Increased Usage of Satellite Check-In:

Reducing Landside Congestion and Increasing Airport Sustainability

(January 2022 - April 2022)

Design Challenge: Airport Management and Planning: Enhanced Management Approaches to Landside Functions to Include Parking and Ground Transportation

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Executive Summary

Landside congestion can be one of the most negative aspects of an airport and their operations. By addressing the **ACRP Airport Management and Planning** Design Challenge of *enhanced management approaches to landside functions to include parking and ground transportation*, this proposal focuses on reducing landside congestion through the implementation of satellite baggage check-in. The design of satellite baggage check-in allows travelers to either complete steps of the baggage check-in process before arriving at the check-in lobby at the airport, or allow passengers to check their baggage in a remote location and walk into the airport baggage free. Once reviewing existing literature, similar projects in parts across the world, and reaching out to industry experts, three innovative solutions were created for the implementation of satellite baggage check-in. Whether it is implementing the simplified version by installing check-in kiosks at different points of travel on the way to the airport, or the most advanced and long-term solution of improving urban infrastructure, travelers can expect a decrease in stress levels on arrival to an airport and airports can expect a reduction in landside congestion. Passengers would then have the opportunity to arrive at the airport at an optimal time, and would be able to spend more time on the airside, causing travelers to be likely to purchase items that make their overall airport experience more enjoyable. For the design, the two largest benefits are airport revenue increase by customer satisfaction and terminal lobby time cut. These benefits represented give us a benefit to cost ratio of 13.13 to 1, all while producing other benefits outside of cost such as operational, environmental, and social sustainability to an airport. The team consisting of three graduate students from two countries and different aviation backgrounds has created a concept of increasing usage of satellite check-in, all while aiming to reduce landside congestion and increase airport sustainability.

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Problem Statement

In today's world, outdated airport infrastructure has started to create a negative airport experience for passengers (Fallia et al., 2014). With an increasing volume of people traveling by air, it is expected that departure lobbies and airport parking lots would reflect levels of traffic that are not supported by current infrastructure. This causes issues not only for the airport, but for the passengers as they may begin their travel experience stressed and unhappy with how their pre-security experience is (Fallia et al., 2014). This is a proposal presenting a project that can reduce landside traffic congestion by promoting other modes of transportation to airports and increasing overall functionality for passengers.

Public transportation to and from an airport is one of the simplest solutions to relieving landside congestion, however, in the United States there are not many airports connected to public transportation. This leaves many travelers forced to provide their own form of transportation to the airport, by using ride-share services or driving themselves to the airport and utilizing an airport parking lot. To improve passenger functionality pre-security, implementing incentives such as pre-arrival check-in at public transportation stations and satellite check-in stations across airport parking lots would alleviate levels of stress before traveling.

Our proposal presents design ideas that focus on decreasing congestion pre-security as well as enhancing a traveler's overall experience. This design utilizes and improves current airport infrastructure and addresses the **ACRP Airport Management and Planning** challenge of *enhanced management approaches to landside functions to include parking and ground transportation.* This design includes a plan to implement satellite check-in and baggage services, increase use of public transportation, and boost airport and passenger efficiency.

Background

The travel experience in the US has become a headache for travelers with customer satisfaction decreasing due to a variety of issues and experiences at US airports (Fallia et al., 2014). Travelers frequently face situations such as: leaving early to be prepared for the traffic around the airport, dragging bags through train stations to the airport terminal, or waiting for a connecting bus in a parking lot for an extended period of time. As airlines and airports increasingly focus on the airside functionality of the airport, the landside inefficiency has not always caught the attention of airport managers. On top of travelers' experiences, it is worth noting that the inefficiency detracts from airport sustainability as the concept of Airport Greening becomes increasingly prevalent (Janic, 2013). Reducing emissions has always been on the radar for airport management, but they are limited by current airport infrastructure (Janic, 2013).

Compared to other parts of the world, the US is behind on innovative solutions towards airport landside traveler experiences. In newer terminals in China, airport planners create an expanded vertical structure to create a smoother flow line of departing and arriving passengers in the airport architecture. In Hong Kong, the service of in-town check-in at the heart of the city provides travelers with convenience when they use the Airport Express service (Hong Kong MTR, 2022).

In this paper, the authors intend to conduct research on current US airport landside facilities and its problems, and come up with practical and efficient solutions toward alleviating congestion and improving airport travelers' experience. The purpose of this paper combines the goal of elevating passenger experience and decreasing airport emissions, for the future of US airports.

Summary of Literature Review

Our team initially focused our literature review on different methods for reducing airport landside congestion. However, after locating many sources on methods like In-Town Check-In, and reading about its success in other countries, the team decided to focus the research on satellite check-in, as well as its relationship to different modes of transport.

Methods for Reducing Airport Landside Congestion

In-Town Check-In (ITCI) Locations

While In-Town Check-In (ITCI) has seen success in its limited implementation around the world, one place it has not seen any success is in the United States. ITCI locations are airline check-in counters located off site from the airport, usually located in the city center, and are connected to the airport by a direct public transportation link (Yang et al., 2020). Many of these satellite airline check-in locations have passengers check their luggage in the city center, as if you were at the airline counter at an airport, thus beginning your journey in the city center rather than the airport (Yang et al., 2020). These check-in stations vary in size, with some check-in centers resembling that of the terminal lobby of major airports (Hong Kong), to a few kiosks in a train station with a couple airline employees to collect your bags (Bangkok)(Yang et al., 2020). While future ITCI locations can be larger than what currently exists, they cannot get smaller, as Yang et al. (2020) stresses the importance of having airport employees at said check-in stations (Yang et al., 2020). This is to improve the passenger experience for those who may not be as familiar with the self-service technology (SST) normally seen in airline check-in halls (Yang et al., 2020). In the current locations where this type of service exists, the service is the product of a partnership between the airline and local transport company (usually state owned), where the local transport company owns the stations and operates the trains, and the airline will rent out ticket counters and station employees at these locations, thus generating revenue for the city (Yang et al., 2020).

One of the most important aspects of ITCI is that it is an alternative to driving, which reduces congestion at airports. With the increase of passenger air travel in the past few decades, many cities have been unable to build new facilities to keep up with demand, resulting in over-capacity, congested airport facilities that have a negative effect on the passenger experience, airport development, and airline network expansion (Xiao et al., 2016). There are two different ways that ITCI decreases airport congestion; on roadways and inside the terminal itself. First, airport roadways (Tam, 2007). One study found air-rail intermodality (incorporating both a rail segment and air segment in one trip), one of the main tenets of ITCI, reduced airport road congestion (Tam, 2007). Second, ITCI increases the number of the check-in options for the airline in the municipal area both in and outside the airport, meaning if the number of passengers remains constant, and an efficient ITCI location is opened, congestion in an airport lobby itself would decrease (Tam, 2007). This option has gained popularity in various parts of the world in recent years, with Taiwan using ITCI as its main course of action when it comes to decreasing road congestion at its main international airport in Taipei (Yang et al., 2020).

The most popular example of this is Hong Kong MTR's Airport Express link, which opened in 1998 and connects Kowloon Station in the city center of Hong Kong, with Hong Kong International Airport 40 kilometers away (Hong Kong MTR, 2022). After arriving at Kowloon Station in Hong Kong, passengers can drop their luggage at an airline check-in counter at the train station, where it undergoes a security screening similar to what it would go through at the airport and is then loaded onto a baggage car at the end of the train (Hong Kong MTR, 2022). Meanwhile, the passenger is able to print their boarding pass, purchase the fare for the Airport

Express, and board the train without the burden of heavy luggage (Hong Kong MTR, 2022). The train is made up of nine passenger cars (which are able to hold carry-on bags) and one baggage car, and connects the city center to the airport in 24 minutes (Hong Kong MTR, 2022). Upon arrival at HKG, passengers are able to go directly to airport security, thus avoiding a more congested airline check-in experience at the airport (Budge-Reid, 1999).

Increased Usage of Public Transportation

When it comes to intermodal air-rail journeys (i.e., a passenger taking public transportation to the airport for their flight), one of the most important drivers is the option for ITCI (Liu et al., 2021). This relationship goes both ways, as public transportation links to airports are essential to the function of most (if not all) ITCI systems in Asia (Liu et al., 2021).

