Modernization of Airport Cell Phone Lots:

Reduce Landside Congestion and Increase Airport Sustainability

(January 2021 - April 2021)

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

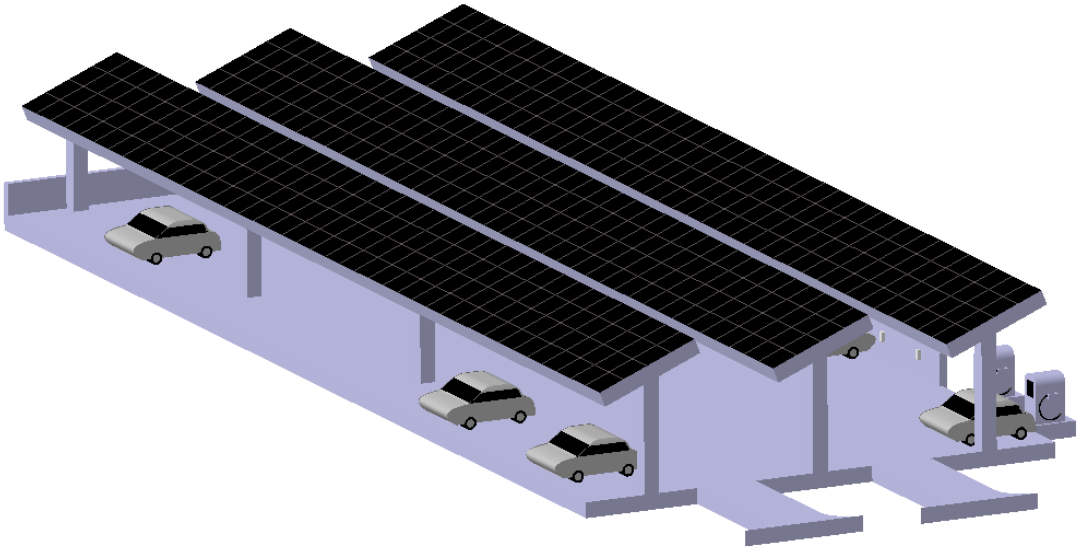
Team Members: Curtis Bouchie, Adam Dunham, Hsuan-Hui Wu

Number of Graduate Students: 3

Number of Undergraduate Students: 0

Project Advisor: Dr. Mary Johnson, PhD

Affiliated University: Purdue University



Executive Summary

The modernized airport cell phone parking lot presented in this proposal will increase airport efficiency and address the ACRP **Airport Management and Planning** Design Challenge of *enhanced management approaches to landside functions to include parking and ground transportation*. The proposed design focuses on modernizing cell phone lots to incentivize usage and decrease severe congestion occurring at the arrival curbside pick up areas at airports. Improvements in parking lot amenities will increase the appeal of such lots in order to maximize utilization. After reviewing existing literature and contacting industry experts, the project team created an innovative design for the modernization of airport cell phone lots. Solar panel covered parking, franchise food and beverage options, web based flight information displays, wireless internet, and increased security measures will incentivize customer use of the cell phone lot. Increased driver use will mitigate the hazards associated with airport terminal curbside congestion by reducing curbside waiting and circling traffic. This allows for an increase of the landside capacity for the airport. Particular benefits for the airport are revenue generation, increased customer satisfaction, reduction in CO2 emissions, and boosting community engagement. The projected benefit to cost ratio for this innovative design is **4.51**, while also increasing airport sustainability. Our team consisting of three graduate students from two countries and different aviation backgrounds has created the *Modernized Airport Cell Phone Parking Lot* design. The aim of this design is to reduce congestion and increase the sustainability of the airport.

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Problem Statement

Airports receive high volumes of passenger traffic during peak periods. A large bottle neck area for this high traffic volume is the landside arrival curbside pick up area. A problem for both airports and passengers is the severe congestion faced in the arrival curbside pick up area. Due to congestion, peak travel periods can lead to negative passenger experiences, create security and safety risks at curbside areas, and decrease airport efficiency. This proposal presents a solution to assist in alleviating terminal arrival curbside pick up area congestion using modernized cell phone parking lots.

Cell phone lots at airports provide a short-term parking service to relieve traffic at the arrival pick up area at the terminals. These parking lots have the potential to reduce the amount of congestion experienced in the arrival pick up area. To do this effectively, the cell phone lot must be convenient and comfortable so that more airport travelers use them.

ACRP Synthesis 62 *Cell Phone Lot at Airports* reports that a large portion of airport cell phone parking lots are not fully equipped with the modern amenities airport users are seeking (NASEM, 2015a). Airport travelers are likely unaware of the location of cell phone parking lots or that they even exist. Additionally, cell phone lots can be viewed as uncomfortable, unsafe, and unattractive due to a lack of appealing amenities.

Our proposal presents a design that incentivizes airport users to use the cell phone parking lots by adding convenient and wanted amenities to existing cell phone lots. This design will maximize airport capacity and address the **ACRP Airport Management and Planning** challenge of *enhanced management approaches to landside functions to include parking and ground transportation*. The design includes a plan to generate revenue through solar panels, advertisement, and franchised food service. Lastly, the design aims to combat the issue of

landside terminal congestion by implementing an easy to access web-based flight information display to allow for precise pick up timing of arriving passengers by providing real time flight information.

Background

With the increasing global air transportation network reaching more customers, it is apparent that many large airports in the United States face an increase in landside congestion. A majority of this congestion occurs in the arrival and pick up area for passengers at their final destination. With an expanding passenger network increasing passenger numbers exponentially and road infrastructure being constrained at airports, landside congestion has increased (Failla, et al., 2014). Furthermore, adding additional lanes for vehicles is not a feasible solution as many passenger pick-up areas are limited by curb space availability (Eibert et al., 2019). By optimizing arrival pick up timing to reduce the number of stationary cars waiting, congestion will decrease, and passenger experience and safety will increase. One way of preventing land side pick-up vehicle congestion would involve modernizing airport cell phone lots and increasing customer amenities to encourage cell phone lot use. This would allow for the redirecting of arriving vehicle traffic until the passenger is ready to be picked up; therefore, decreasing congestion.

Summary of Literature Review

Cell Phone Lot Description

A cell phone parking lot, or also termed a cell phone waiting lot or park and call zone, is an area where motorists can park for free while they wait for a phone call from an arriving party at the airport terminal (National Academies of Sciences, Engineering, and Medicine (NASEM), 2009). The motorist can then drive to the curbside passenger pick up location at the airport to pick up arriving passengers and exit the airport (NASEM, 2009). According to the ACRP Synthesis 62 *Cell Phone Lots at Airports* (2015a), cell phone lots are a part of the ground access

system to an airport and are a tool used by airport operators as a means to reduce congestion at the curb pick up location of the airport (NASEM, 2015a). Cell phone lots range from being a vacant empty temporary lot that can be paved or unpaved, to paved lots with designated parking spaces and amenities (NASEM, 2015a). Amenities include Wi-Fi, restrooms, Flight Information Displays (FIDs), trashcans, lighting, and at particular airports restaurants and gas stations (NASEM, 2015a). The size of a cell phone lot varies in size; a large portion of cell phone lots have 31 to 100 parking spaces in the lot (NASEM, 2015a). Cell phone lots became popular at airports following the events that occurred on September 11, 2001. The Federal Aviation Administration (FAA) implemented new airport security measures, along with the growth of cell phone usage, created cell phone lots (NASEM, 2015a).

Cell Phone Lot Purpose

ACRP *Guidebook for Evaluating Airport Parking Strategies and Supporting Technologies*, states that the purpose of cell phone lots is to "reduce demand and congestion at the arrivals/pickup curbside area and reduce the volume of recirculating traffic by providing a free parking area, away from the terminal area, where motorists may wait for arriving passengers." (NASEM, 2009, p. 25). Other purposes for cell phone lots include, but are not limited to, increasing airport safety, lowering emissions, increasing airport user experience, reducing parking shortages in paid parking lots, and a form of airport revenue (NASEM, 2015a). Cell phone lots are capable of acting not only as waiting areas for passenger pick up, but have the potential to maintain sustainable operations by adapting infrastructure and including amenities.

Cell Phone Lots Current Status

A survey in ACRP *Cell Phone Lots at Airports* Synthesis 62 focused on gathering information of the current amenities offered at the cell phone lots at 96 airports. The results of

the survey concluded that only 3 of 96 airports had formal restrooms available at their cell phone lots (NASEM, 2015a). This survey found that 19 of the 96 airports had some form of Flight Information Displays (FIDs) in the cell phone lot (NASEM, 2015a). Overall, airports offer very few amenities to their customers and users within cell phone lots (NASEM, 2015a). In some cases cell phone lots at airports are being underutilized. Mead and Hunt, an aviation consulting firm, determined that Phoenix-Mesa Gateway Airport's current cell phone parking lot is underutilized and has too many spots for the current demand (Mead and Hunt, 2020). Denver International Airport (DEN) has a cell phone lot that provides food and beverage options. As shown in figure 1, Denver's cell phone lot also has a building that houses several restaurants such as Dunkin' Donuts ® (NASEM, 2015a).

