Addressing Airport Congestion as Traffic Takes Off in the Age of Uber and Lyft

ACRP University Design Competition

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Executive Summary

This report examines potential solutions to address landside congestion caused by the operation of Transportation Network Companies (TNCs), such as Uber and Lyft, on airport facilities. Since their official introduction to airports in 2015, TNC mode share has risen dramatically compared to traditional airport access modes, including taxis, limousines, shared vans, personal vehicles, and public transportation. The team's recommendations aim to reduce congestion at the terminal curbside, reduce CO_2 emissions, streamline the passenger and driver experience, and recover the airport's costs of providing services to TNCs operating at their facilities.

The recommendations are intended for large-hub airports and include (1) combining TNC drop-off, pick-up, and pre-dispatch staging in a single terminal-adjacent, non-curbside facility, in addition to having a larger non-terminal-adjacent staging area for longer waits; (2) using re-match, which allows drivers dropping passengers off to be immediately paired with another passenger if one is available, to eliminate trips to the staging lot; (3) increasing awareness and enforcement of no idling regulations to reduce CO_2 emissions; (4) restructuring the pricing scheme to allow curbside drop-off and pick-up for a higher price to allow for convenience while incentivizing use of the non-curbside facility, and; (5) raising per-trip fees for TNCs serving airport passengers to cover operating costs. The report also contains a literature review of existing research on the impact of TNCs on airport operations, and a Safety Risk Assessment (SRA) and Cost-Benefit Analysis (CBA) of the proposed policy recommendations and design changes. These analyses, along with several interviews conducted with landside management staff from multiple airports, informed the final recommendations.

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1. Problem Statement and Background

In recent years, airports have faced rising landside congestion and a shift in landside revenue due to changes in mode choice among airline passengers. One impetus for these changes is the rise of Transportation Network Companies (TNCs) operations at airports. TNC drivers often vie for the same curb-frontage and passengers as other, more established airport passenger transport modes, such as private vehicles, taxis, limousines, shared-ride vans, and public transit. A 2019 survey of the top 25 largest U.S. airports found that since the rise of TNC operations, the majority of airports with TNC operations have experienced a decrease in the overall demand for taxis, limousines, shared-ride vans, rental cars, and — important for revenues — private vehicle parking. Of the airports that reported their mode-share revenues, the majority indicated a decline in total revenues from taxi, limousine, and shared-ride vans with the rise of TNC usage (Ricondo & Associates, 2019). A 2016 survey of the largest 100 U.S. airports - herein referred to as the 2016 Mandle and Box survey - found that airports at which TNCs have been operational for more than one year experienced a decrease of 5% to 10% in the number of parking transactions, entries and exits, per airline passenger (Mandle & Box, 2017).

Developing a solution for TNC management is vital for achieving the best operational efficiency of airport landside access and for meeting the desires of airport passengers. Establishing best practices for TNC management now will likely enhance airport efficiency when the impending rise of autonomous vehicles (AVs) becomes a reality and the demand for airport travel modes shifts again.

2. Literature Review

2.1 TNC Background

Although the definition varies from state to state, in general, a Transportation Network Company (TNC) is a mobility service provider or ride-hailing service that connects riders with drivers through a phone application or digital network in which drivers provide their own personal vehicles for transport. TNCs are generally more loosely regulated than taxicab and limousine services and as a result, usually offer less expensive fares (Conway, Salon, & King, 2018). The most popular TNCs in the United States are Lyft and Uber, although there are many additional TNCs, some of which operate at the regional or municipal level.

The rise of TNCs began in San Francisco in 2010 with the founding of UberCab, now Uber, as an app-based luxury ride-hailing service. Lyft, which evolved from Zimride, a 2007 carpooling application designed to reduce vehicle congestion and the cost of car ownership, launched in 2012 (Shaheen, 2018). Reviewing data from the 2017 National Household Travel Survey (NHTS) indicated that since 2009, the use of TNCs has doubled and reached a relatively high market penetration comparable to that of public transit usage (Conway, Salon, & King, 2018).

2.2 TNC Permitting

The first airport to enter into an operational agreement with a TNC company was Nashville International Airport (BNA) in 2014, followed shortly thereafter that year by San Francisco International Airport (SFO). In both cases, TNCs had been in operation at these airports prior to a formalized agreement with airport operators (Mandle & Box, 2017). In 2015, TNCs began to eclipse taxi usage at airports (Nelson, 2018) and today more than 343 airports nationwide have entered into operational agreements with TNCs (Lyft, 2019).

As with taxis, limousine companies, and other private operators, airports generally require that TNCs obtain a permit to operate on airport property. Unlike private services with professional drivers, TNCs receive a company-wide permit because of the large volume of drivers and high turnover rate (Mandle & Box, 2017). According to their respective websites, Lyft has agreements to operate at 343 airports in the U.S. and Uber has agreements to operate at 146 airports in the U.S. (Lyft, 2019; Uber, 2019).

TNC permits cover the use of roads at the airport, the location for pick-up and drop-off, fees charged to the TNC, driver behavior, and Federal Aviation Administration (FAA) or airport specific rules regarding the appearance, vehicle make, and identification of TNC vehicles (Mandle & Box, 2017; Lyft 2019). TNCs are responsible for training and disciplining negligent drivers, in addition to paying any fines incurred by them. Financial requirements for the TNC typically cover insurance, airport fees, use of a geofence (TNC mobile app enabled to track TNC driver movements using GPS), driver training, and remedial action for drivers (Mandle & Box, 2017).

2.3 Congestion from TNCs

Congestion occurs when demand for use of a roadway outstrips its capacity. At airports, growing air traffic has led to increased landside traffic congestion, as passenger demand increases but roadway capacity remains constrained (Failla, Bivono, & Ventola, 2014). Effective roadway capacity at airports is in part limited by curb space; simply adding a travel lane may not meaningfully increase roadway capacity if drivers are all vying for space in the curb lane. Landside congestion, particularly at the curbside, should be mitigated as much as possible as it inhibits passenger flow, a safety concern since it limits airport access and egress. Curbside congestion also detracts from the passenger experience and research has indicated that it directly contributes to a passenger's perception of an airport's quality of service (Failla, Bivono, & Ventola, 2014). In addition, vehicle congestion creates negative environmental externalities, primarily increased greenhouse gas emissions from vehicle emissions and higher rates of crashes.

One solution to growing passenger volumes at airports would be to encourage higher-occupancy vehicle trips. Yet the vast majority of passengers traveling to airports choose to take private transportation due to the high level of reliability. Personal vehicles, taxis, limousines, and private TNC trips all qualify as private trips, whereas public transportation, shared shuttles, and shared TNC rides are classified as shared trips. In 2015, it was found that Los Angeles International Airport (LAX), San Francisco International Airport (SFO), and Oakland International Airport (OAK), three airports where TNC usage is prominent, had private trip rates of 78%, 63%, and 70% respectively (Hermawan, 2018).

Airports looking to reduce congestion would be well advised to encourage travelers to take shared modes of transportation to decrease the number of vehicles entering the airport's roadways. With finite curb space, there is a limit to the number of vehicles that can occupy the pick-up and drop-off zones at a given time, thus vehicles carrying more passengers are more efficient at reducing curbside congestion.

Though many TNCs offer shared-ride services in which multiple passengers can occupy the same TNC vehicle for their trip, they have been relatively ineffective at reducing airport congestion. In 2015, when TNCs began offering shared rides through services like Lyft Line and UberPool, Hermawan found that TNCs replaced a larger number of shared rides than they created at SFO and OAK. As seen in **Table 1**, this study determined that 1.7% and 0.9% of departing passengers at these airports respectively switched from shared modes to private TNC rides (Hermawan, 2018). This indicates that despite the availability of TNC shared-ride services, many airport passengers actually switched from shared modes to private rides, increasing airport congestion. A survey of the largest 25 airports in the U.S. indicated that TNC growth significantly worsened roadway congestion for a majority of airports (Ricondo & Associates, 2019).