Some of the differences between various ITCI schemes seen around the world are the type of public transportation links being used, such as intercity HSR (high speed rail) or intra-city MRT (mass rail transit)(Jou et al., 2010). In a study by Jou et al. (2010) various elasticities for different modes of arriving at the airport were found by the researchers in Taiwan. It was found that TIA MRT (Taipei International Airport Mass Rail Transit) had the highest elasticity, as a 10% decrease in travel time on MRT resulted in a 7-9% decrease in market share for each other individual mode studied (self-driving, pickup, taxi, bus, and HSR) (Jou et al., 2010). HSR did not have as high of an elasticity, as a 10% decrease in travel time on HSR, resulted in less than a 1% decrease in market share for each of the other modes studied (Jou et al., 2010). This demonstrates that between cities at airports, MRT is the most effective public transportation option for reducing roadway congestion on airport landside (Jou et al., 2010).

The effect of decreasing congestion not only has a positive environmental and social impact, but also a positive financial impact for society as a whole, fulfilling the triple bottom line

(Elkington, 2007). This positive financial impact is seen from the reduction of congestion at airports, which Janic (2013) displays in *Greening Airports* in a case study about Amsterdam's Schiphol Airport. Users who continue to utilize car, taxi, or bus options after a rail alternative is introduced will experience less congestion as a result of that new rail link (Janic, 2013). This savings in monetary terms was approximately 3.5 million Euros in 2010, but as time goes on and the rail alternative continues to be utilized and become more popular, this savings can increase to up to 6 million Euros per year (Janic, 2013).

Another important contribution Janic's book introduces is the amenities necessary to make public transportation links to airports successful. Three relevant factors to this paper mentioned are handling baggage conveniently, service reliability and regularity, and a reasonable price relative to other modes (Janic, 2013). First, "handling baggage conveniently", Janic is referring to services such as ITCI, where passengers are able to integrate the air and rail legs of their journey, by dropping their luggage in the city center before the initial rail segment and retrieving it after the subsequent air segment(s) (Janic, 2013, 178). Next, "service reliability and regularity" refers to the punctuality and headways of the transit links to the airport, as services will be utilized the most when trains or buses are frequent and on-time (Janic, 2013, 178). Last, "reasonable price relative to other modes" refers to the price of the service compared to driving, taking a taxi, or riding the bus, as users are usually willing to pay a premium for a direct rail link, but only to a certain extent (Janic, 2013, 178).

Using Different Modes of Transit to Enhance Passenger Experience

New Intra-city Transportation Infrastructure at US Airports

Intra-city transportation infrastructure at airports is important in relieving landside congestion, as providing alternative non-car links to city centers (i.e., rail) can reduce the number of vehicles on the airport roadways (Jou et al., 2010). In a paper by Vespermann et al. (2011), the researchers clustered airports into four different groups based on different airport needs and customer needs, with one of these clusters being airports that should focus on alleviating congestion (Vespermann et al., 2011). Qualifying characteristics of these airports were that users were highly dependent on one mode of travel to get to the airport (normally a car/taxi/rental car) and that these airports were not actively trying to expand the airport catchment area, unlike airports elsewhere (Vespermann et al., 2011). It is noted that to solve this issue, many of these airports (almost all of which are in the US) are undertaking projects that link the airport to an off-site intermodal center (Vespermann et al., 2011). Some specific examples mentioned are Denver (DEN) building a commuter rail line from the terminal to the city center, New York City (JFK) creating the AirTrain to two different intermodal centers in Queens, and Miami (MIA) building an Automated People Mover (APM) to the nearby Miami Intermodal Transit Center (Vespermann et al., 2011).

The main difference between the rail link at DEN, and the rail links at JFK and MIA, is the lack of an APM, with the commuter rail service going straight from the terminal to the city center, rather than being connected to the terminal via an APM (Vespermann et al., 2011). This creates another issue for airports, as building high-quality transit that does not require an APM is ideal, however logistically more difficult. In a paper by Givoni et al. (2008), the researchers stress that the location of the rail station in relation to the air terminal is important in determining whether or not a passenger decides to take rail to the airport (Givoni et al., 2008). They mention that while any rail station that is located closer to the airport terminal is important, it is preferable to have a rail station below the airport, as passengers see this as more integrated, and thus, a more attractive option (Givoni et al., 2008). Some good examples of air-rail connections given were at Amsterdam-Schiphol, Tokyo-Narita, and Zurich (Givoni et. al., 2008).

However, Givoni et. al. (2008) stressed that even more important than having an airport rail station below the airport, is ensuring there is no third link between the rail segment and airport, such as a shuttle bus or APM (Givoni et. al., 2008). This perceived “level of inconvenience” plays a large role in passenger mode choice (Givoni et al., 2008, 98). If passengers see that there is a shuttle bus or APM between their rail journey and their air journey, they will be less likely to choose that option (Givoni et al., 2008). Despite this conclusion by the researchers, many airports in the US are currently in the process of building or refurbishing APM links from the airport to local transit, which is co-located within a multimodal transit facility (these facilities typically include a transit link(s), airport parking, and a rental car center). An example of this is Los Angeles International’s new Intermodal Transit Facility and Consolidated Rental Car Center (CONRAC), which includes a direct transit link to LA Metro, a rental car facility, and an APM Link to the Central Terminal Area (Los Angeles World Airports, 2022).

Interlining Agreements between Rail and Airlines

While air and rail may seem like inherently competitive modes, the modes can be complementary, and each mode can help the other become more efficient. An air-rail partnership is when an airline partners with a rail operator on regional services, where the rail operator will carry passengers to a hub airport and the passenger transfers to the partner airline onto a connecting flight (Chen et al., 2016). The types of partnerships vary, with some partnerships including checked luggage from your point of origin to your final destination or fully integrated ticketing, with both your air and rail segments being on the same ticket (Chen et al., 2016). These partnerships tend to be most successful in areas where high-speed rail is already competitive with flying on a regional level, meaning most successful partnerships tend to be located in East Asia and Europe (Chen et al., 2016).

In a study by Chen et al. (2016), it was stated that intercity air-rail partnerships have benefits such as releasing runway capacity, immediately reducing landside congestion, and improving ground access to and from the airport (Chen et al., 2016). This paper was looking at the Hongqiao Transport Hub at Shanghai-Hongqiao Airport in China. The improved ground access in this case was not only limited to the Shanghai metro area, but also the Yangtze River Delta mega-region as a whole, which has over 140 million people living in it, including the mega cities of Shanghai and Hangzhou (Chen et al., 2016).

Another benefit of intercity air-rail partnerships in areas with this population size and density are a significant increase in the catchment area of airports (Xia et al., 2017). A study by Xia et al. (2017) found that intercity air-rail integration is a viable and more popular idea with the increase in airport congestion seen worldwide (Xia et al., 2017). Air-rail integration decreases congestion at airports, is more environmentally sustainable, and increases social welfare in the surrounding area (Xia et al., 2017). This environmental benefit is a result of not only road vehicles being reduced, but also some regional flights being reduced (Xia et al., 2017).

A good example of this includes Lufthansa’s partnership with German rail operator Deutsche Bahn, connecting the airline’s primary hub in Frankfurt, with several cities including Stuttgart, Bonn, and Cologne (Lufthansa, n.d.). Some benefits of this partnership include shorter and more optimal transfers, one ticket for both the Lufthansa flight(s) and Deutsch Bahn train(s), and in the case your train is delayed, Fast Track at the security checkpoint at Frankfurt (Lufthansa, n.d.). One of the main benefits of this partnership for passengers though, similar to ITCI, is that if the rail segment is the first leg, the passenger can check their bags at their point of origin and retrieve them at their destination, eliminating the need them to carry large, checked bags through an already congested Frankfurt Airport (Lufthansa, n.d.).

Facilities that Improve Customer Experience

Automated People Movers (APM)

An Automated People Mover (APM) is a driverless, rail system that tends to be under five miles long, and (in the case of airports) stays in the general vicinity of the airport (ACRP, 2017). There are two types of airport APMs: airside APMs and landside APMs (ACRP, 2017). Landside APMs go from the landside of an airport terminal to other terminals in the airport, a rail station, parking lots, or other airport-related services (ACRP, 2017). Airside APMs connect passenger terminals that are spread farther apart, in the secure area of the airport (ACRP, 2017). According to ACRP Report 37 *Guidebook for Planning and Implementing Automated People Mover Systems at Airports* landside APM system length depends on what the APM is connecting to the airport (ACRP, 2017). First, if the system only connects a long-term parking lot and a rental car center to the terminal, and has a demand between 1,000 and 2,500 people per hour per direction (PPHD), then the system needs to be 1-2 miles long (ACRP, 2017). Second, if the APM serves a rental car center, a long-term parking lot, other terminals, and a regional rail station, and has a demand between 2,500 and 3,500 PPHD, then it needs to be 2-3 miles long (ACRP, 2017).