Figure 1. Denver International Cell Phone Lot with food amenities (NASEM, 2015a)

In ACRP *Cell Phone Lots at Airports* Synthesis 62 the parking manager at DEN, provided information that amenities in the cell phone lot have received positive feedback. Additionally, the parking manager exemplified having a source of revenue tied to their lot (NASEM, 2015a). The manager also indicated that cell phone lot users do not want to pay for parking, therefore without the lot they are more likely to circle the airport or park on roads and create congestion (NASEM, 2015a).

The design and status of cell phone lots varies by airport. This is due to airport specific design, demand, and having different goals and limitations for the lot. Overall, there still remain numerous opportunities for improvement in airport cell phone lots to reduce airport congestion, increase airport safety, lower emissions, and serve as a hub for revenue generation. Figure 2 displays the current status of the cell phone lot at Indianapolis International Airport.

Figure 2. Indianapolis International Cell Phone Lot (NASEM, 2015a)

Cell Phone Lot Considerations and Amenities

An ACRP report investigated what factors produced positive feedback of existing cell phone lots. The factors that received positive feedback within the cell phone lots were clean bathrooms, trash cans, quality sources of lighting, and a sense of security (NASEM, 2015a). The *Guidebook for Evaluating Airport Parking Strategies and Supporting Technologies* report found that key considerations for airport operators to plan for when designing cell phone lots are good signage, coordination with airport security, and meeting customer needs and airport goals (NASEM, 2009).

The ACRP Report 70 *Guidebook for Implementing Intelligent Transportation Systems Elements to Improve Airport Traveler Access Information* focused on "implementing intelligent

transportation systems to improve traveler airport access" (pg. 1). The report found that FIDs would be very useful in cell phone lots (NASEM, 2012). The ACRP report affirmed the benefits of having a FID in the cell phone lot is to reduce the congestion from people leaving the cell phone lot too early and heading to the arrival terminal at the wrong time (NASEM, 2012). Information of when the aircraft has reached its gate, or when baggage claim from that flight has begun, can create a more accurate time to alert drivers to exit the cell phone lot and head to the terminal curbside pick up area (NASEM, 2012). This is an example of a consideration that can be made to current airport cell phone lots to improve customer experience, reduce congestion, and increase airport safety.

Most airports contain amenities and food services that are designed to boost passenger experience as well as generate revenue. One of the most advantageous amenities to customers is food and beverage (NASEM, 2015a). A survey of 1095 passengers traveling between 2010 and 2013 found that cleanliness at the airport was the sole criteria to be seen as meeting user satisfaction. Some of the criteria that did not meet satisfaction were dining selection, signage, and security-checks.(Bogicevic et al., 2013). Specific categories that passengers rated as dissatisfactory were WiFi and parking (Bogicevic et al., 2013). This reveals that there is a need to include wanted customer amenities and to increase user experience at airport parking lots.

Renewable Energy with Airports

According to ACRP Report 141 *Renewable Energy as an Airport Revenue Source*, renewable energy has become widely used due to technological advancements, public sector policy, and market maturity (NASEM, 2015b). Renewable energy has improved national security and reliability, and created an increase in business competition with states wanting to participate in renewable energy generation (NASEM, 2015b). Airports can engage in this business market

by using existing land and large buildings that are connected to community infrastructure (NASEM, 2015b). ACRP Report 141 further explains that airports have underutilized property that can be used as a source of renewable energy (NASEM, 2015b). Areas such as parking lots can provide a location that can be fully utilized as an area for renewable energy generation and as a source of cost saving for the airport. This can be an opportunity for airports to repurpose some of their parking infrastructure to provide additional revenue, as mentioned in *ACRP Research Report 225: Rethinking Airport Parking Facilities to Protect and Enhance Non-Aeronautical Revenues* (2021).

Solar power can provide a main source of renewable energy utilized by airports. This is due to the large reduction in cost per unit of power. According to ACRP Report 141, the installation cost for solar power was $7.50 per watt in 2009, but the cost reduced to $2.89 in 2013 (NASEM, 2015b). This reduction in cost coupled with the availability of usable locations within airport facilities provides operators with the option for solar energy while serving as a source of revenue. Additional benefits besides revenue generation for airports are reducing energy emissions, local community job growth, source diversification of energy, and long-term cost savings due to fixed energy costs (NASEM, 2015b).

Solar Power

Solar power generation has been instituted in several airports such as Indianapolis International, Fresno Yosemite, and other airports in the United States (Romero, 2014). In addition, 7,332 schools in the United States have incorporated solar energy (CBS, 2021). The FAA *Technical Guidance for Evaluating Selected Solar Technologies on Airports* found that some airports have to institute solar panels on buildings and parking garages due to the lack of available land in proximity to the airport (FAA, 2018). With the installation of solar panels,

Airport Design Advisory Circular (150/5300-13) must be used to avoid airport areas that are not conducive to solar power installation (FAA, 2018). Another aspect to be considered when installing solar panels within close proximity of the airport is glare and reflectivity produced by solar panels and its effect on pilots (FAA, 2018). Glare and reflectivity can be mitigated through anti-reflecting coatings and proper direction orientation during installation to avoid runways and traffic control towers (FAA, 2018).

The initial cost with solar power installation can be substantial, but has decreased over 81 percent in the past decade (CBS, 2021). Several mechanisms to offset solar power costs include power purchase agreements, energy savings performance contracts, and utility energy services contracts (Romero, 2014). The Voluntary Airport Low Emissions (VALE) program can be a resource for obtaining funds that airports can use to assist with solar power installation (Romero, 2014). In some instances, such as at Denver International Airport, airports can receive tax benefits from the installation of solar power (Romero, 2014). With the cost of basic electricity increasing by 38 percent in the past fifteen years, solar power increases in value over time as a fixed cost source of energy (FAA, 2018). The cost savings produced from alternative energy can allow airports to reallocate funds to future airport projects creating an additional increase in airport sustainability. Figure 3 shows the solar panel array at Boston Logan International Airport and that it provides covering for cars.

Figure 3. Boston Logan using Parking Surface for Solar Power Location (FAA, 2018).

Quick Response (QR) Code Connection to Web Based Information

Moore of Colorado State University (2021) states, "Quick-Response (QR) codes are simple square-shaped pixelated barcodes that contain data. They allow the user to easily access websites, videos, text, maps, pictures, or contact information with a quick scan using their camera-equipped mobile device" (para. 1). QR codes have been used in manufacturing and, due to the COVID-19 pandemic, many restaurants have opted to allow customers to access menus virtually (Ryssdal, 2020).

QR code technology already exists within airports. A large number of airports such as McAllen International Airport are using QR codes for ticketing during TSA security checkpoints (City of McAllen, 2014). QR codes are accessible and can be implemented because 94 percent of the U.S. population between the age of 18 to 49 owns a smartphone (PEW Research Center, 2019). Additionally, smartphone usage has increased by 46% from 2011 to 2019 (PEW Research Center, 2019). This widespread use can allow airports to have less screens at the airport and reduce maintenance costs associated with those screens. Airports can provide QR codes for passengers to get flight and airport information directly from their smartphones. With more

airport travelers having mobile access to online information, QR codes can be effectively used in areas such as parking lots and remote locations to obtain relevant information.

WiFi in Parking Lots

Orlando International Airport (MCO) provides free WiFi in their cell phone lot. The purpose of this amenity amongst others, according to the senior director of planning at MCO, is to eliminate congestion and safety issues that arise from travelers circling or parking on the side of the roads of airports (Orlando Sentinel, 2015). Revenue generation can be tied to the availability of free WiFi. While connecting to the WiFi, users must watch a short advertisement. The advertisement can be closed after a certain amount of time and the airport traveler can use the WiFi for no monetary cost. With this scenario, the airport is providing a free service to the user, and generating revenue by advertising while promoting local businesses.

Airport Landside Congestion

The arrival terminal curbside which is accessible to a variety of ground transportation vehicles is one of the "most congested areas of an airport" (Tunasar, 1998, p. 1113). The report *Modeling Curbside Vehicular Traffic at Airports* found that almost all major airports have experienced high levels of traffic congestion (Tunasar, 1998). Congestion can lead to roadway violations for motorists waiting at the arrival terminal for a long period of time (Tunasar, 1998). In the *Special report - Transportation Research Board, National Research Council* (1974), it mentions that with more high-capacity aircraft being used by airlines and the improvement of the air traffic control system, airports should be aware of the balance between landside and airside capacity.

In addition, FAA *Advisory Circular 150/5360-13 Airport Terminal Planning* states, "approximately 70 to 85 percent of all parking lot users are short-term parkers, mainly greeters and well-wishers" (FAA, 1994, p. 123). This statistic reveals that a main focus of landside

airport planning should be short-term parking options to reduce the levels of congestion at the terminal curbside pick-up area. Oftentimes it is impractical or impossible to expand airport land usage due to infrastructure constraints; thereby, limiting the potential capacity of the airport. Pre-existing structures or land must be changed to increase or hold driver flows.