Table 1: Estimated volumes for departing and non-connecting passengers at LAX, SFO, and OAK (2015)

Description	SFO	OAK
Total	2,367,042	232,933
Used TNCs	1,597,121	134,485
Substituted shared modes with TNCs	339,388	40,345
Complemented shared modes with TNCs	71,740	15,069
Substituted transit with TNCs	239,568	28,241
Complemented transit with TNCs	65,881	14,793
Used pooled TNCs	53,344	0

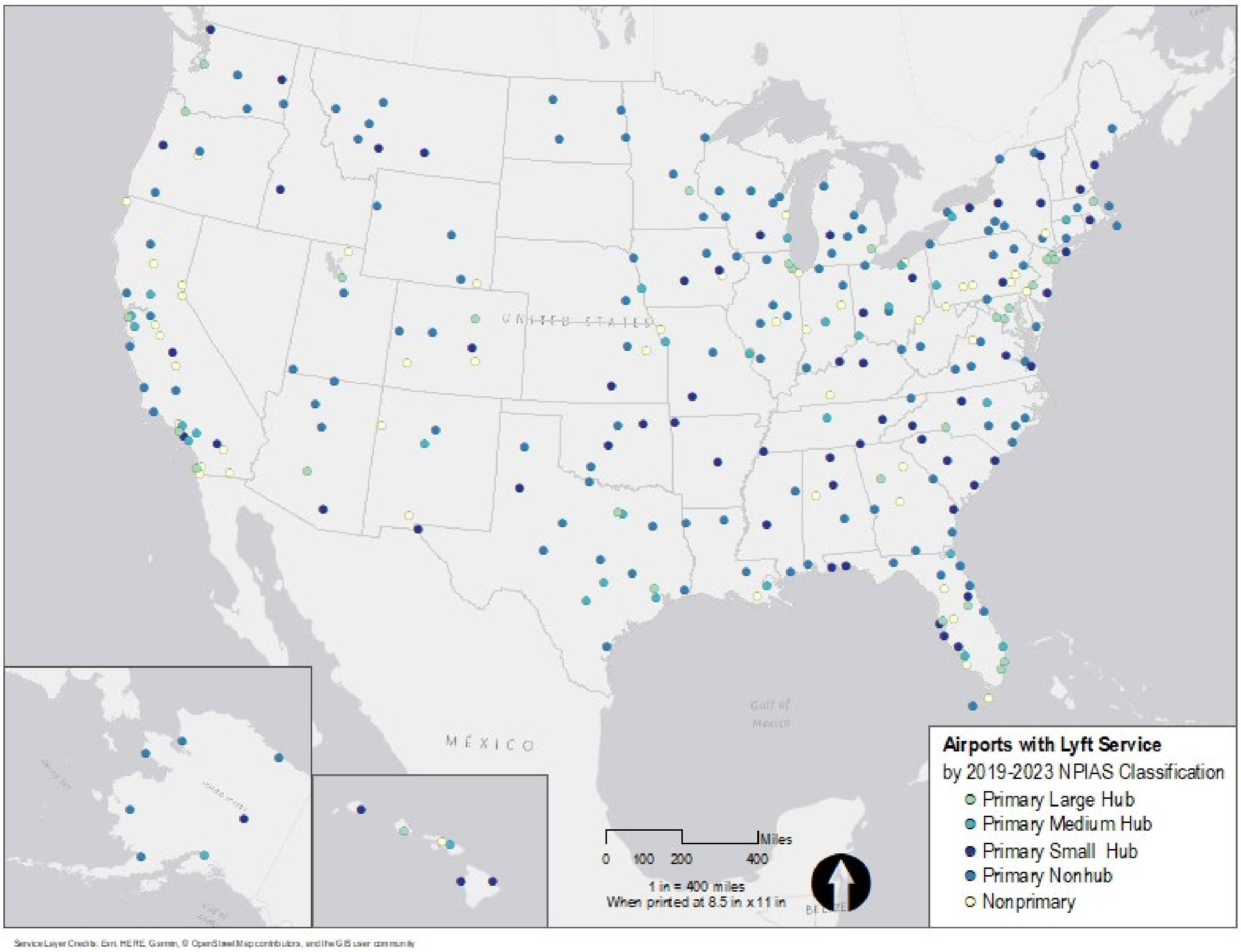
Source: Hermawan, K. (2018). Transportation Network Companies' (TNC) Impacts and Potential on Airport Access. (Doctoral dissertation) UC Irvine. Retrieved from https://escholarship.org/uc/item/01m726rr

2.4 TNC Operations Siting Locations

A major concern of airport operators regarding TNC traffic is that of cruising, where TNC drivers travel slowly through the pick-up lane, hoping for a passenger. This contributes to curbside congestion and creates safety issues. The most common solution to this problem is the creation of staging areas where drivers wait to be matched with a passenger before entering the pick-up zone (Mandle & Box, 2017). A 2016 survey of 100 large airports found that 82% of the responding airports had designated staging areas for TNC vehicles to wait for customers, with 55% providing space in a surface lot, 20% in a parking structure, and 7% in an area utilized by taxis or other ground transportation (Mandle & Box, 2017).

We conducted an analysis of TNC pick-up, drop-off, and staging locations using the information available on Lyft's website which stated rules and locations for pick-up, drop-off, and staging areas for the 343 airports in the U.S. at which they operate. The airports included in this analysis are provided in **Figure 1**.

Figure 1: Airports that have operational agreements with Lyft (2019)



This analysis revealed that all airports allow drop-offs at the curbside and that the majority (224) allow drop-offs at the passenger's airline of choice at the same curbside location as private vehicles. Twenty airports have a designated curbside area for TNC drop-offs and three require TNCs to use the commercial vehicle lane. The majority of airports allow curbside pick-up, with 14 specifying designated areas in surface lots and 10 specifying designated areas in parking garages. Of those airports allowing curbside pick-up, 127 allow pick-up at the passenger's airline, 88 at a curbside designated area, and 10 at a commercial designated area. The percentage of types of airport drop-off and pick-up locations in use by airports according to their NPIAS 2019-2023 classification are depicted in **Figure 2** and **Figure 3** respectively. **Figure 4** illustrates detailed information for airports allowing curbside pick-up.

Figure 2: Lyft airport drop-off location by NPIAS 2019-2023 hub classification (2019)

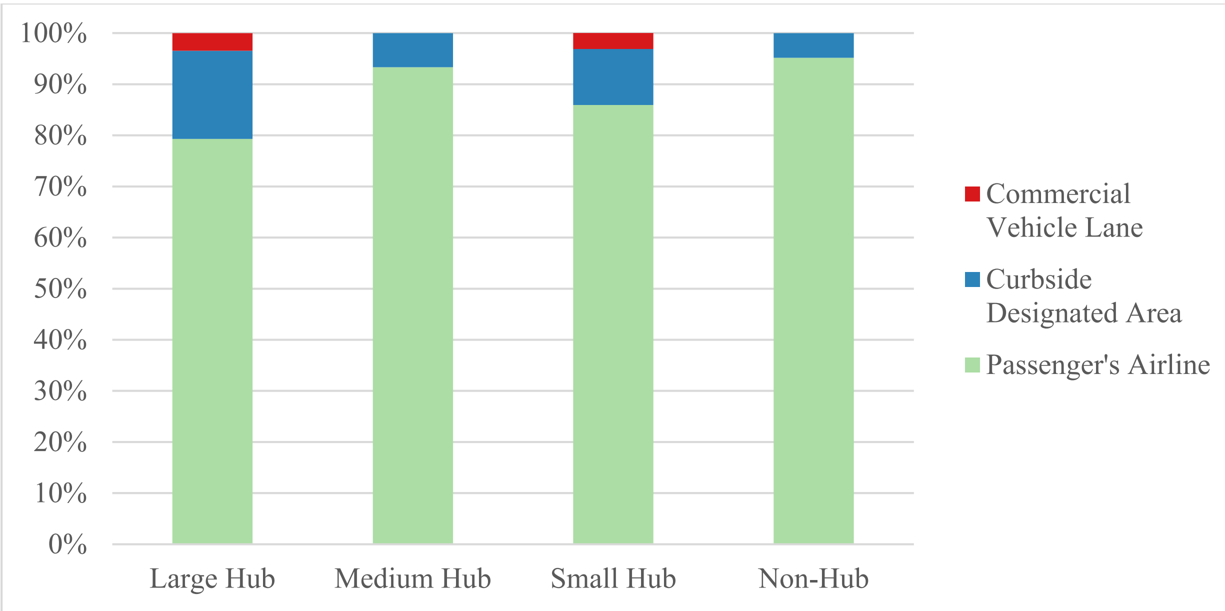


Figure 3: Lyft airport pick-up location by NPIAS 2019-2023 hub classification (2019)