The same ACRP report also explains how landside APMs have an effect on airport congestion. APMs, due to their shorter headways, are able to have much higher capacities, which makes them much more efficient than vehicles in landside roadways (ACRP, 2017). In addition to decreasing congestion and reducing demand for parking within the terminal area, APM's also reduce noise and air pollution, and are considered more visually appealing (ACRP, 2017). Benefits are also seen for passengers and airport employees, as the reduction in vehicles on the road, as a result of a new APM, leads to less roadway congestion which allows employees and travelers alike to better plan their travel, saving both time and money (ACRP, 2017). While there are benefits of building an APM, they do not eliminate the previously mentioned detriments of building an APM, instead of a direct link to the airport terminal (Givoni et al., 2008).

Parking Lots

While in an optimal world, all airport users have the option to take public transportation to and from the airport, many users still need to drive and park their vehicles at the airport, whether they be travelers or airport employees. Given that airports will always need parking, the question becomes, how do airports optimize the constrained land they own to create the most efficient parking lots?

In a paper by Hsu et al. (2007), the researchers came to two important conclusions. First, business travelers and short-term travelers are most likely to pay the premium to park closer to the airport (Hsu et al., 2007). Second, in high-income areas, remote parking facilities should be built closer to the airport with slightly lower fees, as passengers would be willing to pay the lower fee (relative to the terminal parking lot) to park in a remote lot, as long as it is an acceptable distance from the terminal (Hsu et al., 2007). These results show that airports should have an adequate amount of parking within the terminal area, with a remote parking garage near the airport as well (Hsu et al., 2007). This remote lot could be connected to the terminal via a shuttle bus or APM, which would be an additional time cost to the users paying the slightly lower fees to park in the remote lot (Hsu et al., 2007).

Satellite Check-In in Parking Lots

In another form of satellite check-in, some airports have started check-in services in parking garages, in an attempt to spread out the check-in process and reduce the amount of congestion within the terminal. This concept is seen at one of the most leisure-heavy airports in the United States, Orlando (MCO), where passengers can check their bags up to 90 minutes before their flight departs (Orlando International Airport, n.d.). For passengers flying select airlines, they can go to one of two different parking garages at MCO and go through the same process that they would go through in the terminal (Orlando International Airport, n.d.). Passengers are able to check their luggage and print their boarding passes in the parking garage, allowing them to enter the terminal without having to worry about their checked luggage, and go directly to security (Orlando International Airport, n.d.). Another version of this concept is Southwest Airlines' Skycap services, where Southwest passengers can check bags and print boarding passes on the curb at select Southwest destinations (Southwest Airlines, n.d.). This, however, is only marginally different from the terminal check-in experience, as, at the point where the passenger arrives at the Skycap desk, they have already experienced a similar level of inconvenience as a Southwest passenger utilizing the check-in services inside the terminal.

The Data-Proven Power of Public Transport

In this section, data analysis is conducted to testify to the power of public transportation at the airport. The two main examples to be used in this section are Chicago O'Hare International Airport (ORD) (a major US airport with a rail link), and Hong Kong International Airport (HKG) (a major Asian) that provides a more integrated and streamlined rail link to the airport.

According to Skytrax, a famous international air transport rating organization based in London, ORD is a three-star airport with a four-star public transportation rating (Skytrax, 2020). The main public transportation option at ORD is the CTA Blue Line, which takes passengers from the airport to Downtown Chicago in about 45 minutes, with 3-15-minute headways and various stops in between, 24 hours a day (Chicago Transit Authority, 2022). The airport station is located below Terminal 1, 2, and 3, providing a short connection to the terminal. In November 2021, the airport served 5.3 million people, with the O'Hare Blue Line Station serving 1.6 million passengers in the same month, meaning the equivalent of 30% of the travelers at ORD utilize the Blue Line (Chicago Department of Aviation, 2022; Chicago Transit Authority, 2021).

For Hong Kong International Airport, Skytrax rated HKG a five-star airport, with a five-star rating for public transportation options (Skytrax, 2020). The main rail service that links HKG and Hong Kong Kowloon (downtown) is the Airport Express (Hong Kong MTR, 2022). With a higher fare compared to the rest of the MTR (Hong Kong's metro system) network, it provides passengers amenities such as free wi-fi, charging ports, and most importantly, In-Town Check-In (Hong Kong MTR, 2022). Passengers are able to complete the check-in process at the city center and drop off their bags, creating additional convenience to the passenger (Hong Kong MTR, 2022). The airport had a monthly passenger volume of 6 million in 2019 (Hong Kong International Airport, 2019), and the Airport Express served about 1.3 million people per month in 2019, meaning that the Airport Express served the equivalent of 21% of the passengers at HKG (Hong Kong MTR, n.d.). There are two shortcomings to this; both airports are large connecting hubs of their regions (many passengers flying into and out of the airport would not utilize these rail services), and employees (who are not passengers) are using these services.

Formulation of Design Requirements

Through the ACRP requirements, the formulation of the design is influenced by industry leaders, literature review, and the resources provided by the city in which the research data is collected. The design requirements for the category this topic falls under, Airport Management and Planning, focuses primarily on how improvements to the airfield and planning can improve the efficiency and sustainability of an airport. The design follows the, "enhanced management approaches to landside functions to include parking and ground transportation" (ACRP, 2022, 10), by shifting the focus to encourage travelers to utilize offsite check-in services in order to decrease landside congestion. This suggestion of offsite check-in requires travelers to utilize public transportation from the city center, where they can check-in at a public transportation station, drop their baggage, and take public transportation to the airport with less stress, which in return improves efficiency and overall sustainability.

Team Problem Solving Approach

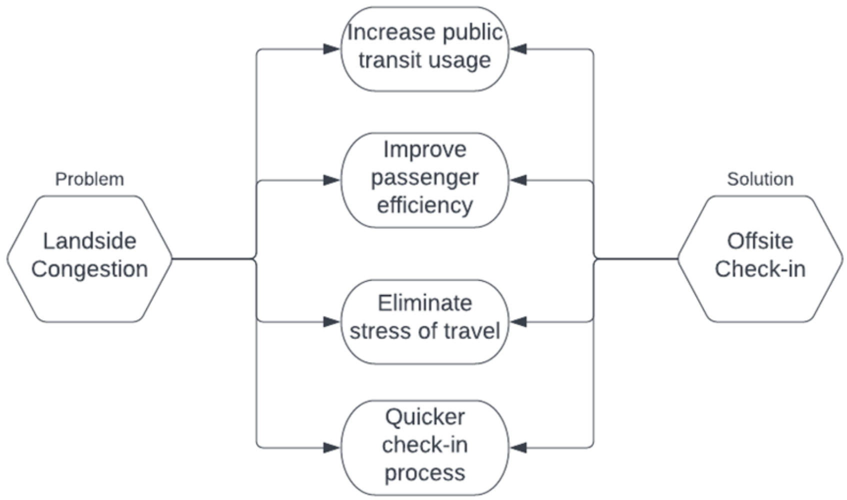
The research team identified several underlying goals that needed to be met to make this project successful. After speaking with the aviation industry experts and getting perspectives from the airline, airport, and consulting sectors of the industry, the research team was able to restructure these goals and narrow them down to three main categories of goals. The three categories determined were: (1) Airport Safety and Security, (2) Airport Sustainability, and (3) Revenue Generation, which each included several sub categories.

Investigating the Problem

To look at the problem more broadly, the team created a converging-diverging diagram to consider the problem, the goals in achieving the problem, and the solution that the research team came to before consulting experts. This converging-diverging chart is shown in Figure 1.

Figure 1:

Converging-Diverging Problem and Solution Chart



The research team presented each of the experts with the chart (Figure 1) and received feedback that inspired the team to restructure its goals. The feedback these goals was as follows:

1. **Increase Public Transport Usage:** The research team learned from Mr. Alan Gonzalez from DFW that public transportation can be vital in reducing landside congestion for busier airports. The team learned that New York City specifically (EWR, JFK, and LGA) has direct transit links that alleviate landside congestion at each of those airports.

2. **Improve Passenger Efficiency:** The team learned from all of the experts that for this project to be successful, it would require improved passenger efficiency. In the conversation with United Airlines, the research team found that airlines divide passengers by how prepared they are when they arrive at the airport, then aim to optimize the efficiency of each group with a different solution to move customers through the airport lobby faster.

3. **Eliminate Stress of Travel:** For passengers to utilize any new process an airport implements; it needs to benefit them in some way the past solution did not. The design of the idea needed to be less stressful and provide greater convenience than the current process to win over customers.