Three main factors that affect passenger pick up times and congestion by the curbside areas at Baltimore-Washington International Airport (BWI) are the number of vehicles using parking facilities, the time passengers spend in the airport, and the number of available parking spaces (Reed, 2003). For drop-off passengers, the median average access time had high variability. Using average leads airports to underestimate access times and lead to serious airport curbside congestion (Reed, 2003). Creating areas where airport users are attracted to park and wait will reduce congestion and have an added benefit of a reduction in CO2 emissions due to less car idling.

The study *Impacts on vehicle occupancy and airport curb congestion of transportation network companies at airports* (2018), uses data from a Los Angeles International Airport (LAX) passenger survey, San Francisco International Airport (SFO) customer survey, and a SFO-Oakland passenger survey to analyze the relationship between share modes and standard service in the airport. The report revealed that a high percentage of airport vehicle traffic was private and low-occupancy vehicles. This is one main factor for causing airport congestion. Modernized cell phone lots at airports can cater to these types of airport users and aid in reducing landside congestion by providing a better alternative than driving around in loops or parking on the side of the road.

Formulation of Design Requirements

Through review of literature and discussions with industry experts and airport operators, multiple design requirements were created. The design requirements are based on the wants and needs from cell phone lot stakeholders. The main stakeholders of focus are airport users, airport operators, passengers, and the local community. Design requirements are listed in Table 1. These design requirements for modernizing airport cell phone lots allow the airport to be more sustainable in social, economic, and environmental ways.

Table 1. *Design Requirements*

Design Requirements	Reference
Covered Parking	Industry Operators, TVC Parking Survey and Analysis
Revenue Generation	Industry Operators, ACRP Research Report 225: *Rethinking Airport Parking Facilities to Protect and Enhance Non-Aeronautical Revenues*
Electrical Vehicle Charging	Industry Operators
WiFi	ACRP Sythesis 62*Cell Phone Lots at Airports*
Food and Beverage Option	ACRP Sythesis 62 *Cell Phone Lots at Airports*
Restrooms	ACRP Sythesis 62 *Cell Phone Lots at Airports*
Waste Control System	ACRP Sythesis 62 *Cell Phone Lots at Airports*
Sense of Safety	ACRP Sythesis 62 *Cell Phone Lots at Airports*
Renewable Energy	FAA Technical Guidance for Evaluating Selected Solar Technologies on Airports, ACRP Report 141 *Renewable Energy as an Airport Revenue Source* , ACRP Research Report 225: *Rethinking Airport Parking Facilities to Protect and Enhance Non-Aeronautical Revenues*
Real Time Flight Information	ACRP Report 70 *Guidebook for Implementing Intelligent Transportation Systems Elements to Improve Airport Traveler Access Information*

Team Problem Solving Approach

Through research into the challenge of airport congestion coupled by the need for space to locate motorists arriving to pick up passengers, the team decided to focus on modernizing existing airport cell phone parking lots. The design takes into consideration the cost and land use savings compared to constructing a new airport cell phone lot. Additionally, the team held

multiple conversations with industry experts and airport management employees to gain a broader perspective on existing approaches to congestion and the subsequent use of cell phone parking lots. There were three main categories that the team determined would need to be included to benefit all stakeholders.

1. Customer Satisfaction
2. Revenue Generation
3. Arrival Information

Investigating the Problem

The team used the decision making process of convergent and divergent creative problem-solving thinking to arrive at the decision of using the three categories listed. Anne Manning, a founding partner of the insights and innovation firm Drumcircle, explains the convergent and divergent thinking model as a "constant switch between modes of idea generation (divergent thinking) and idea analysis (convergent thinking)" (Manning, 2016). This approach involves starting with a central problem or want, diverging it into several causes and effects, and then converging back to a central solution that addresses all of the listed problems.

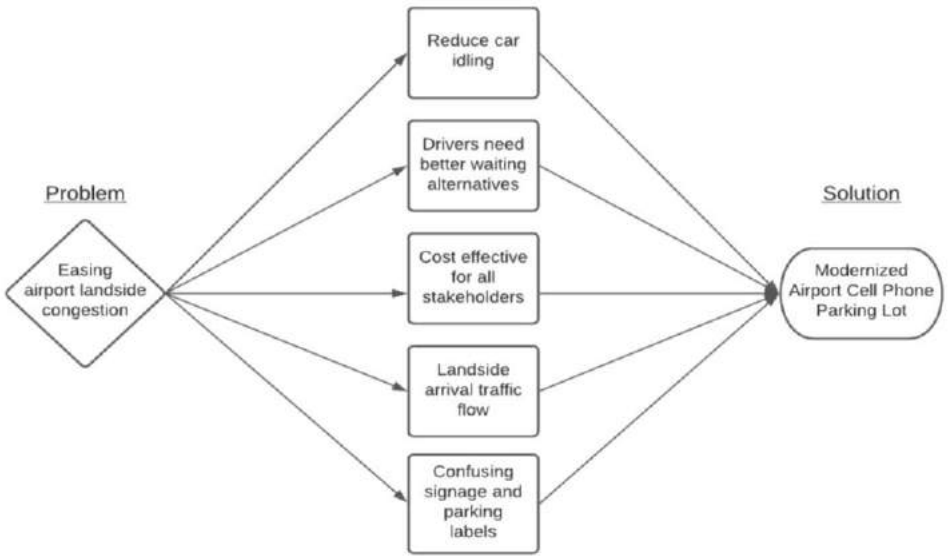

Figure 4. Converging and Diverging Problem/Solution

Figure 4 outlines the process used to investigate the problem. After the problem of landside congestion at airports was determined, the idea was diverged and the team found five main issues that would need to be addressed: reduce car idling at the curbside arrival area, drivers requiring better waiting alternatives, a cost-effective measure to benefit all stakeholders, streamlined traffic flow, and a need for better airport signage.

1. Reduce car idling: Nearly all experts mentioned that a recurring issue at curbside arrival areas are cars idling. In conversation with Michael R. Stephens, director of Operations and Public Safety at Dane County Regional Airport, the team learned vehicle back-ups and security risks come from cars not moving at the pick up area.
2. Drivers need better waiting alternatives: There is a need to relocate occupied vehicles that are waiting to pick up passengers for extended periods of time in the arrival area. From conversation with Dr. Stewart Schreckengast of Purdue University, the team learned that this location must be convenient to access, appealing to users, and easy to locate.
3. Cost effective for all stakeholders: In order for a solution to be implemented by airport authorities, the design needs to be economically sustainable.
4. Landside arrival traffic flow: Dr. Maria Muia, a Senior Planner/Research Specialist Consultant at Woolpert Inc, advised that a significant contributor to congestion are vehicles driving in loops until the passenger is ready for pick up. From this, the team decided that the idea must provide an area where traffic flow is redirected to wait for the specific pick-up time.
5. Confusing signage and parking labels: Drivers may plan to wait in a separate area and then pick up passengers. However, we learned from Dr. Schreckengast that a lot of arrival areas are oversaturated with arrival information and confusing signage. The team

learned that the design must be clearly detailed for users to know what service is provided.

Considering expert advice and researched literature, the five issues were then converged. The team determined that the most effective solution to the problem would be modernizing airport cell phone parking lots to increase their utilization.

Concept Process Development

Through multiple expert interactions and literature research, the team found no specific documents that pertain explicitly to the design of cell phone parking lots, recommendations for implementation, or regulations. The tree diagram in Figure 5 shows the three categories mentioned that encompass the measures to be implemented: (1) customer satisfaction, (2) revenue generation, and (3) arrival information.

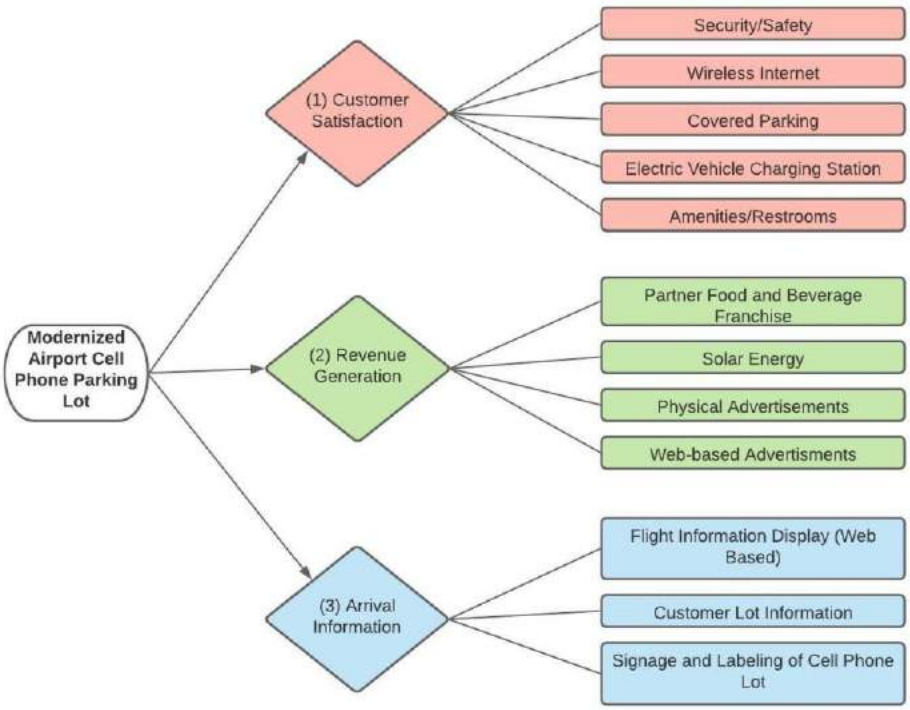

Figure. 5 Developed Process Idea

1. **Customer Satisfaction**

a. Security and Safety: According to Michael Daigle, CEO & Executive Director at St Joseph County Airport Authority, South Bend International Airport utilizes security CCTV cameras in their parking lots. From this, the team decided in order to increase safety and comfort of cell phone lot users, security cameras as well as sufficient lighting must be in place.