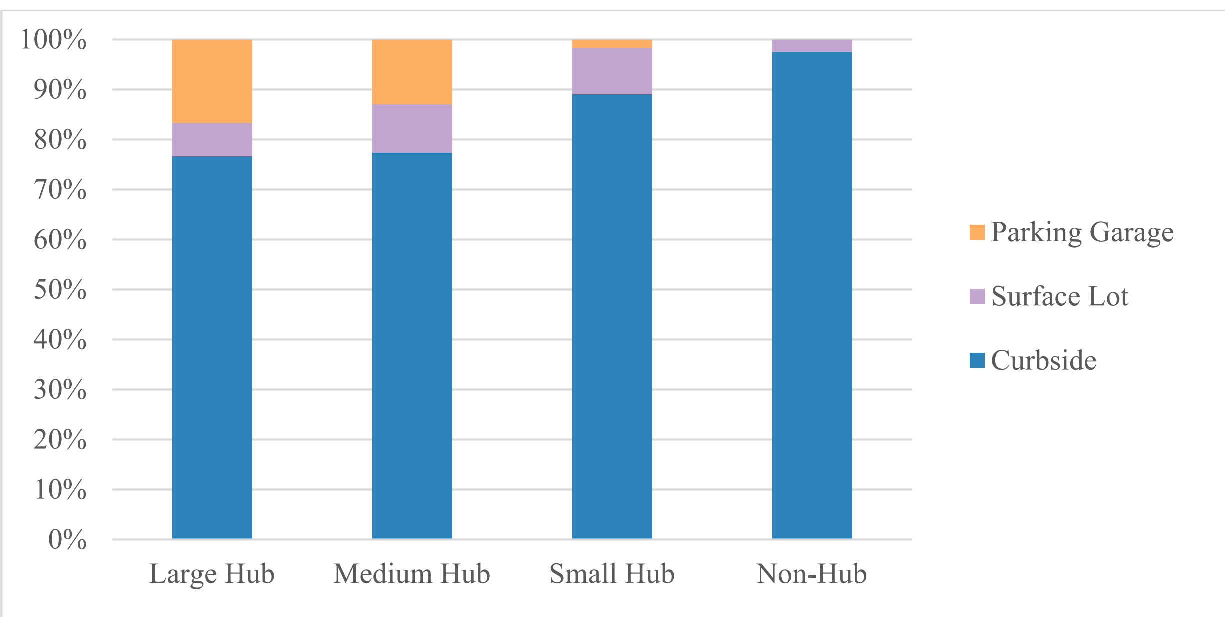
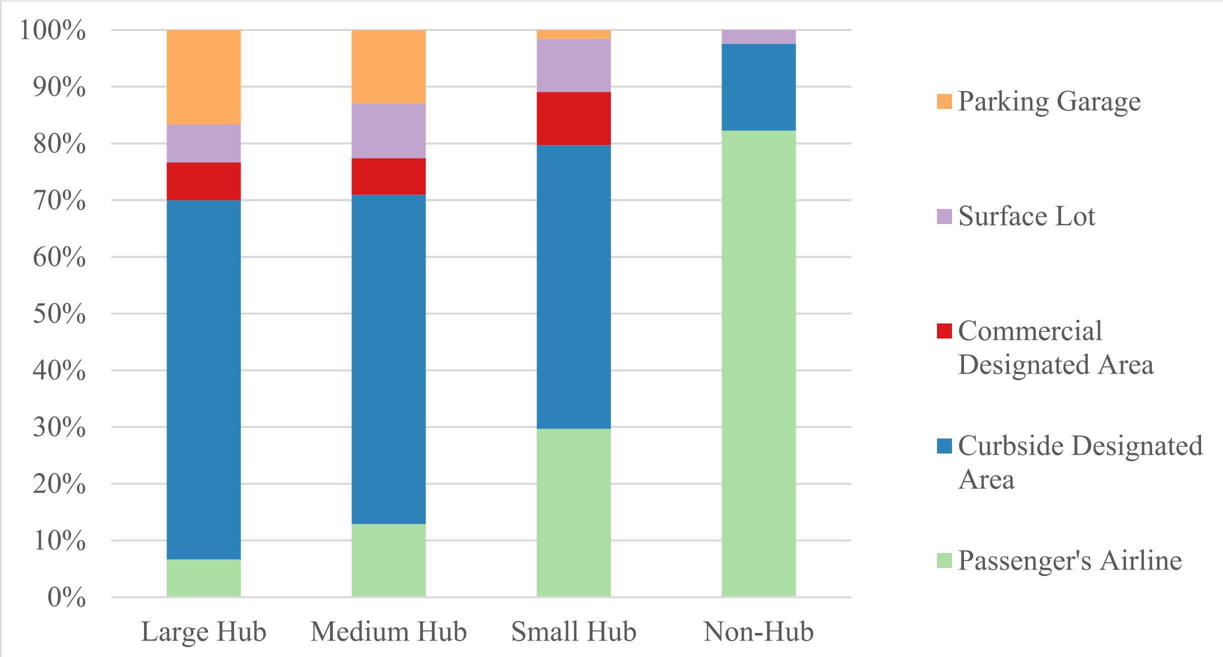


Figure 4: Detailed curbside Lyft airport pick-up location by NPIAS 2019-2023 hub classification (2019)



Categorizing the airports in this dataset using the National Plan of Integrated Airport Systems (NPIAS) 2019-2023 classifications for large, medium, small, and non-hub airport highlights some trends in pick-up and drop-off location (U.S. Congress, 2019). First, large hub airports use parking garages for pick-ups at higher rates than surface lots (**Figure 3**). This may indicate that large hub airports tend to have parking garages in close proximity to the airport rather than surface lots. Second, a higher percentage of large hub airports require pick-up at designated areas on the curbside than at medium and small hub airports (**Figure 3**). Regardless of an airport's NPIAS hub-size classification, all hub airports require curbside pick-up at a designated location at a significantly higher rate than non-hub airports (**Figure 4**).

2.5 TNC Enforcement

The addition of TNC traffic to airport pick-up and drop-off zones has shifted responsibilities for airport employees. The 2016 Mandle and Box survey found that 87% of responding airports depend on traffic officers and operations employees to enforce TNC rules. Approximately 50% of the airports relied partially or completely on police officers to enforce TNC regulations (Mandle & Box, 2017). A 2019 survey of the top 25 largest U.S. airports indicated that TNC growth has led to additional staff roles in TNC administration, maintenance, security, enforcement, and traffic control (Ricondo & Associates, 2019).

Most airports use geofences to gather data and enforce rules on TNCs. Geofencing is a technology that uses app-based GPS tracking to monitor TNC movements within the geographical boundaries (the "fence") of the system. When a TNC vehicle crosses the geofence boundary, it begins transmitting travel information to the airport's geofence system. This allows airports to track the number of TNC vehicles entering their facility. This information is used to ensure that TNCs are meeting their payment obligations under their operational agreements. (Mandle & Box, 2017).

Geofences can also be used to restrict driver access to TNC apps to a particular staging area, preventing them from cruising through the pick-up area while searching for a new customer (Curtis, 2015). A 2016 survey of 100 large airports found that 44% of responding airports designated their staging area as the sole location at which TNC drivers could receive new customer requests while within the geo-fenced boundary (Mandle & Box, 2017).

2.6 TNC Impacts on Other Modes

Many airports have limited data on TNCs because they have not been operating for long and data collection was initially sporadic. Before-and-after research conducted at SFO found that of individuals now using TNCs, 50% previously used taxis, 22% used transit, and 18% used private vehicles (Mandle & Box, 2017). At SFO, there is an estimated decrease in taxi trips by 5-20%, a decrease in shared van trips, and no change in limousine trips (Mandle & Box, 2017). A 2019 survey of the top 25 largest U.S. airports reported that since the rise of TNCs at their airport, the majority have experienced a decrease in the overall demand for taxis, limousines, shared-ride vans, rental cars, and private vehicle parking (Ricondo & Associates, 2019).

LAX, another early adopter of TNCs, included them as a travel mode option for a passenger study for the first time in 2015. According to LAX data, this new mode has grown significantly, quickly catching up to taxi use (Hermawan & Regan, 2018). In addition, the share of TNC use at the airport is expected to continue increasing due to the lower price point of TNCs over other private modes (taxi, limousine, etc.) and a shorter trip time than shared modes (shared van, public transit, etc.) (Hermawan & Regan, 2018). Interviews conducted by the project team with airport staff at LAX, SFO, JFK, and LGA indicate that this trend is consistent at other large-hub airports.

2.7 TNC Revenue Impacts

According to a review of global airport revenues, non-aeronautical revenues generated approximately $7.12 billion in 2018 (Papatheodorou, 2018). Globally, about 20.5% of this revenue was generated by car parking, but in North America this share was nearly double, at 40.8%, illustrating the importance of parking fares as a revenue source for U.S. airports (Papatheodorou, 2018). Airport revenue is sensitive to parking and ground transportation that could be affected by changes to the general transportation system (Zhang & Wang, 2017). The prevalence and convenience of TNCs causes many passengers to shift their mode choice from taxis and personal vehicles to TNCs, representing a meaningful change to the overall transportation system (Feng & Miller-Hooks, 2014). Despite an average 10-20% decline in private vehicle usage for airport trips and a 5-10% decline in average airport parking customers (Mandle & Box, 2017), aircraft parking capacity and fees are currently formulated based on historical passenger throughput, travel mode splits, and projected future aircraft demand (Feng & Miller-Hooks, 2014). Lost parking transactions due to the rise of TNCs are not included in this, indicating that airports may wish to adjust the pricing of TNC fees to make up for this forgone revenue.

The 2016 Mandle and Box survey found that, in addition to the average decline in airport parking transactions, airport rental car transactions have also decreased by an average of 13% and taxicab trips by an average of 5-13%. Of the 100 airports surveyed, all but two indicated that TNC fees did not outpace the loss of parking, taxi, and rental car revenues (Mandle & Box, 2017). Of those that reported their mode-share revenues in a 2019 survey of the top 25 largest U.S. airports, the majority indicated a decline in total revenues from taxi, limo, and shared-ride vans with the rise of TNC usage (Ricondo & Associates, 2019).

2.8 TNC Revenue Pricing Strategies

Airports are using multiple strategies to price TNCs. The majority of airports (98%) require that TNCs pay one or more of the following (Mandle & Box, 2017):

- Annual permit fees. These have historically averaged $2,000 per year.
- An activation fee, also known as a geofence fee, at the time of signing an operational agreement. These have historically ranged from $1,000 to $100,000.
- Per-trip fees for passenger pick-ups, drop-offs, or both, paid by TNCs on a monthly basis.
- A minimum annual guarantee (MAG) amount which charges the higher of either a per-trip fee or a minimum annual guarantee fee.