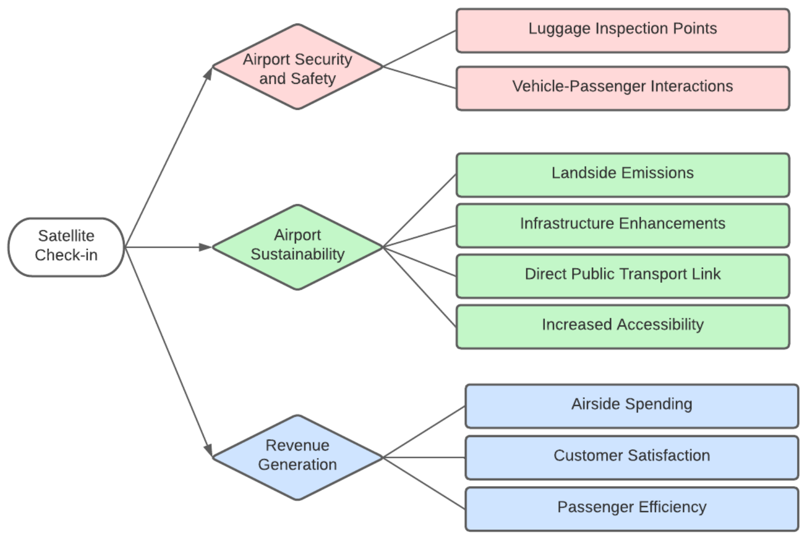
4. **Quicker Check-In Process:** In the conversation with United Airlines, the research team learned the goal for an enhanced transit option was to get passengers through the terminal. It was also learned that passengers should finish the check-in process faster (or even before they enter the terminal) in order to avoid queues that would disrupt the passenger experience, which could be achieved by starting the check-in process before entering the airport (i.e., airline app).

Concept Development

After consulting the industry experts, the research team developed the three main categories of goals for what the project would be focused on; airport safety, airport sustainability, and revenue generation. The team used a branch diagram which starts with the solution (Satellite Check-In) and branches off into the three main categories of branches of goals, and subsequent sub-categories. This diagram is displayed below in Figure 2.

Figure 2:

Developed Branch Diagram



1. Airport Safety and Security

a. **Luggage Inspection Points:** The team received one suggestion from Alan Gonzalez at DFW; that security needed to be a focal point of any solution. The team learned that security could make or break projects such as landside APMs or integrated baggage systems.

b. **Vehicle-Passenger Interactions:** To avoid an increased number of passenger-vehicle interactions and therefore potential accidents, the research team wanted a solution that included fewer cars on airport roadways that could potentially strike passengers.

2. Airport Sustainability

a. **Landside Emissions:** After reviewing the United Nations Sustainable Development Goals, the team wanted to reduce personal vehicle emissions to follow SDGs 3, 11, and 13. Reducing personal vehicle emissions at the airport through increased public transportation usage improves air quality around the airport, and increases reliance on clean energy rather than fossil fuels.

b. **Infrastructure Enhancements:** Shifting passenger travel modes from car-dominant to an evenly-distributed share of modes gives airport roadways a longer lifespan meaning fewer enhancements are required, and allows airports to invest in sustainable infrastructure such as rail.

c. **Direct Public Transport Link:** After a thorough literature review, the team found that airport public transportation linked directly to the terminal transported more passengers than those that run adjacent or nearby the airport, and are connected via APM (Givoni et al., 2008).

d. **Increased Accessibility:** The team's discussion with Alan Gonzalez inspired them to make solutions that are inclusive for all passengers. This follows UN SDG 10: Reducing Inequalities.

3. Revenue Generation

a. **Airside Spending:** The literature review found that a 1% increase in customer satisfaction leads to a 1.5% increase in customer spending (ACI, 2016). The team also included customer satisfaction as one of its goals, as it increases airside spending.

b. **Customer Satisfaction:** The research team learned from all of the experts that increased customer satisfaction would also increase the likelihood the passenger uses that airport again. This benefits the airport, as the more passengers start to prefer that specific airport, the more likely airlines are to further invest into that airport with more flights and services.

c. **Passenger Efficiency:** The team learned from United Airlines that passenger efficiency is important, as having passengers complete as much of the check-in process before entering the airline lobby decreases the time spent landside, and increases the time they spend airside.

Description of Idea

To streamline the process, one of the goals of the design process was to reduce the time spent on the landside of the terminal and initiate the check-in process as early as possible in the travel experience. Considering the feasibility of the current airport infrastructure, there are two possible ways of implementation, with the long-term goal of redesigning the infrastructure involved. Each of the following processes are outlined visually in Figure 3.

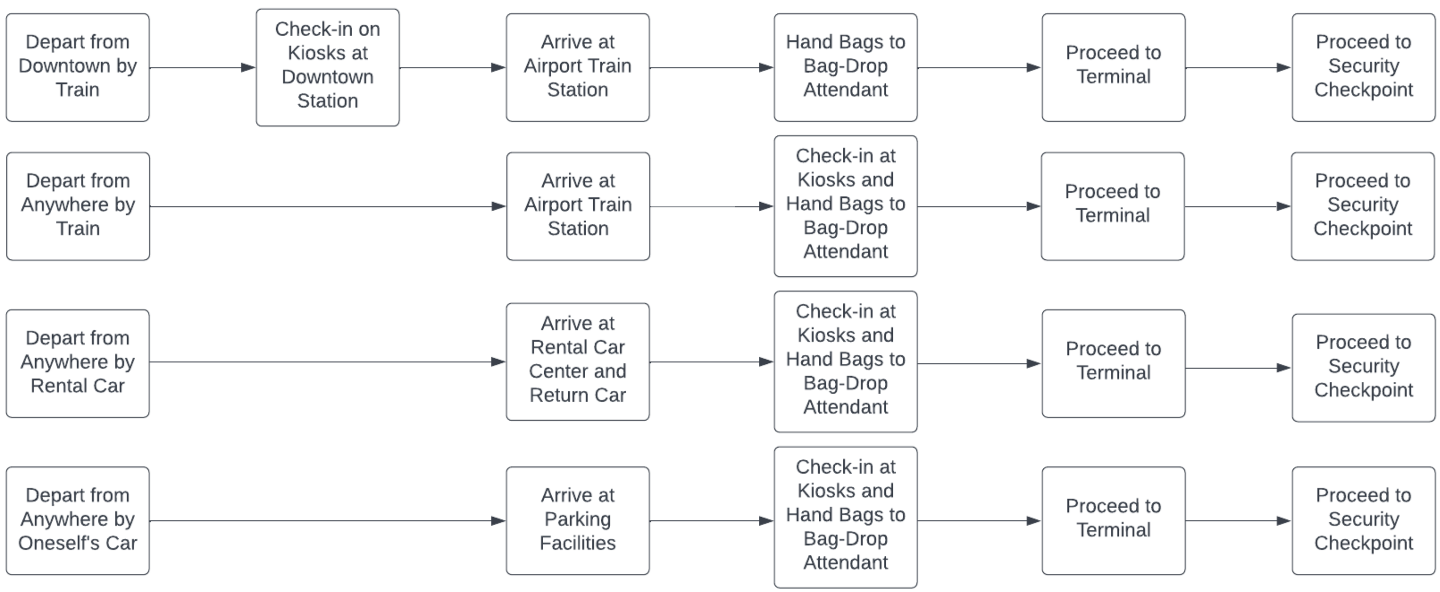
Solution one is the simplified version, with check-in kiosks added at different points of travel en route to the airport terminal. As the check-in process has been made available extensively online, the main function of these kiosks is to help those passengers who need to check their bags. These passengers can pay for the checked baggage fees, print baggage tags, and print boarding passes before they enter the terminal, which reduces the time spent in the terminal lobby. The kiosks are added at parking facilities, ground transportation centers, and if available, different stations on the rail link between the airport and the city, especially the downtown stations. Dedicated counters for baggage drop off can be implemented for easier flow management and improved customer experience.

Solution two is the enhanced solution. Along with those check-in kiosks added, checked bag drop-off is made available at the ground transportation center, parking facilities, and possibly the airport train station. Staff members are onsite to assist passengers with the check-in/bag-tag process, check their ID, and ensure bags are in compliance with TSA regulations. Luggage carts are used to transfer bags onto a van, which takes the bags to the airport terminal. These checked bags undergo required security screenings and enter the terminal baggage system. This solution offers convenience for travelers and allows them to go to the terminal with only hand luggage.