b. Wireless Internet (WiFi): The wireless internet provided to passengers at MCO inspired the team to provide customers with options while waiting. This inspired the team to include WiFi in the design to incentivize parking lot usage as well as increase customer experience.

c. Covered Parking: A survey of passengers at Cherry Capital Airport in Traverse City, MI found that a majority of customers prefer covered parking compared to non-covered (Steven Baldwin Associates, 2019). Therefore, the team will include covered parking in the design.

d. Electric Vehicle (EV) Charging Station: From conversation with Alan Gonzalez, the transportation assistant manager at Dallas/Fort Worth International Airport (DFW), the team was inspired to provide passengers with EV's the ability to charge their car in the cell phone lot.

e. Amenities and Restrooms: The team determined as a way of providing a comfortable experience for users, there must be easy accessibility to food, restrooms, and trash cans.

2. **Revenue Generation**

The team learned from Mr. Gonzalez of DFW that the concept design must be cost-appealing to airports.

a. Partner Food and Beverage Franchise: Dr. Shreckengast provided advice to the team that inspired the team to use a large food or beverage franchise, such as Starbucks™ to generate revenue and enhance customer experience.

b. Solar Energy: With increasing costs of electricity and more efficient solar energy panels being developed, including solar panels in our design can save on energy spending in the long-term while benefiting the environment. Joe Marana, the Director of Operations and Facilities at Fort Wayne International Airport, mentioned the airport's utilization of a guaranteed energy savings contract on solar panel usage in the rental car lot. This guarantees money back to the airport operators if there was insufficient energy created. Additionally solar panels will provide a large surface that could serve as a covering for parking spaces.

c. Advertisements: Unused and empty space is a source of potential revenue. By filling physical vacancies with advertisements such as attractive posters or billboards, airports can collect revenue while benefiting the local community. Web-based advertising can also be utilized through requiring ads to access internet functions.

3. Arrival Information

a. Flight Information Display (FID): An issue arises when passengers communicate prematurely to their driver that they have arrived. The team determined that by providing accurate arrival information and estimated walk times from the aircraft gate to the curbside, drivers would be prevented from trying to pick up passengers too early. This estimated walk time would be derived from quantitative passenger terminal walk time data.

b. Customer Lot Information: As a way of raising public awareness to the functions of the airport cell phone parking lot, airports must provide information on websites as well as on airline ticket information. This would then provide customers and passengers with the information to how they can be most efficiently picked up.

c. Signage and Labeling of Cell Phone Lot: Drivers must be aware of the location and directions to the cell phone waiting lot. To fulfill this need, easy to read signage with a list of available amenities must be presented with enough time for drivers to reach the location. According to Mr. Marana, not all passengers know what a cell phone lot is. To get rid of any confusion, the team will advertise the lot as the "Cell Phone Waiting Parking Lot". The team decided that this labelling is essential to prevent driver confusion.

Safety Risk Assessment

The Federal Aviation Administration (FAA) has created programs and tools to assist airports in determining and managing risk. A particular tool is called Safety Risk Management (SRM). According to the FAA, Safety Risk Management is "a formal process within the [Safety Management System] composed of describing the system, identifying the hazards, assessing the risk, analyzing the risk, and controlling the risk. The SRM process is embedded in the operational system; is not a separate/distinct process" (FAA, 2007, p. 2). Information in *Advisory Circular 150/5200-37 Introduction to Safety Management Systems (SMS) for Airport Operators* provides guidelines to effectively use tools such as the safety risk management to describe systems, identify hazards, determine risk, assess and analyze risk, and treat risk (FAA, 2007).

According to the FAA, a risk assessment is the "assessment of the system or component to compare the achieved risk level with the tolerable risk level." (FAA, 2007, p. 1). The risk level and tolerable risk level are determined using the values severity and likelihood. The product of

these values provide the level of risk associated with that particular hazard (FAA, 2007). Once risk values are determined for hazards and are deemed unacceptable or high, the hazard must be controlled to reach an acceptable level of risk (Timmons, 2016). The project team developed a risk matrix based on information provided in *Advisory Circular 150/5200-37 Introduction to Safety Management Systems (SMS) for Airport Operators.* The matrix chart uses severity and likelihood values to determine a risk priority number (FAA, 2007). The risk matrix chart is provided in Table 2.

Table 2. *Risk Matrix Chart* (FAA *Advisory Circular 150/5200-37)*

	Severity	Minimal	Minor	Major	Hazardous	Catastrophic
Likelihood	Level	1	2	3	4	5
Improbable	1	1	2	3	4	5
Remote	2	2	4	6	8	10
Probable	3	3	6	9	12	15
Frequent	4	4	8	12	16	20
Low Risk	0-4.99					
Medium Risk	5-9.99					
High Risk	10-20					

The design of modernizing cell phone lots at airports will provide positive benefits to airport users and operators. However, there are still potential hazards associated with parking lots and the associated amenities. Primary potential hazards associated with the modernization of cell phone lots at airports are provided in Table 3. Hazards that are considered high risk received a risk value of 10 or above. Hazard #4, #5, and #6 are all at risk values of 10 or higher. Hazard #4 can be effectively mitigated by using durable and reliable materials in design and implementing routine inspections. The increased chance of hazard detection through inspection will lower the risk number associated number within an acceptable level (Timmons, 2016). Hazard #5's level of risk can be reduced through by incorporating pedestrian walkways and proper signage within the parking lot. Hazards #3 and #4 can be mitigated with implementing forms of renewable energy and keeping trash cans indoors or having closed lids to not attract wildlife.

Hazard #6 can be lowered to an acceptable risk level as well with the implementation of security systems and regular monitoring by airport security. An innovative design implemented at Purdue University that can be used in airport cell phone lots is solar powered emergency telephone stations (Purdue, 2011). This device allows a person in danger to press a button and immediately connect with local authorities to assist in an emergency situation (Purdue, 2015).

Table 3. *Potential Risk Safety Assessment of Modernized Cell Phone Lots*

Number	Current Risks	Likelihood	Severity	Risk	Potential Solutions
1	Airport users not using cell phone lot and creating congestion on roadways and terminal increasing risk of safety	4	1	4	Incorporate user wanted amenties such as restrooms, food and beverage options, EV charging, and covered parking to increase cell phone parking lot use
2	Drivers leaving early to terminal creating congestion and increasing risk of safety	4	1	4	Use of web based flight information system to properly inform drivers when to leave cell phone lot
4	Power outage in parking area	2	3	6	Implement solar energy to provide alternative source of energy during power outage
3	Debris from littering attracting wildlife	2	4	8	Trash can implmentation indoors or with closed lids
4	Lighting fixture falling on vehicle or person	2	5	10	Incorporate long lasting materials in product design, and have time based inspection procedures
5	Pedestrian hit by vehicle in cell phone lot	2	5	10	Set in place identified pedestrian walkways and proper signage
6	Criminal activity or misuse of facilities due to remote location	3	4	12	Install security camera system and quick access to law enforcement. Also, have airport security regularly monitor the lot

Description of Idea

The modernization of airport cell phone parking lots includes enhancing customer experience and boosting cell phone lot infrastructure. Table 4 details specific design elements. The aspects of the design that are different from existing cell phone lots is the inclusion of user wanted amenities, forms of revenue generations, and use of real time flight information. These focuses will allow the landside arrival operations to have increased efficiency and support airport sustainability.