A substantial majority (87%) of airports require per-trip fees, which are difficult for airports to price when negotiating an operational agreement because airports lack information about TNC mode-share and the costs associated with providing services to TNCs (Mandle & Box, 2017). Currently, per-trip fees range from $1.00-$5.00 per pick-up trip and $1.00-$4.00 per drop-off trip (Mandle & Box, 2017). When pricing per-trip fees, airports should consider that the demand for outbound TNC trips outweighs the demand for inbound TNC trips (Feng & Miller-Hooks, 2014); existing taxi and limousine fees; fees charged by peer airports; and the revenue needed to cover the provision of TNC services and forgone parking revenue (Mandle & Box, 2017). More than 80% of airports have relied on TNCs for self-reporting trips, but some airports have initiated geofences to track TNC trips to ensure proper payment (Mandle & Box, 2017).

3. Problem Solving Approach

3.1 Reasoning and Methodology

As TNCs gain popularity among airline passengers, airports are searching for ways to address this new source of curbside congestion. One team member was anecdotally aware that airport operators were uncertain of how to handle TNCs as permitting legislation allowed them to operate in more localities.

Data from maps of airports that Lyft serves was compiled to determine the locations of drop-off, pick-up, and staging areas. Lyft was chosen because of the availability of data on their website and because it operates at more airports in the United States than any other TNC. This data informed the decision to focus the project on large-hub airports, as classified by the NPIAS 2019-2023, since large hub airports use parking garages for TNC pick-ups at a higher rate than other airport classifications. This may imply higher rates of curbside congestion at large hub airports, which can be ameliorated through the use of parking garages as pick-up locations.

Based on this information and phone interviews with industry experts, the topic was further refined to focus on reducing TNC-based congestion at large hub airports with the understanding that these airports have the most significant problems due to higher airline passenger volumes.

A review of the January 14, 2019 Draft ACRP 01-35 report titled "Transportation Network Companies (TNCs): Impacts to Airport Revenues and Operations," led to a phone interview with the Principal Investigator, Craig Leiner. Our interview with Mr. Leiner influenced the decision to focus our recommendations on innovative approaches for TNC management. Additionally, personal experiences utilizing TNCs at large-hub airports shaped our desire to promote passenger-friendly solutions.

A phone conversation with landside operations staff at the Port Authority of New York and New Jersey (PANYNJ) informed our decision to move away from recommending the combination of drop-off, pick-up, and staging in one location, to instead recommending the combination of drop-off, pick-up, and pre-dispatch staging in addition to a non-terminal adjacent staging area. Establishing a separation between pre-dispatch staging and the staging done while waiting to reach the front of the queue to be matched with a passenger was changed in response to the large numbers of TNC drivers that may be waiting in staging lots at any one time.

3.2 Recommendations

Our recommendations aim to reduce congestion at the terminal curbside, reduce CO_2 emissions, streamline the passenger experience, and recover the costs of providing services to TNCs serving the airport. The recommendations include (1) combining TNC drop-off, pick-up, and pre-dispatch staging in a single terminal-adjacent, non-curbside location along with a larger non-terminal adjacent staging area for long-term waiting; (2) using re-match for drivers dropping-off passengers to eliminate trips to the staging lot; (3) increasing awareness and enforcement of no-idling regulations to reduce CO_2 emissions; (4) restructuring the pricing scheme to allow curbside drop-off and pick-up for a higher price to incentivize usage of non-curbside location; and (5) raising per-trip fees for TNCs serving airport passengers.

Combining TNC drop-off, pick-up, and pre-dispatch staging into a central location allows for more efficient TNC operations by eliminating travel time between the drop-off and pick-up zones for drivers who are able to re-match after dropping a passenger off. Re-match refers to drivers receiving a new fare (rider) directly after dropping off a passenger, typically within 30 to 60 seconds. Drivers who are able to re-match eliminate a trip to and from the staging lot. Drivers that do not get a re-match proceed to the staging lot to enter the "virtual queue." TNCs use a first-in, first-out model for assigning rides that queues the drivers based on when they arrive at the staging lot. With pre-dispatch staging, once a driver reaches a certain position in the virtual queue, that driver will move from the non-terminal adjacent staging lot to the pre-dispatch staging area near the terminal. This will eliminate wait time for passengers because the TNC drivers will be at the pick-up area when they are matched. It is further recommended that airports locate the combined pick-up and drop-off facilities close to the terminal to allow passengers easier access. Due to decreases in private vehicle parking and rental car usage, some parking garages that house these facilities may have underutilized space that can be repurposed for TNC operations, ensuring that the airport maximizes its use of space.

On average, TNC drivers wait between 10 and 30 minutes in the staging lot before being assigned a ride (Free, Porta, Vasquez, 2019). Airport operators have stated that TNC drivers often have their cars idling the entire time they are waiting to either heat or cool their vehicle (Free, 2019). This means that TNC vehicles contribute to CO_2 emissions at the airports they serve. Increasing awareness and enforcement of no idling regulations will reduce CO_2 emissions from TNC drivers and improve air quality.

Restructuring the pricing scheme to allow for curbside drop-off and pick-up at an increased price allows airline passengers to opt for a shorter journey but enables airports to control TNC-based traffic by encouraging passengers to opt for the non-curbside option. This change would address potential passenger complaints after relocating drop-off and pick-up locations to a non-curbside site, by offering TNC passengers a choice of access points. It could also provide a slight increase in revenue for the airports if the price differential is sufficient enough to cause behavior change, without significantly impacting traffic.

Combining the drop-off and pick-up locations will likely involve minor logistical costs, construction costs, and future operational costs for airports. To cover some of these costs, it is recommended that airports consider charging higher per-trip fees to TNC operators when establishing an operational agreement or re-negotiating an existing operational agreement.

4. Safety Risk Assessment

Safety is a vital consideration for all projects, especially those based at airports. As part of the preparation of this report, the team explored potential hazards to both TNC operators and users in implementing the proposed recommendations and possible methods for risk mitigation. As indicated in **Figure 5**, hazard ratings vary from "Extremely Improbable" to "Frequent" in likelihood and "Minor" to "Catastrophic" in severity. As indicated in FAA AC 150/5200-37, *Introduction to Safety Management Systems for Airport Operators,* a high level of risk is considered unacceptable and cannot be implemented until it is reduced to a medium or low level of risk. A medium level of risk is considered acceptable, but it achieves the minimum safety objective and requires continuous tracking and management. Therefore, achieving a low level of risk was the target objective in developing the final recommendations and as such, the Cost-Benefit Analysis (CBA) will explore the costs of achieving this level of hazard mitigation.

Table 2 identifies the hazards, their likelihood of occurrence, the severity of their impact, and ways to mitigate the risk. This table was developed using the steps taken in formulating a Safety Management System (SMS) and included: (1) describing the system, (2) identifying hazards, (3) analyzing the risk in terms of likelihood and severity, (4) assessing the risk, and (5) controlling the risk.

Figure 5: Hazard rating matrix

		Severity				
		No Safety Effect	Minor	Major	Hazardous	Catastrophic
Likelihood	Extremely Improbable					
	Extremely Remote					
	Remote					
	Probable					
	Frequent					

Table 2: Safety risk assessment including mitigation strategies

Hazards	Likelihood	Severity	Controlling the Risk
Roadway Crashes - Minor, No Injuries	Remote	Minor	Visible Striping on Crosswalk, Lighting in Crosswalks, Rapid Reflective Flashing Beacons, Speed Limit Signage
Garage Crashes - Minor, No Injuries	Remote	Minor	Improved Lighting in Garage, Mirrors Around Sharp Turns, Designated Waiting Area w/ Curb, Speed Limit Signage
Garage Crashes - Minor, w/ Injuries	Extremely Remote	Major	Improved Lighting in Garage, Mirrors Around Sharp Turns, Designated Waiting Area w/ Curb, Speed Limit Signage
Weather Exposure - Cold	Extremely Remote	Major	Indoor Waiting Area
Weather Exposure - Ice	Extremely Remote	Major	Deicing and Snow Removal Strategies
Parking Garage Safety - Robbery	Extremely Remote	Major	Improved Lighting, Police/Staff Presence, Crime Prevention Through Environmental Design (CPTED), Emergency Call Boxes
Getting Lost	Probable	Minor	Wayfinding Campaign
Greater Travel Distance	Frequent	Minor	Handrails, High-traction Surfaces, Elevators and Escalators
Luggage Transport	Probable	Minor	Luggage Cart Collector in Parking Garage, Staff Member Collecting Carts
Parking Garage Safety - Assault	Extremely Remote	Hazardous	Improved Lighting, Police/Staff Presence, Crime Prevention Through Environmental Design (CPTED), Emergency Call Boxes
Roadway Crashes - Minor, w/ Injuries	Remote	Major	Visible Striping on Crosswalk, Lighting in Crosswalks, Rapid Reflective Flashing Beacons, Speed Limit Signage
Roadway Crashes - Major, w/ Severe Injuries or Death	Extremely Improbable	Catastrophic	Visible Striping on Crosswalk, Lighting in Crosswalks, Rapid Reflective Flashing Beacons, Speed Limit Signage
Garage Crashes - Major, w/ Severe Injuries or Death	Extremely Improbable	Catastrophic	Improved Lighting in Garage, Mirrors Around Sharp Turns, Designated Waiting Area w/ Curb, Speed Limit Signage
Terrorism	Extremely Improbable	Catastrophic	Bollards to Protect Waiting Area, Enhanced Security Presence - Cameras and Staff, "See Something, Say Something" Signage