The long-term solution is centered around the improvement of infrastructure in the city center. The rail link between the airport and the city should be completely redesigned, with the capability of offering riders in-town check-in. The downtown railway stations are equipped with check-in counters and luggage belts, and the trains are designed with a car for baggage.

Figure 3:

Process Map for Enhanced Solution: 4 scenarios introduced



The riders are able to complete the check-in process and drop off their bags which are loaded onto the luggage cart of the train. Upon arrival at the airport station, the bags are able to be unloaded and enter the secure airport terminal baggage system with a predesigned process and infrastructure. While this solution is not possible with most US airports (even if they have a current rail link), they should be considered in the long term when a major refurbishment of the public transportation system is necessary.

Interaction with Airport Operators and Industry Experts

Throughout the design project, the research team had multiple meetings with industry experts to get feedback on the design and what the team could improve. These meetings included the team discussing the goals of the project, feedback from the industry experts, and other relevant discussion that could improve the design idea. The experts consulted were:

1. Kenny Frank- Manager, Above the Wing Solutions & Innovation, United Airlines
2. Keith Heisler- Sr. Analyst, Above the Wing Solutions & Innovation, United Airlines
3. Alan Gonzalez- Landside Manager, Dallas-Fort Worth International Airport (DFW)
4. John Van Woesnel- Vice President WSP-USA,

Interaction with United Airlines Above the Wing Solutions Team

The meeting with the team from United Airlines Above the Wing Solutions & Innovation gave the team a great perspective of landside congestion and how airlines address that issue. While this is not directly related to airport revenues, if the airline is not happy with the design of an airport, they are less likely to invest in that airport, meaning the airport could lose revenue.

The most important information the team learned from this interaction surrounded costs, specifically the costs of airport automated kiosks and the inflated costs of doing construction anywhere at an airport. The research team understood to be cautious when forecasting costs in building the fully enhanced solution, as this would require the rearrangement of significant infrastructure at airports, to get the bags from a rail station to the secure baggage facilities. Along with costs, the team used a simple solution of installing automated kiosks that do not require staff in common use areas before the airline check-in hall (i.e. parking lots, airport rail stations, etc.) to forecast costs of automated kiosks, as this reduces the number of people waiting in line in the physical check-in hall and reduces congestion. The research team learned that adapting this process for a common use terminal (i.e, terminals with multiple carriers or lack a dominant carrier) could be beneficial as it would have a wider range of applicability.

Interaction with DFW Landside Management

The meeting with Mr. Alan Gonzalez, Manager of Landside Management at Dallas Fort Worth International Airport (DFW) yielded various insights into the issue of lanside congestion from the point of view of airports. The impression is that there are various techniques that airports currently employ to reduce landside congestion, which included cell phone parking lots, entrance tolls to enter the airport roadway, and performing curbside reallocations to optimize where services are being located on the curbside.

Another insight the research team gained was that the success of the solution that includes public transit is dependent on the metropolitan area the airport serves. While there are two different rail services from Dallas and Fort Worth, respectively, it may not have a significant impact on landside congestion. Conversely, in cities such as New York City, Chicago, and Washington DC, where there are robust transit networks and direct rail links to airports, this solution has a much more significant impact.

A third and final insight was that Mr. Gonzalez emphasized that automated kiosks are preferred to staffed kiosks. A cost for labor may be $15/hour, or about $32,000/year/employee, however the airport could use contracted labor where labor costs are higher, meaning that labor costs could make the project significantly more expensive.

Interaction with WSP-USA

There were multiple insights that the team learned in our conversation with WSP-USA. First, the team learned to look at similar projects under development, such as the LAX CONRAC project. This project is similar to the research team's goals, as it aims to reduce landside congestion through increased transit usage. Second, the team learned it needed to find a solution that was more convenient than the current option, as if the new option is not more convenient than the original option, it will not attract passengers.

Safety Risk Assessment

The team performed a Safety Risk Assessment similar to that found in AC 150-5200/37, in order to assess the level of risk associated with the proposed solution (FAA, 2007). The vertical axis contains risk severity (on a scale of negligible (1) to catastrophic (5)), and the horizontal axis contains risk probability (on a scale of remote (1) to frequent (5)). Total Risk is equal to the product of risk severity and risk probability, and ranges from a score of 1 (remote and negligible risks) to a score of 25 (frequent and catastrophic risk). Below in Table 1 is a Safety Risk Matrix, with each number representing a risk identified in this project. In Table 2 are the safety risks, with their severity, probability, total risk, and potential solutions that could decrease those risks.

For each solution, there are different safety concerns related to the operations of those facilities. First, the simplified solution where extra kiosks are added outside of the terminal, in spaces like parking facilities. It is already common to have these kiosks installed outside of the terminal, but they can be added in spaces that were not designed for such activities, such as a

Table 1:

Safety Risk Matrix

		Probability				
		Frequent (5)	Very Probable (4)	Probable (3)	Occasional (2)	Remote (1)
Severity	Catastrophic (5)					
	Critical (4)		3	2		
	Marginal (3)					
	Minute (2)			1		
	Negligible (1)					

Table 2:

Safety Risk Chart

Risk #	Risk	Severity	Probability	Total Risk	Potential Solutions
1	Car Hitting Automated Kiosk	2	3	6	Adding reflective tape to kiosks when near vehicles or Installing barriers between kiosks and vehicles
2	Baggage Containing Hazardous Items	4	3	12	Ensuring baggage goes through appropriate secruity screening processes in terminal before entering airside
3	Baggage Being Tampered With	4	4	16	Ensure employees have SIDA access & background checks Bags undergo security screening at check-in location & airport

parking garage. Kiosks can be added at the exit of the garage towards the terminal, which can have cars passing by at a close distance. In this example, the risk of a vehicle striking a kiosk is designated by the 1 in the safety risk matrix and safety risk chart above (Table 1 & 2).

Next, the enhanced solution involves baggage check outside of the terminal. Inside the terminal, all collected baggage goes onto a conveyor belt and through an enhanced security screening. With the enhanced solution, bags are collected from those remote check-in locations, which involves a process of baggage collection, transportation, and sending through the terminal baggage system. While customers are required to confirm there is no hazardous content or prohibited items in their baggage, it is still possible that hazardous luggage gets transported to the terminal before staff members can find certain hazardous materials. If these hazardous materials are not found, staff members on site and other bags are at risk. This particular risk is demonstrated as the number 2 on the safety risk matrix and safety risk chart (Table 1 & 2).

With in-town check-in facilities, new infrastructure that is built comes with more safety risks. Hazardous bags can still be a major safety risk in the whole process, therefore, it is important to mitigate the hazardous bag risk by performing a safety screening of the checked bags upon check-in at the downtown location. Even though those bags are screened, it is not guaranteed that they are safe to be loaded on aircraft, with these bags being exposed to various individuals between the downtown check-in location and the secure airport baggage system. This risk can be minimized by ensuring only employees who hold SIDA badges have access to bags, and is displayed by the number 3 on the safety risk matrix and safety risk chart (Table 1 & 2).

Sustainability Analysis

ICAO (2011) has defined sustainability to its best abilities in aviation as, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (ICAO, 2011, 21). As the aviation industry strives to create a more sustainable environment, the Economic vitality, Operation efficiency, Natural resources, and Social responsibility (EONS) approach is a concept that is known to assess sustainability (ACRP, 2015). By expanding the triple bottom line, EONS allows for emphasis on operational efficiency, which allows for success in stimulating economic growth, protecting the environment, being good corporate citizens, and efficiently operating facilities (SAGA, 2015; Elkington, 2007).

A sustainability assessment for Increased Usage of Satellite Check-In is developed using EONS. This assessment is completed by allocating the concepts each impact of the design has to a subject of EONS. Table 3 provides an overview of the sustainability impact and action of the overall project and the assessment of whether it improves or reduces airport sustainability. Each mentioned impact fits into a subject of EONS and is deeply considered in the design process for both the simplified and enhanced version of the design proposal.

Table 3.