Table 4. *Design elements*

Modernization Ideas	Design Elements					
Enhanced parking	Solar Panels ($)	EV Charging ($)	Advertisement ($)	Covered Parking	Sufficient Lighting	WiFi Connectivity
Cell phone lot infrastructure	Food Service ($)	Restrooms	Trash Cans	Web Based FIDs	Security Cameras	Signage

The cell phone lot design idea was inspired from industry expert input, FAA guidelines, and stakeholder demands found in ACRP reports. The cell phone lot will still be a location in the airport facility that users can park without a fee for a certain period of time. Within this lot will be access to WiFi, electrical vehicle charging, covered parking, and food and beverage options will be provided. These amenities will also serve as a source of revenue generation. These elements of design are shown in Figure 6 with a computer aided design (CAD) modeling. Within the franchised food and beverage service there will be restrooms and trash cans. This will meet the stakeholder requirements without the airport having to provide staff to support trash can and restrooms facilities. Proper lighting, closed circuit televisions cameras, and emergency response connection devices will be included in the lot design. This is to meet the demand for a sense of security stated in ACRP Report 62 *Cell Phone Lots at Airports*. These elements of the design support all stakeholder satisfaction components of the design requirements.

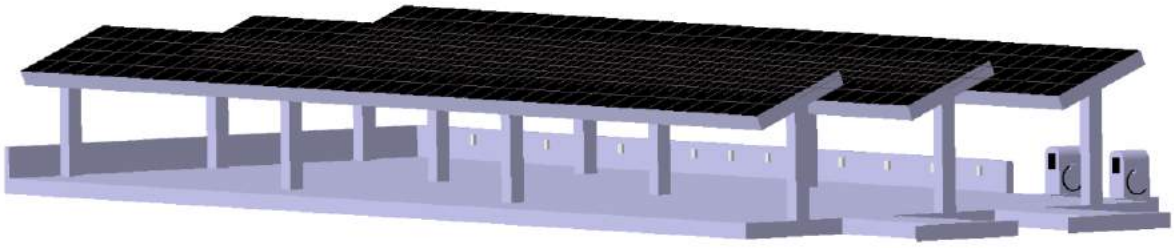

Figure 6. CAD Rendering of Cell Phone Parking Lot Design

Amenities

To boost customer experience the modernized cell phone lot will enhance parking, provide valuable amenities, and support practical facilities. Covered parking will be provided by the installed solar panel array. This will allow parked cars to be protected with the weather and protect drivers that remain in their cars on high temperature days. A food or beverage franchise will be located within the parking lot. This will serve the parking lot users with a valuable commodity and provide an option if the passenger being picked up wants food brought to them. Customer satisfaction will increase and will attract more drivers to use the parking lot when arriving early for the purpose of picking up passengers. Associated with the food or drink provider will be readily available trash cans and restrooms to increase passenger comfort and incentivize their return to the parking lot. Wireless internet will be provided throughout the limits of the parking lot for users to be able to access work or leisure websites. This addition will allow users to arrive at the cell phone lot early and provide a reason to stay before the time to pick up their passengers arrive. This feature also opens up the option for passengers to utilize the provided web based flight display.

Revenue Generation

A large factor considered in the cell phone lot design is revenue generation. The reason for this is to offset the initial investment of implementing features of this design. One form of revenue generation included in this design are food and beverage options. According to industry experts, the success of the concession area will be determined by whether the option is that of a popular franchise such as Starbucks™. Also, a benefit would be if the franchise currently has a location within the airport terminal facility. This would allow for revenue to be generated from airport users that are not paying for parking or entering the terminal facility.

An additional form of revenue that can be obtained from the cell phone lot is solar power generation. Approximately 10 watts of power per hour are produced per square foot of solar panel (Singh, 2019). The required size of a parking space is 9 feet by 18 feet, creating 162 square feet (Temecula Municipal Code, 1993). According to Singh (2019), if you receive 5 hours of solar power a day one parking space can provide 8,100 watts or 8.1 kilowatts per day (Singh, 2019). Therefore, if you had a 100 space parking lot, that lot would provide the airport with almost 300,000 kWh of power a year. With the ever increasing cost of electricity, solar power can provide substantial cost savings per year to the airport. This is a dual purpose element of the design due to it providing revenue generation and creating a form of covered parking for cell phone lot users.

Electrical vehicle charging was a design element heavily mentioned by industry experts. This method of powering vehicles will be a significant part of the future vehicle population and airports will need to be able to provide this service to airport users. Level 2 chargers will be utilized in the design to allow for optimum charging time to cell phone lot users. Level 3 chargers (DC fast charging) are not used in this design due to their high cost and need of extensive level maintenance (U.S. Department of Energy, 2015). The level 2 charges provide the need customers are requesting and provides more ability for a return on the investment of installation. Revenue can be generated from these electric vehicle chargers by charging customers for use in the free cell phone parking lot.

The last form of revenue generation incorporated in the design is advertisement. Advertisement in this design will be incorporated through physical and virtual platforms. Physical advertisements include posters on the pillars of solar panel structure or lighting fixtures. Additionally, if a fence is surrounding the cell phone lot, banner style advertising can be utilized.

With the incorporation of WiFi, short advertisement videos can be embedded as a requirement to have access to connecting to the WiFi. When speaking with industry experts, none mentioned an existing form of revenue from parking lots besides charging for parking. These elements of the design allow for other forms of revenue generation in airport parking lots without being an undue burden on customers.

Web Based Flight Display

With the rapid increase in smartphone and QR technology, the practice of using phone cameras to scan a QR code is becoming commonplace. Airports have been using QR technology to scan boarding passes, and due to COVID-19, restaurants and retailers use QR codes to provide non-contact information to customers. This technology can be incorporated in a cell phone lot to allow users to access an airport website that lists arriving flights. The web based FID will allow drivers to know when the aircraft has arrived at the gate and will provide an estimated time when the passenger will arrive at curbside. Two estimated times will be provided: passengers that do not have baggage and passengers that have baggage on the flight. Information will be derived from historical quantitative data from airports based on the time of day, day of week, and average passenger walk times. The web based FID is another opportunity for advertisements and revenue generation. An example of the web based FID is provided in figure 7.

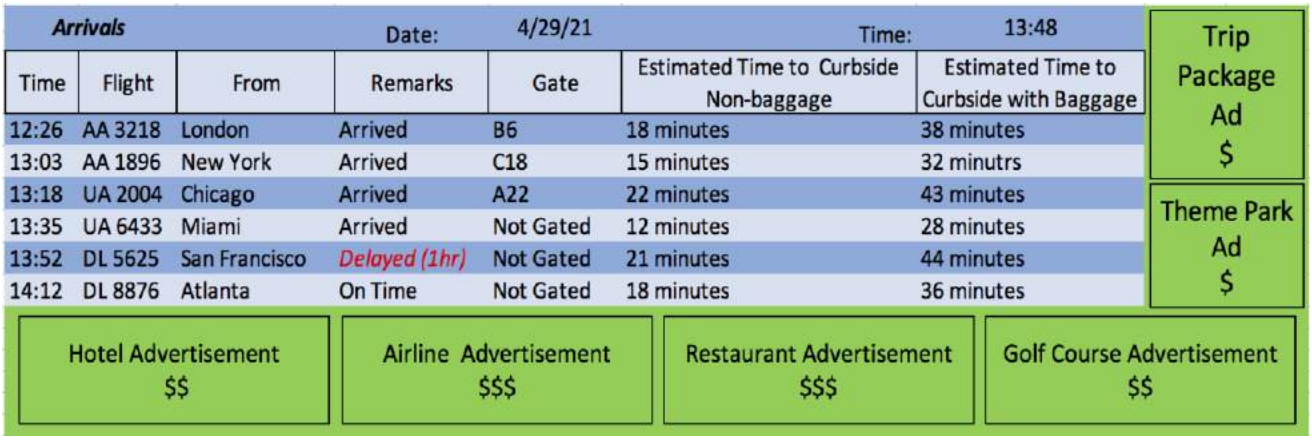

Figure 7. Web Based Flight Information Display Example for Cell Phone Waiting Lots

Interaction with Airport Operators and Industry Experts

The team interviewed 8 airport experts throughout the design process. Each meeting lasted approximately 60 minutes and discussed information pertaining to idea creation, idea design, and existing solutions in the industry. The following experts were contacted:

- Alan Gonzalez- Transportation Assistant Manager at Dallas Fort Worth International Airport (DFW), AAAE, ACI Landside Operations Certified
- Joe Marana- Director of Operations and Facilities at Fort Wayne Airport (FWA), AAAE
- Justin Bessler- Senior Manager of the Operations Center at Cincinnati International Airport (CVG), AAAE
- Kevin Klein- Assistant Airport Director at Cherry Capital Airport (TVC), AAAE
- Dr. Maria Muia- Senior Specialist Consultant at Woolpert Inc and ACRP author.
- Adam Baxmeyer- Airport Director at Purdue University
- Michael Stephens- Operations & Public Safety Director at Dane County Regional Airport (MSN), Former FAA Airport Certification Inspector
- Mike Daigle- CEO & Executive Director at South Bend Airport (SBN), AAAE
- Dr. Stewart Schreckengast- Graduate faculty at Purdue University and Senior Research Fellow at University of South Australia, AAAE

Current Airport Congestion and Parking Designs

When asked about whether the problem is still an ongoing issue at airports, all experts mentioned that there is consistent landside congestion at curbside pick up areas. It was also mentioned that with expected passenger numbers to increase, there needs to be a way to alleviate it. Additionally, no experts were familiar with a document, design recommendation, or regulation that has been published that specifically pertains to the implementation of an efficient and

sustainable cell phone parking lot. Mr. Stephens (MSN) suggested that the team investigate *Advisory Circular 150/5360-13A, Airport Terminal Planning*, in order to see if there was any information specific to cell phone lot design. The only mention of such a parking lot was the possibility of including a cell phone lot, rather than specific uses and design criteria.