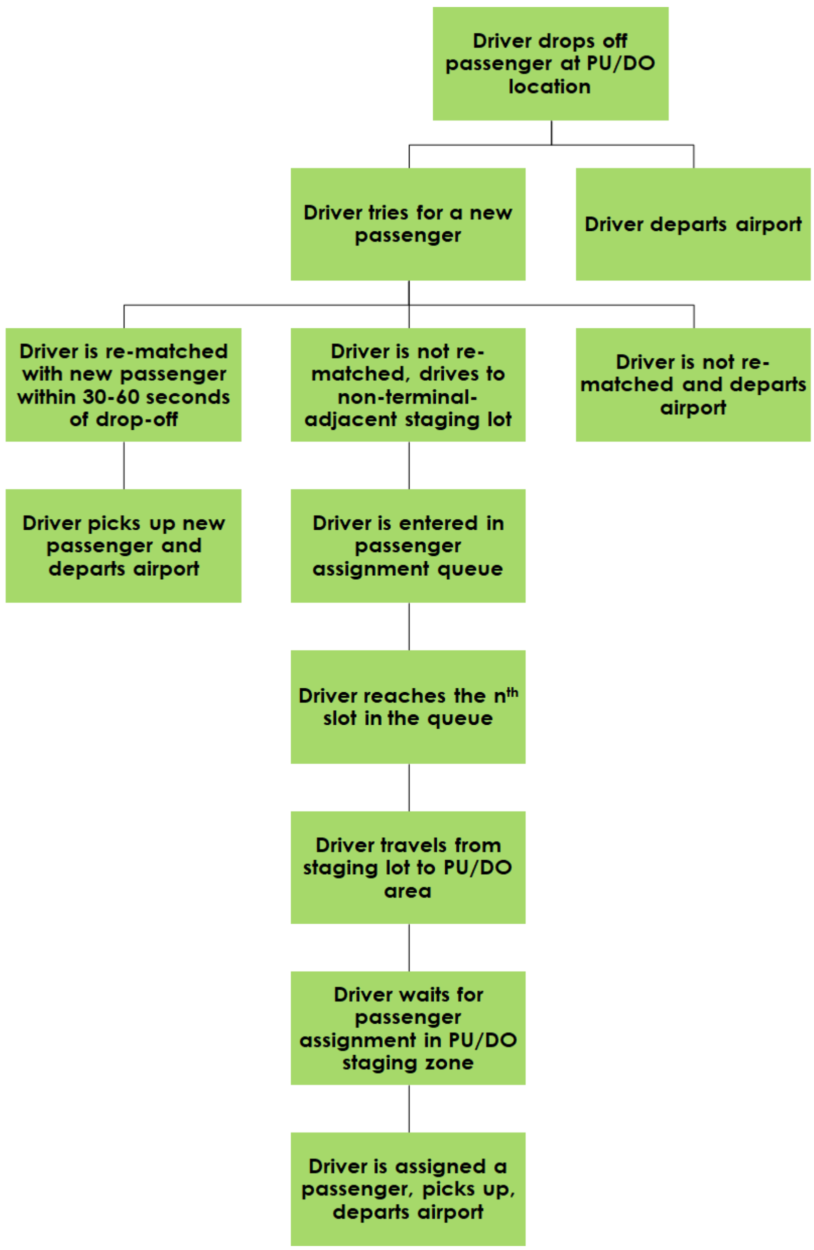
Low Risk	Medium Risk	High Risk

5. Description of Technical Aspects

5.1 Driver Decision Methodology

Figure 6 describes a potential system for TNC driver operations at an airport. After dropping off a passenger at the TNC airport operations facility, the driver can choose to leave the airport without a passenger or attempt to be re-matched with a new passenger.

Figure 6: TNC driver decision process



As seen in **Figure 6**, the system attempts to match the driver within 30-60 seconds. If the system does not find a match, the driver can choose to leave the airport or proceed to the staging lot and join the virtual queue to be matched with a passenger. The driver does not enter the virtual queue until arriving at the holding lot. Once the driver reaches a designated position in the queue as chosen by the airport, they are instructed to travel to the TNC pick-up, drop-off, and pre-dispatch staging area. The queue position at which the driver is instructed to travel to the TNC facility can be altered based on the travel time between the holding lot and the facility, or at the airport's discretion. Once in the pick-up location, the driver waits to be matched with a passenger. Once they are matched, the driver picks up their passenger and departs the airport with the passenger(s). The pick-up location could be staged several ways. For example, it could have waiting parking spots and an area where drivers pull up to pick-up passengers once they are matched. It could also have marked parking spots that the app assigns to drivers and the app would then notify passengers at which parking spot their driver is located.

5.2 Geofence Requirements

The system requires a geofence to restrict drivers to the holding lot when they are in the queue. Geofences utilize a Global Positioning System (GPS) to restrict the use of applications when in a certain geographical area. In the case of TNCs, many airports have already implemented geofences to restrict TNC drivers to waiting in holding lots instead of contributing to congestion by driving around on airport roadways. The system of operations proposed above would require slight alterations to existing geofences to allow drivers in the front of the virtual queue to maintain their position in the queue when traveling to the pre-dispatching staging lot. Pre-dispatching reduces the time that passengers and drivers spend actively waiting for a ride and it also serves to reserve high-value, terminal-adjacent property for passenger use.

6. Description of Interactions with Airport Operators and Industry Experts

In February 2019, the research team contacted Peter Mandle at InterVISTAS as he was one of the authors of the 2017 report, Transportation Network Companies: Challenges and Opportunities for Airport Operators. Mr. Mandle referred the team to Craig Leiner, an Associate Director at Ricondo and Associates, Inc., who is the lead investigator on a follow-up report examining best practices for airport operators to handle interactions with TNCs titled Transportation Network Companies (TNCs): Impacts on Airport Revenues and Operations. The team spoke to Mr. Leiner over the phone regarding his ongoing research. He provided insight on a variety of subject areas the team was considering and provided advance access to a database being developed for airport operators as part of the project that will be publicly accessible at the conclusion of the project for the exclusive purpose of informing our recommendations to airport operators. As a result of this interaction, the team decided to examine how airports can reduce congestion from TNC operations at large airports because Mr. Leiner stated that large airports have the most severe congestion issues and have been considering different alternatives to handle those issues.

The team then reached out to airport operators at LAX, SFO, and the Port Authority of NY & NJ (PANYNJ), which operates Newark Liberty International Airport (EWR), John F. Kennedy International Airport (JFK), and LaGuardia International Airport (LGA). The team spoke with Shirlene Sue, Landside Management and Airport Permit Services at LAX, who provided information about parking revenue at LAX and the considerations that go into siting TNC driver pick-up, drop-off, and staging. The team also spoke with Don Free, Peter Carbonaro, Julian Porta, and Thor Vasquez from the Aviation Department at PANYNJ about the considerations for operating TNCs at JFK, LGA, and EWR. From this conversation, the team learned that TNC pick-up and staging is combined in a parking garage at Terminal B at LGA, which is popular with customers and drivers. However, Mr. Free emphasized that staging and pick-up should not be located in the same location because it contributes to vehicle and pedestrian congestion of in the central terminal area. Mr. Vasquez also discussed the staffing needs associated with the operation of TNCs and parking revenue at LGA. Furthermore, the team spoke with Eva Cheong, Airport Director at SFO, about the airport's TNC operations. Director Cheong discussed the evolution of TNC operations at SFO and their impact on congestion. After initially offering curbside pick-up, the airport switched to a choice between garage pick-up and curbside pick-up at an increased price. However, airport operators found there to be little price elasticity among frequent flyers, with the choice of pick-up locations providing only minimal relief for the congestion problem. Director Cheong discussed the airports exploration of potential solutions, along with the effects of TNCs on ground transportation mode share. Finally, she described staffing needs relating to TNC oversight by SFO. The information gained from these discussions helped to inform the team's Cost-Benefit Analysis and understanding of the projected impacts of the recommendations.

7. Projected Impacts

The team's recommendations are intended to improve vehicular traffic flow at the terminal, reduce CO_2 emissions, improve the passenger experience, and recover some of the costs of providing services to TNCs operating at the airport.

7.1 Cost-Benefit Analysis

The costs and benefits of combining pick-up, drop-off, and pre-dispatch staging into a parking garage close to the airport are calculated below. The costs and benefits calculated here represent those of improving an existing parking garage to serve as a TNC facility rather than the costs of constructing a ground transportation facility that can serve the needs of TNCs and other types of ground transportation. As TNC mode share grows, airports may consider this kind of facility in the future. The benefits to passengers and reduced CO_2 emissions significantly outweigh the costs of improving the parking garage.