Sustainability Assessment

EONS	Sustainability Impact	Improve or Reduce Airport Sustainability
Economic Vitality	Increased passenger airside time and nonaeronautical revenue	Improve
	Employing baggage individuals at remote facilities	Improve
	Increase revenue of airport public transportation fares or any other additional surcharges	Improve
Operational Efficiency	Decrease landside car traffic	Improve
	Improve passenger efficiency	Improve
	Quicker check-in process	Improve
Natural Resources	Reduction in energy use by less time in terminal	Improve
	Implementation of kiosks or other forms of new infrastructure	Reduce
	Increase in cleaner air from less fuel used by personal vehicles	Improve
Social Responsibility	Encouragement to use public transportation	Improve
	Increased accessibility to airports (accommodates those unable to drive to airport and carry heavy bags to terminal)	Improve
	Reduction in CO2 from fewer landside vehicles	Improve

United Nations Sustainable Development Goals

In 2015, the United Nations established 17 sustainable development goals (SDGs) that were meant to be a “blueprint to achieve a better and more sustainable future for all” (United Nations, 2015, para. 1). While these goals can be applied to all types of development, some of these goals are notably applicable to infrastructure development, especially in the wake of climate change around the world. Thus, airports can use these goals as sustainability guidelines when developing new projects in order to achieve sustainable outcomes. Table 4 below displays how this project follows some of these sustainable development goals.

Table 4: *Applicability of United Nations Sustainable Development Goals to Proposal*

UN Sustainable Development Goals (United Nations, 2015)	Specific Applicability to Proposal
3 GOOD HEALTH AND WELL-BEING	"By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination" (United Nations, 2015)
7 AFFORDABLE AND CLEAN ENERGY	"By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology" (United Nations, 2015)
11 SUSTAINABLE CITIES AND COMMUNITIES	"By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport" (United Nations, 2015)
13 CLIMATE ACTION	"Integrate climate change measures into national policies, strategies and planning" (United Nations, 2015)

Regulatory and Legislative Issues

Regulators of the aviation industry are familiar with airports, with the Federal Aviation Administration being the center of the regulation. However, different airports are in different situations in terms of the control of the airport management agency. For example, in Chicago, Chicago Department of Aviation (CDA) manages both Midway (MDW) and O'Hare (ORD), and CDA is directly affiliated with the City of Chicago. In Seattle, the airport management organization is the Port of Seattle, which is a government agency run by elected officials from King County that also manages the sea ports within the Greater Seattle Area. In Boston, the similar functionality is performed by Massachusetts Port Authority, which manages three airports, seaports, and ferry terminals. These examples are representative of the different management entities of US airports. As public facilities, development of these airports has to go through different processes. What each airport management entity can do with the parking lots of each airport can be different when adding new facilities.

As public transportation is one of the approaches to streamline the overall passenger experience, adding extra facilities at the train stations would require the local Department of Transportation to be involved in the design and approval process. On top of different airport management entities, the FAA plays the major role in regulating airports and aviation security. It is a more complicated implementation when passenger baggage is involved in remote check-in projects. The Transportation Security Administration (TSA), who conducts the on-site security check of both passengers and baggage, is the main government authority to gain approval from, as airport management coordinates baggage security check before bags get loaded on the aircraft. Overall, there are various governmental agencies involved in the implementation of this project.

Cost-Benefit Analysis

Reducing landside congestion has many benefits for both passengers and the airport. It is straightforward that a passenger's overall satisfaction with the travel experience increases with the solution implemented, which results in the airport being the preferred choice of travelers, and thus capturing more passengers. The analysis by Airport Council International (2016) found that an increase of 1% in the global passenger satisfaction generates an average growth of 1.5% in non-aeronautical revenue, significantly out-performing the impact of commensurate increases in both retail space and passenger traffic (ACI, 2016). Even though the project's actual implementation can achieve different results at different airports, the improved customer satisfaction can be a big factor to drive revenue at key airports. Take Chicago O'Hare (ORD) as an example. According to a study by J.D. Power (2021), out of the scale of 1,000 points, ORD only scored 758. 22 points below the Mega Airport category average of 780, and 47 points below Phoenix (PHX) which was first in the Mega Airport category (J.D. Power, 2021). The airport had a non-aeronautical revenue of $375.6 million in 2019, and the above sector of revenue has a growth rate of around 7.5% every year (City of Chicago, 2019).

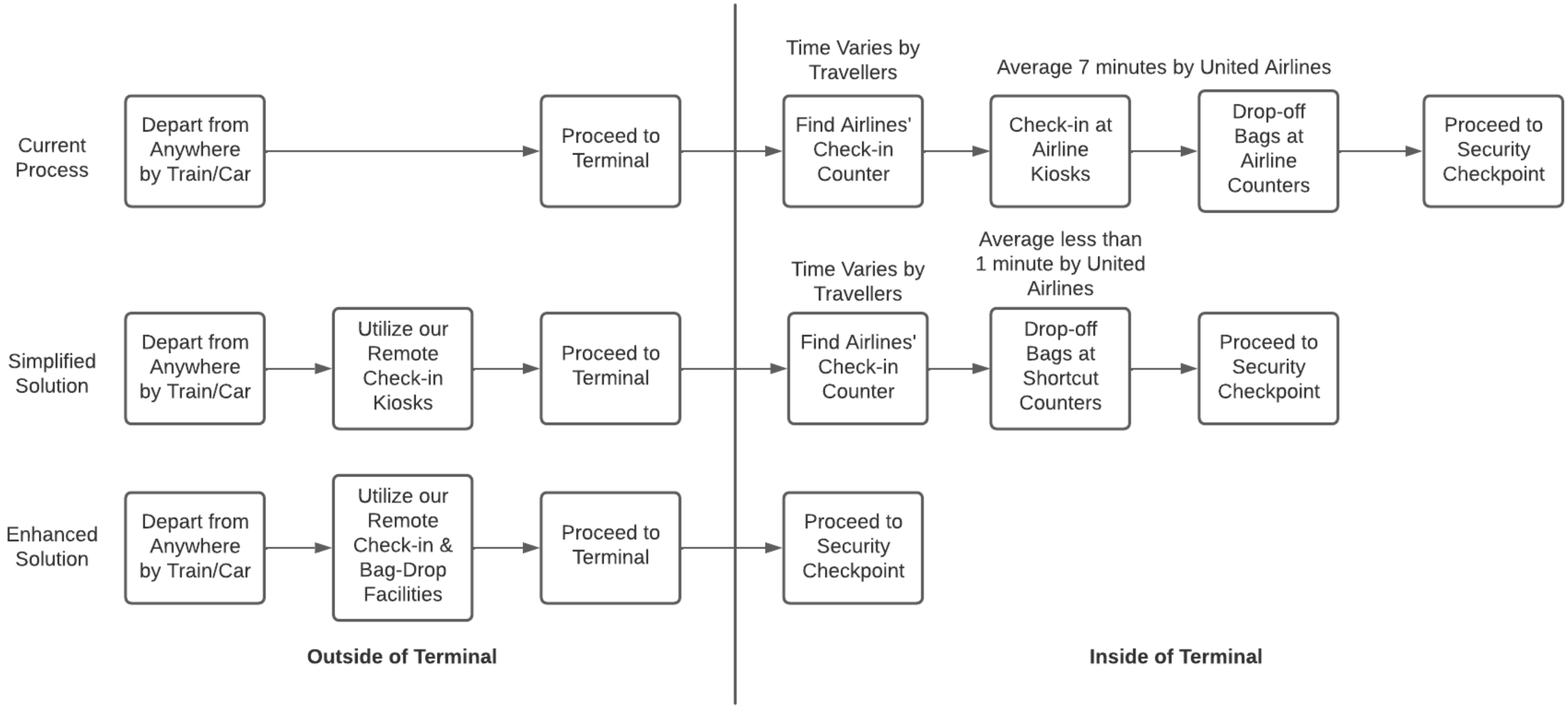
According to J.D. Power (2015) with the same metrics rating customer satisfaction at airports, they stated that check-in and security lines make or break airport satisfaction (J.D. Power, 2015). Satisfaction with the check-in experience among travelers that spend under 5 minutes in the check-in process at the airport (including checking their bags) is 797. This decreases to 773 when the check-in process takes between 6 and 10 minutes (J.D. Power, 2015). After implementing the above solutions, congestion is greatly reduced since kiosk check-in and bag-tag is completed outside of the terminal. Using the JD Power scores above, there is a 3.1% increase in customer satisfaction (773 to 797), when check-in time is reduced to under five minutes (J.D. Power, 2015). When considering the 1.5% increase in non-aeronautical revenue per 1% increase in customer satisfaction figure mentioned earlier (ACI, 2016), this leads to a 4.7% increase in non-aeronautical revenue. To apply that to Chicago O'Hare, ORD would have been able to achieve an increase in revenue of $17.5 million in 2019.