Design Feedback

Feedback of the design was positive and all experts believed that the facilities in the airport cell phone parking lot should be modernized to meet future airport user demands. The following are our interpretation of the ideas, feedback, and recommendations from experts that influenced the outcome of the team's design to modernize airport cell phone lots:

- **Safety:** While designing parking facilities, it was brought up that users must feel safe and protected if they will hold a willingness to return. Mr. Daigle agreed with the implementation of security cameras to increase passenger comfort relating to the safety of the cell phone lots. Additionally, while being located close to the airport and the potential to be near an approach end of a runway, wildlife could present a hazard to air traffic. By covering the trash cans or locating them indoors, the threat of birds flying around will be mitigated.

- **Solar Panels and Parking Cover:** Joe Marana (FWA) mentioned the airport's use of solar panels at their rental car lot. In the long term, the airport will save money while additionally using these wide solar arrays as covering for parking. Because of this recommendation, the team decided that in addition to cost benefits, the solar panels could be used for customer experience too, such as covered parking. When implementing such

solar panels, Dr. Muia and Mr. Stephens mentioned that such a design must take FAA height restrictions into account and a glare analysis to be conducted.

Mr. Klein (TVC) provided a reasoning for covered parking. In the survey that the airport had conducted, a majority of users desired covered parking (Steven Baldwin Associates, 2019). This gave the design team justification to use the solar panels as a means to protect cars from weather or heat.

- **Revenue Generation:** All experts recommended that for the cell phone lot to be implemented by an airport, there must be a return on capital invested in addition to the intangible benefits created, such as decreased congestion. This inspired the team to focus on numerous methods to boost revenue such as a food service, energy savings from solar power, electric car-charging, and advertisements.
- **Customer awareness:** According to Mr. Marana (FWA), it is important for first-time users to understand what a cell phone lot is. To increase awareness and decrease confusion, he recommended that there is a parking specific label to the signage, such as the labelling of "airport cell phone waiting lot".

Benefit-Cost Analysis

A benefit-cost analysis is used to provide a realistic approach and financial analysis to determine the overall benefit of the team's design (Byers, 2016). The analysis covers design conceptualization to design implementation. A 10-year life cycle cost of operation and maintenance is included in the benefit-cost analysis.

There are two sections included in the cost component of the cost benefit analysis: the alpha stage and beta stage (Byers, 2016). The alpha stage consists of costs associated with the conceptualization and development of the Modernization of Cell Phone Lots design. Beta stage

includes the implementation and operation cost of the team's design. The benefit portion was separated into two categories: tangible and intangible benefit (Byers, 2016). Tangible benefits are formed from revenue generation opportunities of the modernized cell phone lot. Intangible benefits include areas such as operational efficiencies, managerial benefits, and environmental benefits (Byers, 2016). All tables utilized in forming the Benefit-Cost analysis were inspired by the advice from *ACRP design competition - Dave BYERS - guidance for Preparing Benefit/cost analyses* (Byers, 2016).

The alpha stage begins with the concept design development. The items that contributed the most to this section were the labor of the students and faculty advisor. This stage in the design process consists of forming the concept and creating a general prototype computer aided design. The total concept design development cost is $7,500 as shown in Table 5.

Table 5. *Concept Design Development Cost (Alpha)*

Concept Design Development Cost				
Item	**Rate**	**Quantity (hr)**	**Subtotal**	**Notes**
Labor-university design team				
Student effort	$20	150	$3,000	Combinaton of 3 Graduate students efforts
Faculty advisor	$100	30	$3,000	Project Advisor
Concept 3D Modeling	$50	20	$1,000	CAD Concept Model
Miscellaneous	$500	--	$500	Physical Rendering
Totals		**200**	**$7,500**	

The alpha stage continues with the development cost of the Modernized Cell Phone Lot that the airport would assume for generating plans and preparing for implementing the design. The main cost associated with this phase is site planning and quote creation with contract companies to complete the construction of design aspects. Specifically, solar panel and supporting structure installation. In addition, the food service preparation and planning were a large cost in this stage. Specific values are shown in Table 6.

Table 6. *Development Cost Project Preparation for Modernizing Cell Phone Lots (Alpha)*

Airport Project Development Cost of Modernized Cell Phone Parking Lot				
Item	**Rate**	**Quantity (hr)**	**Subtotal**	**Notes**
Solar Panels	$60	160	$9,600	Cost to recieve project quote and contract solar panel installer organization (BLS, 2020)
Solar Panel Supporting Structure	$50	160	$8,000	Cost to recieve project quote and contract structure organization (BLS, 2020)
Food service	$60	320	$19,200	Cost of site preparation and planning (BLS, 2020)
Web Flight Information Display Concept	$40	80	$3,200	Web developer concept development cost (BLS, 2020)
Web Flight Information Display Creation	$40	320	$12,800	Web developer creation cost (BLS, 2020)
Airport Development Team	$50	2880	$144,000	Cost of airport employees to oversee and manage project development (BLS, 2020)
Third Party Architect	$40	480	$19,200	Cost to prepare structure and parking lot design elements (BLS, 2020)
Project Development Cost Total		**4,400**	**$216,000**	Total cost to develop, plan, and prepare for modernizing cell phone lot

The next section is where the beta phase begins. This phase has two components. Construction and implementation component are described in table 7. Continuous operation and maintenance with total costs of design implementation are included in Table 8. This is the cost of implementing the Modernized Cell Phone Lot design. In this section, the implementation and 10-year life cycle cost is included. This includes the cost of installation of design features and maintenance and operating cost of the team's design. The total 10-year cost is estimated to be $1,022,078. All values are included in Table 8.

Table 7. *Construction and Implementation of Modernized Cell Phone Parking Lot (Beta)*

Project Constructiona and Implementation Cost of Cell Phone Parking Lot				
Item	**Rate**	**Quantity**	**Subtotal**	**Notes**
Solar panels	$2.87	162,000	$325,458	Solar panel installation cost is estimated per watt. With 10 watts a square feet of panel, and 16,200 square feet in a 100 space lot provides and approximate cost. Then subtract 30 percent due to federal renewable energy tax deductions (Power Solar Phoneix, 2021) (Romero, 2014)
Solar Panel Supporting Structure	$748	100	$74,750	Cost per space of the strucutre to support solar panels (Absolute Steel, 2020)
Food service	$100,000	1	$100,000	Cost of preparing land for franchise to build (Building Advisor, 2021)
Signage	$3,000	1	$3,000	Cost including roadway signs and individual parking space signs
Blue Light Connection Boxes	$5,000	2	$10,000	Cost of installation
Wifi connectivity	$1,000	1	$1,000	Cost of installation
EV Charging Stations	$6,000	2	$12,000	This incorporate avaerage utlity and infrastrucutre set up (Department of Energy, 2015).
Lights	$800	20	$16,000	This is including post structure and solar powered LED light fixture.
CCTV Cameras	$2,500	2	$5,000	Average cost based on ACRP report *Guidebook for Evaluating Airport Parking Strategies and Supporting Technologies* (NASEM, 2009)
Construction and Implmentation Cost			**$547,208**	

Table 8. *Project Operation Cost (Beta)*

Project Operation Cost (per year) of Cell Phone Parking Lot				
Item	**Rate**	**Quantity**	**Subtotal**	**Notes**
Wifi connectivity	$1,200	1	$1,200	
Web Based Flight Information Display Annual Maintence	$930	1	$930	
Blue Lights Annual Maintenance	$100	2	$200	
EV Charging Annual Maintenance	$300	2	$600	
Annual Pakring Lot Mainenance	$250	100	$25,000	Rate provided by ACRP report *Guidebook for Evaluating Airport Parking Strategies and Supporting Technologies*
Recurring year subtotal			**$27,930**	Per Year
Year 2-10 Subtotal			**$251,370**	
Construction and Implmentation Cost			**$547,208**	
Development Project Preparation Cost			**$216,000**	Project preparation cost
Concept Development Cost			**$7,500**	Concept development cost
10 Year Total Cost			**$1,022,078**	Total 10 year cost including concept, project development, implmentation, and operation cost

The design of modernized cell phone lots at airports has four main tangible benefits. The four benefits are food service revenue, solar panel energy savings, advertisement revenue, and electric vehicle (EV) charging revenue. An estimated value of yearly revenue is $460,573. Using this value, a 10-year tangible benefit of a modernized cell phone lot is projected to be $4,605,732. All values related to tangible benefits are presented in Table 9.