The costs include one-time planning, engineering, and construction costs per terminal, and recurring maintenance, security, and operation costs to improve a garage to function as a TNC waiting area. The costs incorporate recommendations from the Safety Risk Assessment to mitigate risks. The team did not monetize the cost of forgone parking revenue due to the variety of parking rates and availability at different airports. Though some parking revenue may be lost due to the loss of these spaces, many airports are already facing decreasing parking transactions (Ricondo & Associates, 2019). As parking transactions continue to decline due to the increasing mode share of TNCs, airports should consider repurposing any underutilized garage space near terminals to locate TNC pick-up and drop-off. By raising per trip fees on TNC trips, airports can recover some of the revenue lost to re-allocating parking garage space to TNC operations.

The costs of developing the project include the cost of the project team, project advisor, and professionals that gave their time to help the project team. The cost of labor was calculated using wage statistics from the Bureau of Labor Statistics (BLS) and a 1.47 multiplier was applied to account for benefits and overhead (U.S. Bureau of Labor Statistics, 2018). These costs totaled to approximately $6,000 (**Table 3**).

Table 3: Costs of developing the project

Item	Rate ($/hr.)	Quantity (hr.)	Total ($)
Professionals*	$54.93	8	$439.47
Graduate Students (Project Team)*	$21.77	210	$4,571.85
Professor (Advisor)*	$53.71	20	$1,074.23
*Wages from BLS multiplied by 1.47 for benefits and overhead		**Total:**	**$6,085.55**

The research team estimated a high and low range for the costs of planning, engineering, and construction (**Table 4**). The cost of labor was calculated using wage statistics from the BLS along with a 1.47 multiplier to account for benefits and overhead (U.S. Bureau of Labor Statistics, 2018). The costs of construction materials were estimated using the cost estimate document "Average Bid Prices for Awarded Contracts State Aid Projects Not Included 1/1/2017 to 12/31/2017" from the Minnesota Department of Transportation (MNDOT). The sources for other costs are shown in **Table 4**. The cost ranges between $100,000 and $460,000 for altering the garage to serve TNCs and to provide ongoing staff support for security, operations, maintenance, and customer support (**Table 4**). These costs would be incurred by the airport.

Table 4: Costs of combining pick-up, drop-off, and pre-dispatch staging

			Low Scenario		High Scenario	
	Item	**Cost**	**Quantity (hr.)**	**Total ($)**	**Quantity (hr.)**	**Total ($)**
Staff Costs	Planner*	$50.52	40	$2,021	250	$12,631
	Engineer*	$59.90	120	$7,188	750	$44,927
Construction Costs	Item	**Cost**	**Quantity (per item)**	**Total ($)**	**Quantity (per item)**	**Total ($)**
	Wayfinding Signage**	$115	10	$1,150	20	$2,300
	Speed Limit Signage**	$115	0	$0	5	$575
	"See Something, Say Something" Signs**	$115	0	$0	2	$230
	No Idling Signage**	$115	2	$230	4	$460
	Sign Installation**	$112	12	$1,344	29	$3,248
	Parking Garage Lights[1]	$1,157	20	$23,140	50	$57,850
	Install Lighting Unit**	$527	20	$10,540	50	$26,350
	Emergency Call Box System[2]	$600	0	$0	2	$1,200
	CCTV Cameras**	$8,381	0	$0	3	$25,143
	CCTV Installation**	$1,668	0	$0	3	$5,003
	Fire Extinguisher[3]	$500	2	$1,000	3	$1,500
	Bollards**	$1,308	10	$13,075	20	$26,150
	High Visibility Crosswalk[4]	$2,500	1	$2,500	2	$5,000
	Luggage Cart Area[5]	$500	1	$500	1	$500
	Bench**	$1,961	3	$5,883	6	$11,766
	Garbage Can[6]	$350	1	$350	4	$1,400
	Recycling Can[6]	$350	1	$350	4	$1,400

	Item	Cost	Low Scenario Quantity (hr./yr.)	Low Scenario Total ($/yr.)	High Scenario Quantity (hr./yr.)	High Scenario Total ($/yr.)
Recurring Costs	Security Guard*	$19.05	1095	$20,861	2,190	$41,722
	Janitor*	$17.67	365	$6,449	730	$12,899
	Maintenance - General*	$26.62	156	$4,153	260	$6,922
	Maintenance - Snow/Ice*	$26.62	0	$0	20	$532
	Operations Manager*	$87.24	0	$0	50	$4,362
	Customer Service Representative*	$23.24	0	$0	7,300	$169,657
Notes: *Wages from BLS multiplied by 1.47 for benefits and overhead (U.S. BLS, 2018) **Cost estimate from MNDOT (Minnesota DOT, 2018)			**One-Time Total:**	$69,271	**One-Time Total:**	$227,632
			Recurring Total:	$31,463	**Recurring Total:**	$236,094
			GRAND TOTAL:	$100,734	**GRAND TOTAL:**	$463,726
Sources: 1 (U.S. Department of Energy, 2013) 2 (Telcom Data, 2019) 3 (Home Advisor, 2019) 4 (Federal Highway Administration, 2019) 5 (Carriage Trade Service Co, Inc., 2018) 6 (Global Industrial, 2019)						

The recommendations will not only benefit TNC drivers and passengers, but also airport passengers that do not take TNCs. These benefits include a reduction in CO_2 emissions due to stricter enforcement of no idling laws in the parking garage and saving non-TNC passengers' time by reducing curbside congestion. Re-match at the parking garage and pre-dispatch staging will improve driver productivity and lessen the time spent waiting for a passenger. These benefits accrue to the airport customers, TNC drivers, and society-at-large for the reduction in CO_2 emissions.

The research team did not calculate the monetary benefits to airports of raising the per-trip fee for TNCs or using a price differential for garage and curbside pick-up and drop-off due to variation in airport permits and pricing schemes. However, airports can recoup some of their costs by using these methods.

The research team calculated four benefit scenarios as shown in **Table 5**. The benefits of reduced CO_2 emissions from reduced idling and driving to and from staging lots are something that airports can incorporate into their goals for improving sustainability and reducing emissions. A high and low range for the monetary benefits of reducing CO_2 emissions by reducing idling and driving to and from staging lots was estimated using the following assumptions (**Table 5**):

- The high and low range are determined by calculating the 1st and 3rd quartile for the passenger volume for all large-hub airports. This means that 25% of large-hub airports would see greater benefits, 25% would see lesser benefits, and 50% of airports would see benefits within the range calculated.
- The TNC passenger volume is assumed to be 8% of this passenger volume because research at both LAX and SFO found that 8% of passengers were using TNCs to access the airport (Hermawan & Regan, 2018).
- The amount of CO_2 saved by not idling is assumed to be one pound of CO_2 per ten minutes for a typical passenger vehicle (Environmental Defense Fund, 2009).
- The social cost of carbon for 2020 with a 3% discount rate is used. This is $42 per metric ton of CO_2 (U.S. Environmental Protection Agency, 2016).

Table 5: Description of Benefit Scenarios

Scenario	Description
1	Low time estimate, low passenger volume estimate
2	High time estimate, low passenger volume estimate
3	Low time estimate, high passenger volume estimate
4	High time estimate, high passenger volume estimate

A high and low range for saving non-TNC passenger time was calculated using the average wage for a person employed in business and finance to account for the relatively higher wages of individuals that fly, especially frequent fliers (U.S. Bureau of Labor Statistics, 2018). It was assumed that the reduced congestion would save 0.25 minutes per passenger not using a TNC (**Table 6**).

A high and low range was also calculated for TNC driver time by averaging the estimates for hourly wages from surveys of Uber and Lyft drivers (Ridester, 2018). It was assumed that about 25% of drivers would get a re-match immediately and that drivers that got re-matched would save five to ten minutes by not having to drive to and from the staging lot and an additional five to twenty minutes by not waiting for a new passenger.

Table 6: Benefits of Combined Pick0up, Drop-off, and Pre-dispatch Staging

		Scenario			
		1	**2**	**3**	**4**
Reduced Idling	Rate of CO2 production from idling	1lb./10 min.			
	Reduced Idling Time (mins)	10	30	10	30
	TNC Trips	958,284	958,284	1,882,265	1,882,265
	CO2 Saved (lbs.)	958,284	2,874,852	1,882,265	5,646,796
	CO2 Saved (metric tons)	435	1,304	854	2,561
	Social Cost of Carbon	$42/metric ton			
	Subtotal:	**$18,256**	**$54,769**	**$35,859**	**$107,578**
Trips Avoided	Rate of CO2 production from driving	1.5lb/5 min.			
	Reduced Driving Time per Trip (mins)	15	30	15	30
	TNC Trips to Staging Lot Avoided	239,571	239,571	470,566	470,566
	CO2 Saved (lbs.)	1,078,070	2,156,139	2,117,549	4,235,097
	CO2 Saved (metric tons)	489	978	961	1,921
	Social Cost of Carbon	$42/metric ton			
	Subtotal:	**$20,538**	**$41,077**	**$40,342**	**$80,683**
Non-TNC Passenger Time	Time Saved per Trip (mins)	0.15	0.25	0.15	0.25
	Wage of Average Businessperson ($/hr.)	$32.55	$32.55	$32.55	$32.55
	Number of Passengers	23,957,102	23,957,102	47,056,636	47,056,636
	Subtotal:	**$1,949,509**	**$3,249,182**	**$3,829,234**	**$6,382,056**
Driver Time	Time Saved per Trip (mins)	5	7	5	7
	Wage of Average TNC Driver ($/hr.)	$16.78	$16.78	$16.78	$16.78
	Number of Passengers	958,284	958,284	1,882,265	1,882,265
	Subtotal:	**$1,340,001**	**$1,876,001**	**$2,632,034**	**$3,684,848**
	GRAND TOTAL:	**$3,328,305**	**$5,221,029**	**$6,537,469**	**$10,255,165**

The benefits for Scenario 1, which assumes a low amount of time saved and a low passenger volume, are \$3.3 million. This may represent the benefits experienced by large hub airports with lower passenger volumes. The middle range of benefits, represented by Scenarios 2 and 3, were \$5.2 million and \$6.5 million, respectively. The benefit for Scenario 4, which assumes a high amount of time saved and a high passenger volume, are \$10.3 million. This may represent the benefits experienced by large hub airports with higher passenger volumes. The benefit of saved time accrues to non-TNC passengers and TNC drivers. It may also accrue to TNC passengers who may not have to wait for their driver to arrive if pre-dispatch staging works as intended, however this was not monetized. The benefit of reduced air pollution from the airport accrues most acutely to those employed at the airport and individuals who live near the airport. However, these benefits also accrue to society at-large due to the reduction in greenhouse gases. The airport may recover some of their costs of providing services to TNCs by raising per trip fees when establishing or renegotiating a contract with TNCs.