The effectiveness of cutting wait time at the airport is an important metric to analyze the performance of the satellite check-in facilities. Most US airlines and airports advise passengers to arrive at the airport two hours prior to domestic departure, and three hours prior to international departure. It is also common that minimum check-in time before flight departure is 45 minutes with checked bags, and 30 minutes without them. According to Frank (2022) from United Airlines Above the Wing Solutions team, the average lobby time spent by passengers checking bags is around 7 minutes (Frank, 2022). Bag Drop Shortcut is a new solution created by United Airlines that enables passengers who are Travel-Ready, meaning those who have checked in and paid for their bags, to use a touch free kiosk and designated counters to have their ID checked and their bag dropped off (Frank, 2022). This team claims that the passengers spend less than 1 minute on average to complete the process (Frank, 2022). Therefore, it is reasonable to assume that the simplified solution can save 6 minutes on average, as passengers arrive at the terminal with their bags already tagged (Frank, 2022). Similarly, the enhanced solution which enables the process to be completed outside of the terminal, can save even more time.

The Greater Toronto Airports Authority has found that the faster passengers clear security, the more likely it is they spend money once airside. The GTAA prediction model shows that reducing the average security wait time by just one minute across the airport leads to an additional US$1.5m to US$2.3m annual increase in sales (James, 2016). Even though this analysis provides numbers based on the security waiting time cut, this translates into all landside activities. Additionally, a Chicago-based airport ground transportation provider GO Airport Express found that with the airlines collecting record-high bag fees, 55% of travelers still check their luggage either all or some of the time (Airline Industry Information, 2013). With ORD as an example again, the enhanced solution can eliminate the lobby time all at once, meaning an average of 7 minutes cut in the landside time. To translate the figures from Toronto to ORD, this 7 minutes of time saved on the landside per passenger can bring the airport a $11.0 million increase in revenue. Below in Figure 6 shows how the different solutions eliminate some of the steps in the travel process and can bring an easier understanding.

Figure 6:

Process Map Showcasing the Benefit of the Solution



Frank, K. (2022, Mar 30). *Bag Drop Shortcut Project.* United Airlines, Chicago, IL.

Along with the monetary and time benefits of this solution, there are other benefits that can be difficult to assess. The solution can increase the usage of public transportation and decrease the usage of parking facilities. Curbside drop off volumes decrease, with less vehicles dropping off passengers and more passengers taking rail. Some invisible benefits include further improvement of the passenger experience of curbside drop off or longevity of the roads around airports. All in all, both airport revenue and sustainability are improved through this project.

On the other hand, cost is considered for this project to be beneficial for the airport. According to Frank (2022) from the United's Above the Wing Solutions team, an overall cost of an individual kiosk can be up to $20,000 with the consideration of rental space, operating cost, and manpower to maintain (Frank, 2022). Assuming these kiosks have a 5-year life span, the annual cost can be around $4,000 per kiosk. Using Chicago as an example, simplified solutions can be implemented with kiosks installed at airport stations such as O'Hare and downtown stations such as Clark/Lake, Monroe, or Jackson, along with parking and multi-modal transportation facilities. An implementation similar to this would include a total of 50 kiosks.

The enhanced solution has increased costs as more employees are needed for kiosks, and the operating cost for a van. For the labor cost, we assumed the van operates 16 hours per day (5am-9pm) with 10 people at the same time and that the wage was $18.30/hr (wage of customer service agents at ORD) (Delta Air Lines, 2021). Two onsite supervisors (16 hrs) and two business-hour managers (8 hrs) are added to the cost, leading to a labor cost of $1,652,720.

For the operating cost of the van, the average cost of operating a minivan per mile is $0.67 (AAA, 2020). For three round trips every hour between the Chicago O'Hare Multimodal Transportation Center to the terminal, it costs $58,692 to operate the van annually.

When including the cost of labor, kiosks, and operations (including a van), the overall cost for operations for the enhanced solution at Chicago O'Hare equals $1,711,412.

Other costs beyond operations can be estimated as well. The research and development part of the team including the advisor, can be roughly estimated with $20 per hour per student and $100 per hour per advisor. With the 3 student and 1 advisor team, an annual cost of $1,200 is included, assuming 5-year validity. An airport development team would be in charge of the meetings for negotiation, interactions with the authorities and other tasks, adding an annual cost of $5,000 to the calculation. Kiosk installation and space layout change induces a yearly cost of $2,600 assuming a 5-year validity. The team plans on hiring architects for further design plans and compliance for the initial installation with an annual cost of $20,000, with a 5-year validity. Consultants are also hired to assist in planning operations, take care of permits and contracts, and provide general guidance, which induces a cost of $225,000 annually. The overall benefit with the enhanced solution is $26,272,688 per year considering a five-year timespan, with a benefit/cost ratio of 13.13. Table 5 below summarizes all of the items of cost/benefit with the calculations and explanation for the example at Chicago O'Hare, for a 5 year timespan.

Table 5:

Cost-Benefit Analysis Example for Chicago O'Hare

Annual Cost/Benefit Analysis for Chicago O'Hare / ORD	**Benefit Per Year**	**Cost Per Year**	**Breakdown**
Revenue Increase by Customer Satisfaction	$ 17,465,400		3.1% * 1.5 * $375,600,000 Percentage of satisfaction increase with translation to revenue increase at ORD (J.D. Power, 2015, ACI, 2016 & City of Chicago, 2019)
Revenue Increase by Terminal Lobby Time Cut	$ 10,972,500		7min * $2,850,000 * 55% Wait time cut times revenue increase by minute applying to ratio of passenger checking bags (Based on study for Toronto YYZ, James, 2016 & Air Industry Information, 2013)
Kiosk Cost with Initial Purchase and Maintenance		$ (200,000)	50 Kiosks * $20000 / 5 years lifespan (Frank, 2022)
Bag Drop Facility Operations Cost — Staff (Include Training)		$ (1,068,720)	16h * 10 * $18.3/h * 365 days (10 people operations for 16h per day, Delta Air Lines, 2021)
Bag Drop Facility Operations Cost — Onsite Supervisor		$ (292,000)	16h * 2 * $25/h * 365 days (2 supervisor operations for 16h per day)
Bag Drop Facility Operations Cost — Management		$ (292,000)	8h * 2 * $50/h * 365 days (2 manager for 8h per day)
Bag Drop Facility Operations Cost — Van		$ (58,692)	$0.67 * 2.5 miles * 96 * 365 (ORD Multimodal to Terminal Distance, 3 roundtrips per hour, AAA, 2020)
Research & Development		$ (1,200)	($20/h * 150h + $100 * 30h)/5 (Student + Advisor, good for 5 years)
Airport Development Team		$ (5,000)	$50/h * 100h (Meetings for negotiation, interactions with other authorities as necessary)
Kiosk Installation and Space Layout Change Cost		$ (2,600)	($30/h * 100h + $10,000)/5 (100h labor and infrastructure change for 5 years)
Architects for Plans and Compliance		$ (20,000)	$100,000/5 (Initial cost of architects)
Consultants for Permit, Contract, and Operations Advisory		$ (225,000)	($75/h * 15h * 50 *4) 4 consultants with 15h weekly work
Summed Benefit and Cost	$ 28,437,900	$ (2,165,212)	
Overall Benefit per Year	**$ 26,272,688**		
Benefit/Cost Ratio	**13.13**		Note: All numbers averaged over a 5-year time span

Projected Impacts of Design

The idea and designs of increased usage of satellite check-in, with the three solutions, can be implemented at almost every airport where commercial service exists. The first solution, being the most simplified, would be the largest input as this requires either a parking facility, ground transportation centers, or public transportation stations that connect travelers from a downtown area to the airport. Solution two would be a step up from this, and available at large airports where more people are traveling with checked bags. Finally, solution three is a long-term idea focused on improving infrastructure, primarily providing an in-town check-in for travelers in a city where the airport is connected to the downtown area via train. Each solution would be uniquely considered.

Increasing satellite check-in would improve landside congestion as more people who are checking bags would be inclined to use one of the satellite check-in stations to check-in before entering the airport lobby. These travelers would then be using either a bus, van, or train to get to the airport, which decreases the number of cars in the arrivals and departures curbside of airports. This leads to decreased emissions, which translates to improving the airport's sustainability as well as creating cleaner air in the surrounding area.

Altogether, satellite check-in alleviates a level of stress that travelers have upon arrival to an airport, but now travelers can walk bagless and stress free into their journey, and allow more time to be spent on the airside of the airport. With an increase of travelers spending more time on the airside of the airport, it is safe to assume that airport booths would experience more traffic therefore causing an uptick in airport sales. Overall, implementing one of the suggested solutions for satellite check-in would allow for less stressed travelers, a decrease in landside congestion and emissions, and an increase in revenue for airports.