Table 9. *Tangible Benefits Revenue Generation*

Tangible Benefits: Revenue Generation				
Item	**Rate**	**Quantity**	**Subtotal**	**Notes**
Food Service Revenue	$8.70	21,780	$189,486	Based on FAA Compliance Guidance Letter 2018-3, Appraisal Standards for the Sale and Disposal of Federally Obligated Airport Property, the Gross Rent to be received on the airport land with an FMV of $10/sq. ft. for a market required 8% return on value is $8.70 per square foot/year before expenses (time we are providing 21,780 ft2 land) (FAA, 2018)
Solar Panel Energy Savings	$0.11	295,650	$32,137	Five hour direct sunlight per day *162,000W=810kWh (the electricity price is based on the data from U.S. Energy Information Adminitration that the avreage U.S. Commercial electricity price is 10.87 cents/kWh in 2021) (then times 365 days) (EIA, 2021)
Advertisements Revenue	$114,000	2	$228,000	The average small business using Google advertising spends between $9,000 and $10,000 per month on their online advertising campaigns. (9,500*12 month=114,000) There is two opportunites for web advertisment in the design. (WordStream, 2020)
EV Charging Revenue	$5,475	2	$10,950	Assume that the cell phone parking lots are using Blink-charging level (level 2)-charging rate 7.2kW-pricing 0.05 per minute (assume average time using EV charing is 15 minutes, average driver using is 20 times) (then times 365 days) (U.S Department of Energy, 2020)
Year 1 Subtotal			**$460,573**	
10 Year Total Benefit			**$4,605,732**	Year 1 multiplied by 10

The benefit to cost ratio for this design is **4.51** as shown in Table 10. This value was calculated by dividing the 10-year total quantitative benefit by the 10-year total cost of the design. The 10-year total cost includes costs from both the alpha and beta stages (Byers, 2016).

Table 10. *Benefit to Cost Ratio*

Benefit to Cost Ratio			
Item		**Subtotal**	**Notes**
10 Year Total Benefit		$4,605,732	Year 1 multiplied by 10
10 Year Total Cost		$1,022,078	Includes concept, project development, implmentation, and operation cost
Benefit Ratio		**4.51**	10 year total benefit divided by 10 year total cost

Some benefits provided from the modernized cell phone parking lot are unable to be measured directly. Such qualitative benefits identified are operational efficiencies, managerial benefits, and environmental benefits (Byers, 2016). Operation efficiencies include safer curbside areas to lower the risk of congestion related accidents and decreased congestion to improve passenger pick up times. Additionally, the ease of use and quality of facilities will incentivize further use of the cell phone lot for future trips and increase user satisfaction. Managerial benefits include less personnel monitoring the curbside area, therefore freeing them to perform other essential duties. Environmental benefits that increase social connection involve boosting local businesses in the community through advertisement. Other such benefits that directly impact the environment are less car emissions from car idling and more efficient energy usage from solar panels. A summary of all intangible benefits related to this design are in Table 11.

Table 11. *Intangible Benefits of a Modernized Cell Phone Lot*

Intangible Benefits	
Benefits	**Explanation**
User satisfaction	Users will have an improved experience and have a higher willingness to return and use the lot in the future
Safer curbside area	Reducing the risk of serious injury or fatality will boost the airport safety record and decrease probability of being liable in an accident
Decreased congestion allows better pick up efficiency	Increase airport reputation regarding congestion and on-time pick up. Will also decrease passenger waiting times and frustration.
Promoting local businesses	Adversisements will boost customer awareness of local businesses
Reduce Emissions	Decreased waiting time at curbside pickup areas will allow for the lowering of car emissions assocaited with idling
Solar Alternative Energy	Provides airport with fixed cost power source and additional mode of energy that is more environmental friendly compared ot other energy sources.
Less security personnel monitoring idled cars	Re-allocates essential security workers to other areas of airport that would require enhanced monitoring

The intangible benefits have the potential to be analyzed further to be quantified to provide additional cost savings.

A large benefit of this design are the various forms of revenue generation. *ACRP Research Report 225: Rethinking Airport Parking Facilities to Protect and Enhance Non-Aeronautical Revenues* states that since 2015, revenue generated from airport parking has decreased. (NASEM, 2021). These multiple modes of revenue generation from an airport's parking facility can allow for the opportunity to regain lost revenue. Other benefits from this design that have a large impact on airports are the potential to decrease CO_2 emissions, decrease landside congestion, and increase passenger and user experience. Overall, the design will provide intangible benefits to the airport and its users, but also have tangible benefits in the form of revenue generation to offset the cost of developing and implementing the design of modernizing airport cell phone lots.

Projected Impacts of Design

The design of modernized cell phone lots can be implemented at any current airport with an adequately sized cell phone lot. Each airport is unique and faces unique challenges regarding

parking and land availability. With this in mind, the project team's design is a general concept that can be customized to a specific airport cell phone lot scenario. The Modernized Cell Phone Lot design impacts curbside congestion, airport revenue, airport user experience, and amount of greenhouse gas emissions.

The modernized cell phone lot improves curbside congestion by allowing more people to use and be aware of the cell phone lot. This will be completed by incorporating adequate signage, providing food and beverage options, and other user wanted amenities such as covered parking and restrooms. Also, the modernizing of cell phone lots combats congestion by the use of a web based flight display. The flight display will allow for drivers to exit the lot at an estimated pick up time and not create more congestion at the terminal or be forced to circle the airport roadways.

Airport revenue is addressed in the airport design by providing food and beverage options to users, solar alternative energy, electric vehicle charging, and advertisements. The design needed to incorporate revenue generation to offset cost of installation and provide revenue from airport users who are not paying for parking.

Modernized cell phone lots design increases the airport user experience. With incorporating the amenities described in ACRP Synthesis *Cell Phone Lots at Airports,* airport users are more likely to use airport facilities and have a reduction of stress when at the airport. These amenities will provide customer satisfaction and aid in the social sustainability of the airport.

If more users are using the parking lot rather than idling their vehicle in the curbside arrival area, there will be a reduction in greenhouse gas emissions produced at the airport. This will support the airport in being more efficient and environmentally sustainable.

Project Alignment with ACRP Goals

The design meets the ACRP goal of the academic community addressing airport operations and infrastructure issues and needs. This goal is met by providing a solution to combat landside congestion, therefore increasing landside safety and increasing customer satisfaction at the airport. Also, the design provides revenue generation to the airport from an area that was not generating revenue.

Another aspect of the project design that aligns with the ACRP goals is that this project developed an awareness and interest in airports and aviation as vital and challenging areas for careers in engineering and technology. Throughout this project the graduate students involved developed an interest in airport landside operations and issues involved with this sector of the airport. This project gave students awareness of the various roles and responsibilities associated with airport landside operations.

Another goal of this project aligns with is increasing airport sustainability. This project saves monetary investment by revitalizing and using an already developed portion of airport infrastructure. Roadways, parking lots, lighting, walkways, and signage already exist in some form. This is a large cost savings benefit to the airport. Also, the modernized cell phone lots will provide sources of revenue for the airport increasing the airport's economic sustainability. The project increases airport sustainability also by decreasing landside congestion, increase in airport user safety, increasing customer satisfaction, reducing CO2 emissions related to the airport, and limiting future airport land use.

Finally, this project aligns with the goal of providing a framework and incentives for quality educational experiences for university students. Students learned new skills valuable to project and airport management such as safety risk assessment and cost benefit analysis. Also,

students learned how to formulate a design from conceptualization to a proposal for implementation. All of these experiences have a large impact on the student's education and ability to perform these tasks in their future career endeavors.

Sustainability Assessment

In the recent decades, the aviation community has made a commitment to operating in a more sustainable manner. Organizations such as International Civil Aviation Organization (ICAO), Air Transport Action Group (ATAG), International Air Transport Association (IATA), and the aviation community as a whole have implemented goals and programs to combat climate change and increase sustainable development (ATAG, 2021). According to the United Nations, (1987) sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (para. 1). The manner in which some airports approach sustainability is through the EONS concept (SAGA, 2015). EONS is an acronym that stands for Economic vitality, Operational efficiency, Natural resources, and Social responsibility. The EONS concept promotes a holistic approach to assessing sustainability. With the EONS method, sustainability is not solely based on financial performance, but also by how implementations and actions affect economic growth, protecting the environment and our natural resources, being good corporate citizens, and efficiently operating our facilities (SAGA, 2015).

Using the EONS framework, a sustainability analysis was completed on the Modernization of Airport Cell Phone Lot design. This analysis was completed by determining the effects the project team's design had on each of the four pillars of the EONS concept. The largest sections of the EONS concept to benefit from the project team's design is economic vitality and natural resources. Overall, the project team's design had some impact in every aspect

of the EONS concept. Table 12 *Design's Sustainability Assessment* provides the specific ways in which the design will impact sustainability of the airport.