The costs and benefits were projected for 10 years using a 3%, 5%, and 7% discount rate. The discount rate accounts for the opportunity cost of spending money instead of investing it where it would earn a return. It accounts for the tendency of people to discount future benefits in favor of more immediate gain. When a discount rate is used, it shows the present value of the costs and benefits expected to accrue over the projected time period. These costs and benefits are also annualized at each discount rate to show the present value of the cost and benefits that will accrue each year. In all cases the benefits outweigh the costs (**Table 7**).

Table 7: The costs and benefits projected for 10 years using a 3%, 5%, and 7% discount rate

	Costs	Benefits	Total Benefits
Total (3% DR)	$1,159,729	$24,908,080	$23,748,350
Total (5% DR)	$1,054,048	$21,388,364	$20,334,317
Total (7% DR)	$963,031	$18,432,088	$17,469,057
Annualized (3% DR)	$115,973	$2,490,808	$2,374,835
Annualized (5% DR)	$105,405	$2,138,836	$2,033,432
Annualized (7% DR)	$96,303	$1,843,209	$1,746,906

7.2 Other Considerations

To improve the passenger experience, TNC pick-up and drop-off locations should be within comfortable walking distance of the terminal. These locations should be prioritized because they can greatly inform a passenger's first and last impression of the airport. At LGA, which is managed by the PANYNJ, passengers previously had to take a bus to get to the TNC pick-up location. After the pick-up location was moved to a parking garage within walking distance from the terminal, staff saw a 15% increase in TNC rides due to the improved convenience. From the customer and driver perspective, the relocation has been highly successful.

There are some costs associated with locating TNCs in parking garages, such as lower parking revenue due to space allocation to TNCs and traffic management challenges because the garage being used was not designed to accommodate the traffic patterns of TNC operations. To handle these challenges, the PANYNJ use operations staff to direct traffic at LGA. The landside planning staff recommended that future garages have a separate TNC entrance if they will be used for TNC pick-up and staging.

There are also considerations if an airport allows users to choose between a garage or curbside pick-up or drop-off location. After initially assigning TNC pick-ups to the departure level of the terminal in 2015, airport operators at SFO found a high level of congestion generated by the additional vehicle trips. In an attempt to mitigate some of this congestion, TNC pick-ups were moved to one floor of a nearby parking garage, with curbside pick-up being offered at an increased rate. Airport Services Director Eva Cheong discussed the effects of this move with the team, explaining that while irregular flyers tended to choose the reduced-rate garage pick-up, frequent flyers often paid the fee for the more convenient curbside pick-up. Overall, the change in policy had a minimal effect on congestion, implying that there may not be a high level of price sensitivity for premium curbside pick-up. The team is recommending airports consider offering this service, primarily for customer convenience, but caution airports since it is unclear whether moving pick-ups away from the curb is effective if this policy is implemented alongside the shift.

8. Conclusion

The recommendations examined above were designed with the goal of reducing congestion at the terminal curbside, reducing CO_2 emissions, streamlining the passenger experience, and recovering some of the airport's costs of providing services to TNCs operating at their facilities. As long as hazards are mitigated as described in the Safety Risk Assessment, airports could see future time savings for their passengers and improved air quality for employees, passengers, and residents living nearby as shown in the Cost-Benefit Analysis. As TNC mode share continues to rise, airports should take these recommendations into consideration to address increased congestion from TNC.

Appendix A.

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Appendix B.

Rutgers, the State University of New Jersey

Rutgers, the State University of New Jersey, is a leading national research university and the state of New Jersey's preeminent, comprehensive public institution of higher education. Established in 1766, the university is the eighth oldest higher education institution in the United States. More than 70,000 students and 23,400 full- and part-time faculty and staff learn, work, and serve the public at Rutgers locations across New Jersey and around the world.

Edward J. Bloustein School of Planning and Public Policy

The Edward J. Bloustein School of Planning and Public Policy at Rutgers University seeks to improve our increasingly urbanized and interconnected world by exploring planning approaches and public policy solutions that are healthier, greener, fairer, and generate greater prosperity than current practices. It pursues equitable and efficient solutions to public problems at multiple levels from the global to the local and emphasizes the professional perspectives of urban planning, public policy, and public health. Within each of these domains, the school advances its aspiration to be a global leader in teaching, research, and service by engaging society's challenges with focused programs that align current strengths with emerging needs.

The Program in Urban Planning and Policy Development at the Bloustein School is ranked among the top five planning programs in the country. Faculty in the program are nationally and internationally renowned scholars who are actively involved in shaping the fields of transportation, development/redevelopment, environment, community development, and international planning health policy, workforce development and social policy. The faculty's cutting-edge research and policy work are augmented by the numerous research centers within the school, providing a rich, vibrant learning environment.

Appendix C.

Ricondo & Associates, Inc.

Ricondo & Associates, Inc. is an international, private aviation consulting firm that provides facilities and operations planning, environmental planning, and financial planning services. Ricondo specializes in airport facilities planning, airport master planning, environmental planning, feasibility studies, airport financial analyses, airfield and airspace analyses, and airport development programs. Clients of Ricondo include airport owners and operators, airlines, and federal and state aviation-related agencies through on-call consulting services or project-specific services. The team specifically worked with a Craig Leiner, an Associate Director for Ricondo.

Los Angeles World Airports (LAWA)

Los Angeles World Airports (LAWA) is the governing body for Los Angeles International Airport (LAX), the Van Nuys (VNY) general aviation airport, and the Palmdale aviation-related property. As the aviation authority for these airports, LAWA plays an integral role in Southern California's regional demand for passenger, cargo, and general aviation services and serves the nation's second largest city.

LAWA is a self-supporting department of the City of Los Angeles and is governed by a seven-member Board of Airport Commissioners. As an airport operator, LAWA is responsible for overseeing airfield and landside operations and aviation-related enterprise, and commercial air carriers while providing compliance with local, state, and national laws and regulations such as those enacted by the U.S. Department of Homeland Security, the Transportation Security Administration, the U.S. Department of Transportation, and the Federal Aviation Administration.

The team specifically worked with Shirlene Sue, Airport Manager of LAWA's Landside Management and Airport Permit Services.

San Francisco International Airport (SFO)

San Francisco International Airport (SFO) is an enterprise department of the City and County of San Francisco. SFO provides service to the San Francisco region, and serves 58 million passengers annually.

The team specifically worked with Eva Cheong, the Director of Airport Services in the Operations and Security Division at SFO. This group includes AirTrain Operations, Duty Management, Landside Operations, and Wayfinding at the airport.

Port Authority of New York & New Jersey (PANYNJ)

The Port Authority of New York and New Jersey (PANYNJ), builds, operates, and maintains much of the transportation infrastructure in the New York City area. The agency's network of aviation, ground, rail, and seaport facilities is among the busiest in the country, supports more than 550,000 regional jobs, and generates more than $80 billion in annual economic activity.

PANYNJ's airport facilities, include Atlantic City International Airport (ACY), John F. Kennedy International Airport (JFK), LaGuardia Airport (JFK), Newark Liberty International Airport (EWR), Stewart International Airport (SWF), and Teterboro Airport (TEB). For this project, the team consulted with Julian Porta, Don Free, Thor Vasquez, and Peter Carbonaro from the PANYNJ's Ground Transportation Programs and Systems regarding their knowledge of landside operations at JFK and LGA.

Appendix D.

Form included on next page.

Appendix E.

Student Evaluation

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

The ACRP University Design Competition for Addressing Airport Needs provided a unique opportunity to explore an area of planning to which we have not previously been exposed. Though Rutgers University has a strong transportation planning program, there are no classes focusing on airport planning offered. We decided to participate in this competition due to our interest in the field of airport planning. We were excited to apply what we have learned about congestion and curbside-management to an airport context. Overall, this project offered a meaningful learning experience to the entire team by providing us with a snapshot of the world of airport planning and the chance to hone our project management skills.

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

Our team encountered two main issues, the lack of literature on our subject and quantifying the benefits of our policy recommendation.

