gain of $257,731 [50].

In addition to having a more enjoyable travelling experience, the airport passengers will save time, and thereby money as well. The average hourly salary in the United States is approximately 30 dollars [51]. Virtual queuing will save all passengers time as they will not be standing in line. This newfound time can then be used productively. Even an hour saved would result in an average of a $30 benefit for passengers. Using Key West International Airport as an example, 497,656 passengers traveled through the airport in 2019 [52]. If they each saved an hour using virtual queuing, then this would result in a total benefit of $14,929,680 directly to passengers, which in turn would help the overall economy.

Return on investment would vary by the airport but could be quite substantial over time as fewer airport workers are required to operate physical queuing systems and checkpoints, and passengers save time that would be otherwise spent waiting in line and are able to spend that time instead patronizing airport restaurants and shops. Payback analysis and net present value would also vary by airport due to the difference in airport sizes. Increased passenger flow would also increase the number of passengers traveling through the airport and using the airport, resulting in the possibility of a greater number of flights arriving and departing to and from the airport. This would increase potential revenue for the airport as they experience more passenger traffic while simultaneously increasing their passenger flow.

The Cost/Benefit Analysis chart below is based on a case study of Key West International Airport. The costs are distributed on a national scale while the benefits are based solely on Key

West International Airport. The national cost divided by the number of airports (19,636 in 2019 [53]) yields the cost per airport. This is done since the infrastructure and support systems for the app will be used nationally, and the individual airports will not need to make any major modifications to implement the system other than removing the queue barriers.

Cost/Benefit Analysis of Developing a Virtual Queuing App for Airports (Key West International Airport)							
National Costs							
	Initial Costs	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Total (5 Years)**
App Development team	$792,000	$792,000	$395,000	$395,000	$395,000	$395,000	
Customer Service/Call Center agents	$250,000	$1,500,000	$1,500,000	$900,000	$900,000	$900,000	
Gross Annual Costs	**$1,042,000**	**$2,292,000**	**$1,895,000**	**$1,295,000**	**$1,295,000**	**$1,295,000**	**$9,114,000**
Cost Per Airport	**$53**	**$116**	**$96**	**$65**	**$65**	**$65**	**$460**
Localized Benefits							
Increased Revenue from Concessions		$257,731	$257,731	$257,731	$257,731	$257,731	
Check-in kiosks rather than airport workers		$168,000	$168,000	$168,000	$168,000	$168,000	
Net Benefit	**-$53**	**$425,615**	**$425,635**	**$425,666**	**$425,666**	**$425,666**	**$2,128,195**

Table 3 - Cost Benefit Analysis

Summary and Conclusions

Congestion and long lines in airports have been a major problem in recent years. The increasing number of passengers that travel each day through airports results in an unfavorable amount of delayed and missed flights, as well as lost baggage. Additionally, with the presence of a pandemic, these large groups are a public safety hazard. Although the method of having people queue in a physical line, separated by barriers was once effective, it is now outdated; the needs of today's fast-paced society are no longer served by these systems. In fact, they can be detrimental to the flow of airport traffic. There is a need for a newer system that can easily adapt to the growing number of people and can mitigate the problems that come with them.

Some of the possible solutions identified through our research included moving the physical queuing location, reworking physical queues to provide ample space between passengers, and implementing a virtual queuing system. The team decided that the best possible solution to the problem was a virtual queuing system that could be accessed through passenger's mobile devices, similar to what is currently done for certain rides at Disney and Universal Studios Orlando. Next, the team began brainstorming possible app designs while simultaneously outlining the necessary functions of the app. The app guides the user through the entire process between arriving at the airport and boarding the plane while using a virtual queue in the background to ensure users never need to stand in a physical queue.