Table 12. *Design's Sustainability Assessment*

EONS Section	Design's Sustainable Impacts	Action on Airport Sustainability (+) *Improves* (-) *Reduces Sustainability*
Economic Vitality	Revenue generation opportunities for airport operators	+
	Reduced congestion creating increased airport capacity and allowing increased operations	+
	Reduction of airport costs through the use of alternative energy	+
	Provide more high quality jobs related to airports (FAA funding for solar panel)	+
	Fixed cost source of energy with solar power	+
Operational Efficiency	Decrease landside transportation delays	+
	Reduction in airport landside congestion	+
	Increased user experience of airport operations	+
	Potential to increase cell phone parking lot congestion	-
Natural Resources	Reduced Greenhouse Gas Emissions from reduction of car idling and circling	+
	Implementation of alternative renewable energy	+
	Prevent the need to use more land for airport operations	+
	Provide trash cans to decrease solid waste and protect wildlife	+
	Increase in pavement covering land	-
Social Responsibility	Increase in safety with advanced security technologies	+
	Increase curbside safety through increased airport cell phone lot use	+
	Reduction in stress and confusion for passengers when completing tasks at the airport	+
	Implementation of modern ammenties such as electric vehicle charging	+
	Increased quality of life with less emissions and convientent operations with wanted amentities	+
	Increase airport innovation and become and industry leader within parking infrastructure capabilites	+

Conclusion

To meet a future with increasing passenger numbers and a constrained landside pick up area, airports will need a sustainable and innovative method to minimizing early pick up arrivals and decreasing congestion. Efforts to provide drivers with an alternative waiting location other than the curbside pick up area resulted in the creation of cell phone parking lots. These lots however are often overlooked due to poor signage, driver awareness, and practicality. After reviewing published literature, pre-existing designs, and contacting industry experts, the team

decided to create a modernized airport cell phone parking lot design in order to minimize the hazards associated with curbside arrival congestion.

The design provides an incentive for drivers to wait at the parking lot rather than circle around the busy airport roadways or create traffic and security threats by idling in the curbside pick up area. Incorporated within the design is solar panel covered parking, wireless internet, franchise food and beverage options, web based flight information display, and sufficient security measures. With a positive benefit ratio of **4.51** over a 10-year forecast, the design will address congestion reduction needs while additionally providing intangible benefits to the surrounding community, passengers, and the environment.

Appendix A: Contact Information

Advisor Information:

Mary E. Johnson, PhD

Associate Head for Graduate Programs & Professor

Purdue University: School of Aviation and Transportation Technology

Email: mejohnson@purdue.edu

Student Information:

Curtis Bouchie

Email: bouchie.curtis3@gmail.com

Adam Dunham

Email: dunhama@purdue.edu

Hsuan-Hui, Wu

Email: wu1697@purdue.edu

Appendix B: Description of the University

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

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

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 1-3, 2019).

Appendix C. Description of airport operators and industry experts who provided advice and feedback for your design process.

Alan Gonzalez works as Transportation Assistant Manager at Dallas Fort Worth International Airport (DFW). He is an Airport Certified Employee (Safety Management System) in AAAE. He also obtained both Certificate in Terminal and Landside Operation and Certificate in Airside Operation from ACI World.

Adam Baxmeyer works as Airport Director at Purdue University. He had worked as Airport Operations Supervisor at Cherry Capital Airport and Deputy Director, Operations and Facilities at Bloomington Normal Airport Authority.

Joe Marana works as Director of Operations and Facilities at Fort Wayne Airport (FWA). He obtained Accredited Airport Executive, Airport Security Coordinator Certification (ASC), and Airport Certified Employed (ACE) - Operation from AAAE.

Justin Bessler now works as Senior Manager of the Operations Center at Cincinnati International Airport (CVG). He obtained the certificate of Airport Certified Employee (ACE) - Operation from AAAE.

Kevin Klein is the Assistant Airport Director at Cherry Capital Airport (TVC), he also won the Airport Manager of the Year Award in 2017 (The Michigan Association of Airport Executives). He is now an Accredited Airport Executive (A.A.E.) in AAAE.

Dr. Maria Muia is now a Senior Planner and Research Specialist Consultant at Woolpert Inc. She is also a contributor in ACRP research report 129 and 202.

Michael Stephens now works as Operations and Public Safety Director at Dane County Regional Airport (MSN). He is also a Former FAA Airport Certification Inspector.

Mike Daigle is currently the CEO and Executive Director at South Bend Airport (SBN). He is also an Accredited Airport Executive (A.A.E.) in AAAE.

Dr. Stewart Schreckengast is a member of the Graduate Faculty of Purdue University and the University of South Australia. He conducts undergraduate and graduate courses in aviation safety and security, along with applied research in airport development, safety management and multi-modal security programs. He is also a Certified Member (CM), American Association of Airport Executives (AAAE).

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. The ACRP University Design Competition provides the team both meaningful and fulfilling learning experience. The design competition allows students to use tools that are commonly used in industry. Specific tools include safety risk assessment and cost benefit analysis. Gaining experience with these tools and interacting with industry experts and operators provided the project team with an immense learning experience. The team members are grateful to have this chance to give their first try at the national competition. The more effort the team spends on this project, we found out that we are learning more about the aviation industry.

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

One of the main challenges was realized while interviewing industry experts and operators. This challenge was that all airports are designed differently and have different strategies for parking and investment. This caused the project team to formulate design elements that can be applicable to a large majority of airports throughout the country. Another main challenge experienced by the project team was what all could be included in the design. The team had abundant ideas such as license plate reading to determine if a car has been in the cell phone lot for an abundant amount of time and could be charged, but the team had to focus on the design requirements formed by industry experts and operators and the literature review. By

focusing on design requirements it allowed the team to identify needed design elements and ideas that were not material to cell phone lot operation.

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

At first, the team wanted to bring the parking related design into the project. Later, we realized the parking facilities in most airports have not been updated in several years. Most airports are seeking the solution of congestion by expanding the short-term parking area. Then we were inspired by the ACRP report *Cell Phone Lot at Airports*, which presents a large portion of airport cell phone parking lots are not fully equipped with modern amenities that users are seeking. Then the team spoke with industry experts and operators. This interaction allowed the team to understand the current situation of airport cell phone lots and determine what amenities and features are most needed in the lot. This formed the team's design requirements along with an extensive literature review. These steps helped the team formulate hypotheses for the project and provide a solution to solve problems faced by airports.

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

Yes. Participation by industry played an important role in the modernization of airport cell phone waiting lots. It was industry experts that helped the team realize certain design requirements that affected the plan and design approach the team used. Furthermore, the experts pointed out some situations that the team has not considered before. As a result, the combination of amenities in cell phone parking lots was a final result from our interviews with industry experts and the literature review. Therefore, the team believes that the participation by industry

was very appropriate and meaningful for the project to reflect actual problems currently faced by the aviation industry.

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*?

The team members learned about developing a safety assessment and performing a Benefit-Cost analysis based on information provided by ACRP website. Another lesson learned from this project was how to conduct effective research to solve congestion in the aviation industry. This project is unique because the team is constructing innovative solutions to solve airport issues. Also, the project caused the team to analyze all improvements an airport potentially can make and configure a solution from them. These are skills that are highly valued in the aviation industry and we believe will help the students be successful in future projects.

Faculty

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

This project team really embraced this whole idea of creating an innovative solution to a real problem facing airports. Resilience and persistence in the face of adversity (sometimes we call that grit) are two qualities exhibited by this team. They have been amazing at contacting airport managers and experts to better understand the needs of airports, and listening to the expert inputs. This semester has been a challenge for the students as we meet face-to-face and abide by the Purdue Pledge regarding COVID-19 (distancing, de-densifying classrooms, working from home if they feel ill, random testing, and more), and the increased levels of concern for friends and family across the globe. For students in my aviation sustainability course, this competition has great value primarily due to the challenges and topics coming from real airports,

the interactions with industry experts, and the structure of the project report being a proposal in response to the competition guidelines that mirror a request for proposals. This competition encourages the students to do deep dives into not only what to do to improve airports, but also to quantify the risks, costs, and for my students, to describe the impact that these projects may have on airport sustainability. One key to the educational value of the experience is the interactions with industry experts from airports, airlines, and consultants.

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

Yes. This is a graduate level applied aviation sustainability course where the airport improvement projects are also evaluated on the sustainability analysis. The required literature review was a game changer for this team as they began to know more and more about terminal landside congestion, and the use and features of cell phone lots. Due to interactions with airport managers and experts, this team changed entire sets of features, and learned more about what makes cell phone lots more usable for people picking up passengers. For instance, having flight information displayed, and having some space for advertising as a way to inform airport customers and to generate revenue.

3. What challenges did the students face and overcome?

As they learned more and more about cell phone lots and as they wanted to add more and more features, the team learned more about the regulations, safety concerns, and the very difficult task of choosing which features to include and to exclude given the situation of having incomplete and imperfect information. The corona virus restrictions also changed the way the team communicated with each other, myself, and the industry experts. The students overcame the challenges and produced a high-quality project. I am very proud of them.

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

Yes. This competition inspires students to learn more deeply, to seek out regulations and guidance, to read the available literature, and to learn how to learn - skills needed for the rest of their careers.

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

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

Appendix F: Reference List

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