Conclusion

While COVID-19 created a significant drop in airline passenger numbers in 2020 and 2021, passengers are increasing in 2022 and are exceeding 2019 levels. This dramatic increase in passengers along with a shortage in staffing at airports, reducing landside congestion is a vital part of ensuring a positive customer experience, which increases the number of passengers traveling through that airport. The solution of installing kiosks in various locations outside the dedicated airport check-in lobby such as parking garages, rental car facilities, or airport rail facilities, allows an airport to grow without increasing congestion.

Another equally important responsibility of airports is improving sustainability in aviation. While the number of passengers increases, the footprint left by the industry does not increase. The solution incentivizes public transportation usage by co-locating automated airport baggage check-in kiosks with public transportation hubs both at the airport and in-town locations. This helps improve aviation sustainability, as well as quality of life in the neighborhoods surrounding the airport. The solution is financially sustainable, as it has a benefit-cost ratio of 13.13 to 1, for the example at Chicago O'Hare (ORD).

In the future, this solution may be expanded to create dedicated in-town check-in facilities that integrate with the baggage system at the airport, which would create an unrivaled experience for travelers. An investment of this type would require a significant amount of funds from airports and governmental sources. Despite the costs, a project like this could have a significant positive effect on public transit ridership to the airport, as well as a positive effect on landside congestion. The overall benefit brought by this project would still outweigh the cost for each of the three solutions, especially for congested airports. Therefore improving the economic, operational, environmental, and social sustainability of the airport.

Appendix

Appendix A: Contact Information for Team Members and Faculty Advisors

Advisor Information:

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Appendix B: Description of University or College

“About Purdue University” (Purdue University Polytechnic Institute)

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

Founded in 1869 in West Lafayette, Indiana, the university proudly serves its state as well as the nation and the world. Academically, Purdue’s role as a major research institution is supported by top-ranking disciplines in pharmacy, business, engineering, and agriculture. More than 39,000 students are enrolled here. All 50 states and 130 countries are represented. Add about 950 student organizations and Big Ten Boilermaker athletics, and you get a college atmosphere that’s without rival.” (Purdue Polytechnic Institute, para. 1-2, 2022)

“About Purdue University School of Aviation and Transportation Technology” (Purdue University Polytechnic Institute)

“Purdue University’s School of Aviation and Transportation Technology, one of six departments and schools in the Purdue Polytechnic Institute, is recognized worldwide as a leader in aviation education. All seven of Purdue’s Aviation and Transportation Technology undergraduate majors are world-class educational programs. Take a virtual tour of the school, including Flight Operations, the Simulator Building, Terminal Building, Laboratories and Research Centers, and the Niswonger Building of Aviation Technology.” (Purdue Polytechnic Institute, para. 3, 2022)

Appendix C: Description of Contact with industry contacts and airport operators

Kenny Frank is a manager in Above the Wing Innovation & Solutions at United Airlines in Chicago, IL. Before joining United, Mr. Frank worked in Airport Operations for Southwest Airlines at Chicago-Midway Airport.

Charles (Keith) Heisler is a Senior Analyst at United Airlines in Innovations & Solutions in Los Angeles, CA. Mr. Heisler also held a role as Analyst in Customer Experience and Analytics as well.

Alan Gonzalez is a Landside Manager at Dallas Fort-Worth Airport (DFW). Mr. Gonzalez has previously held roles as a Ground Transportation Supervisor and a Ground Transportation Assistant Manager, both of which at DFW.

John Van Woensel is the VP of WSP's USA Division. Mr. Van Woensel was previously a Director of Airport Planning at CH2M Hill and Landrum & Brown, and has nearly 40 years of experience in the aviation industry.

Appendix E: Evaluation of Educational Experience Provided by the Project

Students

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

Yes, this design competition provided a meaningful learning experience, as there were various aspects of the project that allowed us to learn more about the complex issue of airport landside congestion. This project allowed us to be connected with industry experts and airport operators to learn more about landside operations, and how reducing congestion can affect airport and airline revenues. Additionally, the literature review performed allowed us to learn much more about issues tangential to landside congestion as well, such as airport mobility, airport public transportation, and in-town check in.

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

Our team incurred multiple challenges while performing the technical analysis, particularly with the cost-benefit analysis and safety-risk assessment. The cost-benefit analysis was difficult as many of the costs for this project (i.e. cost of automated check-in kiosk, infrastructure development, etc.) are not publicly available, and the research team was able to overcome this issue by reaching out to industry experts (i.e. United Airlines) who helped us better understand certain costs. For the safety-risk assessment, it was also difficult because on the surface, there are few obvious safety issues with the solution. The research team solved this issue by making a process map, which forced us to list each step and find a potential safety issue in each step, which allowed us to populate the safety risk assessment.

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

The research team developed the hypothesis based on the three potential solutions created in the project. The hypothesis is, as these solutions are implemented, both a decrease of airport landside congestion (inside the terminal and on the curbside) as well as an increase in airport airside revenues. This hypothesis was initially based on literature reviewed in the beginning of this project (i.e. 1 less minute in the landside area equals 1.5% of increase in airside revenues) (ACI, 2016). However, after meeting with industry experts, it has been substantiated by what they have said as well (i.eSatellite check-in can reduce lobby time (from when a passenger enters terminal to when a passenger hands bag to employee) by 83%) (Frank, 2022).

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

Yes, the participation from industry experts contacted were very meaningful and appropriate given the scope of the project. The research team contacted three industry experts at United Airlines and Dallas Ft. Worth Airport, all of which allowed us to increase the knowledge base on landside congestion, but also items tangential to that issue including costs associated with satellite check-in and second-hand effects for the airport when landside congestion is reduced. Particularly with United Airlines, the research team learned about landside congestion in terminals at their hubs, but also costs associated with kiosks that allowed them to reduce this congestion as well.

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

From this project, the research team learned that solutions to landside congestion are very diverse, and are unique based on the situation of individual airports. Initially, it was planned on focusing the solutions on public transportation, however as a broader view was taken, the team realized a more broad solution was necessary, which is why one of the solutions is simply adding check-in kiosks in airport parking lots. This project did help with the knowledge base to be successful for entry into the workforce, as this issue affects all sectors of the airport environment (i.e. airport, airlines, vendors, etc.), meaning the knowledge used can be applied in various sectors of the aviation industry.

Faculty

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

For this team, the experience provided a vehicle for this team to explore ways to make travel more accessible, more convenient, and increase airport landside capacity by connecting airport passenger baggage check-in to existing rapid transit. For this class, the educational experience provided by this competition is an opportunity for student teams to respond to a Request for Proposals (RFP) with a proposal to design a specific airport improvement that will respond to one of the challenge areas and increase sustainability in four dimensions: economic, operational, environmental, and social, and to connect their design proposal to one or more UN Sustainable Development Goals. One thing that I encourage is to have small (3-4 students) teams made up of a diverse mix of cultural, social, and/or disciplines. In this way, the teams are practicing skills that are used in industry (proposing ideas for improvement on paper and in presentations, developing justifications to move the idea forward, collecting ideas and deciding on implementation, and working in teams made up of a varied group of people). One of the unique values of this experience is for the team members to interact with experts. This team excelled at it – not only the experts on the competition recommended list - but others as well.

Talking with the experts is valuable because the airport operators and industry experts volunteer their time and share their experiences with these students. Due to this sharing, the teams make changes to the design or implementation, and gain experience by obtaining and listening to feedback to improve their projects.

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

Yes. This competition is one option in a one-semester graduate level course in sustainability. The other option is to prepare a manuscript for publication in an academic journal. Thankfully, this team chose the competition because it helped the team refine and improve their idea.

3. What challenges did the students face and overcome?

Remote check-in of baggage is one idea that helps airports regain landside capacity as it shifts some passengers to available rapid transit. After talking with airport managers and to other experts across the country, the team considered details of implementation that extend beyond ideation and into implementation. Speaking with other experts helped them understand the issues and concerns that airports and their customers have with baggage check-in and rapid transit. This helped focus the team to develop an idea for remote kiosks located in select rapid transit stations, and develop a design improvement that helps airports that are or soon will be connected to rapid transit.

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

Definitely, yes! Three students with differing education and experiences worked together to find and refine a solution to include rapid transit stations in a plan for remote baggage check-in. We do this project within one semester, that is effectively 8-weeks after subtracting other class assignments, tests, and spring break. It is a challenge for the teams to develop as a team and become productive in that short 8-week time span between project teaming and project delivery. With this type of experience, this team will be better prepared to hit the ground running when they start their careers.

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

As always, keep updating the challenge areas to include existing project ideas and newer technologies.

Appendix F: References

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