Currently, there are far too many people who miss their flights due to long lines and confusion within airports. Additionally, these lines create congestion in airport terminals and allow for the spread of such diseases as Covid-19. The app the team designed, titled DragonFly, is designed to take customers through a virtual queue for baggage, airport security, and boarding. Its virtual queuing system will allow travelers to keep track of their place in line without having to stand in the often excruciatingly long lines that exist in airports today. While waiting in

DragonFly's digital queues, travelers are allowed to roam around the airport or sit in designated waiting areas. The app's user-friendly interface allows travelers of all ages to easily navigate the airport processes and to keep track of their positions in the queue. The app can effectively lessen airport congestion, as well as alleviate the threat of the spread of infectious diseases. An virtual queuing system such as DragonFly is the future of organized airport travel.

Appendix A: List of Complete Contact Information

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Appendix B: Description of Binghamton University

Nestled in the Triple Cities area of Binghamton, Endicott, and Johnson City, New York, Binghamton University, State University of New York (SUNY) is at a crossroads of an international education experience. Binghamton University's history dates to 1946 when Triple Cities College was opened in Endicott, New York to provide education for returning World War II veterans. After four years, Triple Cities College became a part of the State University of New York system and was subsequently named Harpur College after the pioneer and teacher Robert

Figure 14 – SUNY Binghamton University Campus View

Harpur. By 1961, Harpur College was moved to Vestal, and by 1965 was officially renamed to the State University of New York at Binghamton [54]. Sixty years later, Binghamton University is the top public college in New York with a focus on unity, identity, and excellence. With over 14,000 undergraduate students, almost 4,000 graduate students, and over 130 majors, minors, certificates, concentrations, emphases, tracks and specializations, Binghamton University encompasses global learning through an inclusive community [55]. Binghamton University currently has six schools and colleges for their academic communities: the Harpur College of Arts and Sciences, the Watson College of Engineering and Applied Science, the School of Management, the Decker College of Nursing and Health Sciences, the College of Community and Public Affairs, and the School of Pharmacy and Pharmaceutical Sciences [56]. The students at Binghamton University are always striving for excellence both in and out of the classroom; the student population holds an average GPA of 3.7, and an overall acceptance rate of 40.5%. Binghamton University hosts over 450 clubs and organizations, as well as a leading role in Division I athletics [57]. Through academic performance and a community of leading students and staff, Binghamton University is a top institution both in New York and across the nation [58].

Appendix C: Description of Non-University Partners

i. Richard Strickland

Richard Strickland has been Senior Director of Airports at Key West International Airport since 2018 and is responsible for the airport's management and operations. Mr. Strickland has over 20 years of experience in airport management. He worked as the Director of Airports for Meadows Field Airport and has also worked for San Diego International Airport, Detroit International Airport, and Palm Springs International Airport. Mr. Strickland is a Certified Member of the American Association of Airport Executives and a prior Board Director of the Southwest Chapter of the American Association of Airport Executives.

ii. Jonathan McCredie

Jonathan McCredie is the co-founder managing principal of Fennick McCredie Architecture, which specializes in aviation architecture. With his 25 years of experience, Mr. McCredie has worked on projects with over two dozen airports across ten states. Many of these projects, including hangars and passenger terminals, have received awards and recognitions due to their complex nature in active airports. Mr. McCredie is a registered architect in five states and has worked as a guest lecturer at Northeastern University School of Architecture. Mr. McCredie used his knowledge of airport design and construction to provide the team with an insight into the possible implementation of virtual queuing systems in airports.

Appendix E. Evaluation of the Educational Experience

i. Student Response

1.) Did the ACRP Design Competition provide a meaningful learning experience for you? Why or why not?

The ACRP Design Competition was able to provide our team with many lessons, and impactful learning experiences we will all use in the future. Among the many reasons this competition was meaningful to our group is that it allowed us all to work on a group project in a more structured way than any of us had before and in addition to this many of us have never worked in a group of such magnitude before. Outside of the group aspect of the project, our team was also pushed to move outside of our comfort zones as it was completely up to us to develop our research project which is very different than a lot of our experiences in the past with research projects. Additionally, the ACRP Design Competition allowed us to come up with a design that could have real-world applications in the future which was a very novel experience for many of us. Overall, this Competition created a new group environment for us to develop our thoughts and ideas and really provided us with the space to exercise the creative and academic areas of our skill sets; this project has been an immersive experience and has shaped all of us in our ways of communicating with others and tackling issues in the future.

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

As with any research project, our team experienced our share of issues throughout the development of our system. As stated previously, for all of us this was the largest group project any of us had worked on, so the biggest initial challenge that had to be overcome was communication between everyone and their respective sections of the project. Our team was able to overcome this issue with extensive use of online communication in addition to having multiple

Zoom meetings every week to ensure that everyone involved in the group was able to contribute effectively to the project. Additionally, one challenge for our group, in particular, was that Binghamton University had a shortened semester this spring giving the team approximately three weeks less time to work on our project. Our team was able to overcome this and finish our submission before the deadline by extensive communication with one another as well as having clear definitions of what work was expected from everyone each week leading up to the project submission. The ACRP Design Competition presented many challenges that we hadn't seen before and encouraged us to be more creative with our solutions and allowed all of us to develop our research and teamwork skills as well as forcing us to be diligent and methodical which will greatly help all of us as we move through the rest of our lives.

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

When developing the hypothesis for our project we initially started the process by performing research into current systems within the airport industry that could be improved and then coming together as a group to discuss the different problems and potential solutions we had individually come up with. After deciding on the scope of the project more specific research was performed into the topic until the hypothesis was developed. Once the research project was decided to be the implementation of virtual queuing our team looked into the current use of technology in airports and how this technology could be improved or introduced in order to create the efficiency of airports as well as increasing customer satisfaction.

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

Participation by industry in the project was appropriate, meaningful, and useful because the industry experts were able to provide new perspectives that we had not previously considered.

Both have worked in areas that would be affected by our research and therefore their perspectives were especially valuable, as the sort of observations and advice they provided would be hard to come by without first-hand experience. It is the kind of information that cannot simply be gleaned from a journal article because it's their personal and lived experiences. They were also able to answer questions and add clarification that we were unable to find elsewhere. These answers and clarifications provided us an opportunity to improve our project, and to accommodate the problems they saw arising from our technology. Their suggestions also guided us on how to improve our project and provide the optimal service for passengers. Overall, the project benefited from the point of view of the industry experts and their exposure to fields relevant to our work.

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

We learned how to work as a part of a team, which means being accountable to others, and managing your own responsibilities, so that no one person bears too much of the burden for the success or failure of the project. Additionally, the project helped us learn how to develop unique solutions to problems that have always existed. This project helped to prepare us to be successful both for entry into the workforce and for continuing our education. It is important to be able to research a problem and brainstorm a solution and be able to present it in a manner that is understandable by someone who is not an expert in the field. Additionally, it is vital to be able to work effectively with people from different areas of expertise and disciplines. The project also helped develop necessary skills of time management, because there were many components to the project as a whole, and it required working on them in a timely manner, so as not to let the tasks accumulate until they became overwhelming. It also taught us how to seek out reputable sources to educate ourselves on a problem that we seek to address, and how to integrate this knowledge into our project, which will be beneficial for any future researcher conduct as well.

ii. Faculty Response

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

The ACRP University Design Competition continues to provide a unique opportunity for students to learn about and formulate solutions to real problems. Such an opportunity is not typically included in the curriculum for freshman and the Competition provides this experience early in their college experience and enables many of them to work outside of their comfort zones to identify solutions to a problem in an industry where they have no previous experience. As part of the Competition, these students have learned to identify, research, and develop a concept to solve a specific problem. In addition, our students had to consider risks that may occur as a result of the implementation and consider the real-world implications that could occur as a result. While the initial thought of the student's proposal may seem substantially correlated to the Covid-19 pandemic and the desire to adequately maintain distance between passengers as they traverse the airport, they eventually took their concept further to address a passenger convenience aspect as the queueing technology will surely enable social distancing but will also provide passengers with increased comfort in planning their trip to the airport and reduced opportunities for delays. The students have taken a concept that is currently loosely used in the aviation industry, particularly with boarding groups used by airlines, as well as seen in other industries (such as theme parks), and have created a concept that could be widely used to significantly improve passenger experience and throughput at airports.

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

Yes. All of the students on the team are undergraduates and are in the second semester of their freshman year. As freshmen, nearly all of these students have had limited opportunities to work in a team setting, as many introductory classes available to freshmen have much higher enrollment and fewer interactions with other students. Further, due to the impacts of the Covid-19 pandemic, these students have a limited number of in-person classes and even further reduced opportunities to work in a team setting. The ACRP University Design Competition enabled us to bring two small groups of students with varying academic interests together to work as teams.

The effort required constant communication and cooperation to ensure that submitted documents meet the course and competition requirements. As the course is offered in the spring semester, our students had to ensure that they were always able to meet at timelines due to the submission deadlines imposed. Further, with modifications to the spring semester timelines due to the Covid-19 pandemic, our course meetings started nearly a full month after they would in typical years, while the competition deadline remained unchanged. These timelines required the teams to work cooperatively and adequately manage their time to meet specific deadlines set for members of the teams. All of these elements are vital to the learning experience that will be useful for these students as they continue their education and move to professional fields.

3. What challenges did the students face and overcome?

There were a number of challenges for our students to overcome as they completed the proposal. The most dominant impact to date is the impact to classes associated with the Covid-19 pandemic. Our students met twice weekly throughout the semester, but in a hybrid manner with students meeting in person one week, and via Zoom the next. Further, the students had to cope with being placed in quarantine or isolation due to testing positive for Covid-19 or being a close contact with someone who had. These students had to relocate from their housing and participate in all class sessions via Zoom (including the in-person meetings). Further, as noted previously, the spring semester commenced on February 12, 2021, nearly four complete weeks after the typical start of the semester. While the University did eliminate most breaks throughout the semester, this still required our students to complete the necessary research within a truncated period to adhere to the competition guidelines.

Outside of the impacts of the Covid-19 pandemic, each student had limited to no knowledge of the aviation industry, which required additional time for them to learn about the key topics that relate to our proposal. We worked with our students early in the semester to ensure that they understood basic information concerning airports and airport facilities. Students were required to complete further research to confirm that they were competent in the areas necessary for their proposal. While a trip to a local airport to meet with airport executives and better understand the queuing process today would have been ideal, it was infeasible in the current environment. However, the students substituted this experience with Zoom interviews of an airport executive and an airport architect.

In addition, the type of research completed in this course is not typical for students at the beginning of their college careers and included concepts and requirements that may not have been covered in many of their previous courses or in high school. The ACRP University Design Competition maintains a strict deadline that requires the project leader to ensure that the submission schedule was followed. The project leader regularly checked in with each team to see what progress was made and set up portals for team members to share work efficiently.

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

Yes. We have used this format for over ten years, and plan to continue its use in the future. The format and structure of the Competition are ideal for this course at Binghamton University. Students who have previously completed this course regularly comment on the value of the experience after it has been completed, both in terms of understanding project management but also in their increased knowledge in one aspect of the aviation industry. This project allows students to not only work on a challenging academic exercise but to work on one with real-world applications that could potentially change how passengers traverse an airport. This experience will be valuable as they continue through their academic career and move into the workforce.

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

The ACRP and FAA have ensured over multiple years that the suggested research topics remained relevant, and we recommend that the practice should continue. Should the current academic environment and calendars remain similar in future years, including later starts to semesters, we would recommend that ACRP and FAA consider extending the deadline for Notice of Intent submission and for final project submission.

Appendix F. Reference List in Full

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