Our initial research found only a few articles relating to TNC operations at airports, which can likely be attributed to the fact that TNCs only recently rose to popularity and were not legally operating at airports before 2014. We were able to fill gaps in the literature through the many interviews conducted with airport professionals and access to a data set for an upcoming report for research purposes, provided by Craig Leiner of Ricondo & Associates.

While our costs were primarily tangible, our benefits focused on intangible savings, including time saved and a reduction in carbon emissions. Valuing time presented a challenge, as we needed to estimate the earnings of the average airport passenger, to determine the value of time saved by the reduction in curbside congestion. Valuing the time saved on the part of TNC drivers was a simpler process, as we were able to use the estimated hourly wage of drivers. When determining the benefits of carbon emission reductions, we used the social cost of carbon to estimate the monetary value of the reduction. However, the difficulty came in estimating the amount of CO_2 emissions that would be saved by our policy recommendations. After conducting some research on the subject, we were able to determine the average emission rates for both vehicles in transit and idling vehicles, and thus determine the approximate volume of CO_2 emissions saved by implementing the recommended policies.

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

After our team decided to compete in the ACRP University Design Competition in early December we began searching for topic ideas. As we returned home and set out on trips across the nation, we each took TNC trips to and from airports during our vacation. Our personal experiences with TNC operations at various airports were markedly different. Some of us encountered difficulty accessing the service, due to the location of the pick-up area; others were able to easily navigate to the service due its prominent placement and wayfinding efforts on the part of the airport. As individuals who often utilize TNC services, we noticed that there was potential for operational improvement at airports. Finally, we all noticed the high level of congestion common to airports across the country. Based on these experiences we decided to explore TNC operations at airports. The literature review provided an appreciation for the complexities involved with providing services for TNCs at airports beyond our personal experience. Interviews with industry experts helped us to hone our focus towards congestion at large hub airports because of the significant congestion they experience as compared to even medium hub airports. Having developed our hypothesis, we then set about developing recommendations to address TNC-based congestion at large hub airports.

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

The participation in our project by industry professionals was very helpful. By discussing issues airport operators had regarding TNC operations, we were able to focus our research on solutions to real-world problems that airports face. Our initial ideas for potential problems were generally correct, but with our limited experience in the industry, we overlooked a few key issues, including staging lots near the terminal and congested parking garage entries. Our interactions with industry experts provided us with important insights and some potential solutions to the issues, improving the overall quality of our recommendations.

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 ACRP University Design Competition provided our team with a meaningful opportunity to apply a variety of skills we have developed throughout graduate school. Our team was able to apply both qualitative and quantitative research methods through interviews and gathering and analyzing data. We were also able to learn a new skill through conducting a real-world Safety Risk Assessment. Furthermore, conducting a Cost-Benefit Analysis for our recommendations allowed us to apply a tool that we had previously only applied to theoretical examples. This experience will serve us well, as we enter the workforce with the practical skills necessary for this design competition.

Faculty Evaluation

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

The competition proved to be highly educational for the students on this team. Our university does not offer courses on airport planning, and so this competition provided an opportunity for students to delve deeply into landside issues related to airports. Further, it provided the students with valuable real-world experience in data gathering, interviewing, and understanding the existing literature on TNCs and airports. This real-world aspect additionally provided students with experience working on a team in a consulting-like environment, which will be valuable for them as they transition from the academic world to the professional world of planning.

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

The competition was very appropriate for graduate students, as it mimicked the studio-like atmosphere that is central to the training of professional urban planners. The students were able to use some of the skills they have learned in the classroom setting (data gathering/interviews) to tackle a real-world problem.

3. What challenges did the students face and overcome?

As the students mentioned in their statement, the challenges were twofold. First, the topic is under-researched, meaning that they had to gather significant primary data and rely heavily on the limited literature. Second, conducting a cost-benefit analysis was a challenge, as reliable estimates for some of the items they wished to quantify were hard to come by; this, however, reflects the real-world experience of planners conducting cost-benefit studies in many cases.

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

Certainly. The students learned a tremendous amount about a pressing issue and gained real-world experience that the traditional classroom setting often struggles to provide, given large class sizes.

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

Some flexibility in the structure of the students’ submission would be helpful, potentially.

Appendix F.

References

Carriage Trade Service Co., Inc. (2018). Cart Corrals. Retrieved from https://shopcarriage-trade.com/cart-corrals

Conway, M., Salon, D., & King, D. (2018). Trends in Taxi Use and the Advent of Ridehailing, 1995–2017: Evidence from the US National Household Travel Survey. Urban Science, 2(3), 79. Retrieved from https://doi.org/10.3390/urbansci2030079

Environmental Defense Fund. (2009). Attention drivers! Turn off your idling engines. Retrieved from: https://www.edf.org/attention-drivers-turn-your-idling-engines

Failla, S., Bivono, E., & Ventola, N. (2014). Exploring Airports' Landside Congestion Impacts on the dynamic of Passengers Satisfaction. System Dynamics Society. Retrieved from https://www.systemdynamics.org/assets/conferences/2014/proceed/papers/P1233.pdf

Federal Highway Administration. (2019). Pedestrian Safety Guide and Countermeasure Selection System. Retrieved from http://pedbikesafe.org/PEDSAFE/countermeasures_detail.cfm?CM_NUM=4

Feng, L., Miller-Hooks, E., Schonfeld, P., & Mohebbi, M. (2014). Optimizing ridesharing services for airport access. Transportation Research Record, 2(2467), 157-167. doi:http://dx.doi.org.proxy.libraries.rutgers.edu/10.3141/2467-17

Free, D., Porta, J., & Vasquez, T. (2019, March 11). Phone interview.

Global Industrial (2019). Global Industrial Outdoor Metal Slatted Waste Receptacles. Retrieved from https://www.globalindustrial.com/g/janitorial-maintenance/garbage-recycling/containers-outdoor-steel/outdoor-metal-slatted-waste-receptacles?trackType=null

Hermawan, K., & Regan, A. C. (2017). On-Demand, App-Based Ride Services: A Study of Emerging Ground Transportation Modes Serving Los Angeles International Airport (LAX). Journal of the Transportation Research Forum 56(3), 111-118. Retrieved from https://trforum.org/wp-content/uploads/2018/02/07-On-Demand-App-Based-Ride-Services.pdf

Hermawan, K., & Regan, A. C. (2018). Impacts on Vehicle Occupancy and Airport Curb Congestion of Transportation Network Companies at Airports. Journal of the Transportation Research Forum 2672(23), 52-58. Retrieved from https://doi.org/10.1177/0361198118783845

Hermawan, K. (2018). Transportation Network Companies' (TNC) Impacts and Potential on Airport Access. (Doctoral dissertation) UC Irvine. Retrieved from https://escholarship.org/uc/item/01m726rr

Home Advisor. (2019). How Much Does it Cost to Install Fire Protection? Retrieved from https://www.homeadvisor.com/cost/safety-and-security/install-fire-protection/

Lyft. (2019). Airport Information for Drivers. Lyft. Retrieved from https://help.lyft.com/hc/en-us/articles/115013080528-Airport-Information-For-Drivers

Mandle, P., & Box, S. (2017). Transportation Network Companies: Challenges and Opportunities for Airport Operators. The National Academies Press, Retrieved from https://doi.org/10.17226/24867.

Nelson, N. (2018, April, 20). Ground Transportation's New Normal [Blog post]. Retrieved from https://airportscouncil.org/2018/04/20/ground-transportations-new-normal/

Papatheodorou, A. (2018). Conference Report: 4th ACI-World Bank Aviation Symposium (9 April 2018) and 10th ACI Airport Economics and Finance Conference (10-11 April 2018). Retrieved from http://aci-economics.com/conference-report/

Minnesota Department of Transportation. (2018). *Average Bid Prices for Awarded Contracts State Aid Projects Not Included 1/1/2017 to 12/31/2017*.

Ricondo & Associates. (2019). [Task 3 Airport Survey and Model Development data collected for ACRP 01-35 Transportation Network Companies (TNCs): Impacts to Airport Revenues]. Unpublished raw data.

Ridester. (2018). Ridester’s 2018 Independent Driver Earnings Summary. Retrieved from https://www.ridester.com/2018-survey/#results%20&%20https://www.ridester.com/how-much-do-lyft-drivers-make/

Shaheen, S. (2018). Shared Mobility: The Potential of Ridehailing and Pooling. UC Berkeley: Transportation Sustainability Research Center. Retrieved from: https://escholarship.org/uc/item/46p6n2sk

Telcom Data. (2019). Emergency Phones, Call Boxes and Industrial Phones. Retrieved from https://www.telcom-data.com/emergency-phones-call-boxes-and-industrial-phones

Uber. (2019). Airport transportation at your fingertips. Retrieved from https://www.uber.com/us/en/airports/#North-America

U.S. Bureau of Labor Statistics. (2018). May 2018 National Occupational Employment and Wage Estimates United States. Retrieved from: https://www.bls.gov/oes/current/oes_nat.htm#13-0000

U.S. Congress (2019). National Plan of Integrated Airport Systems (NPIAS) (2019-20231) [Cong. Doc.]. Washington, D.C.: U.S. Federal Aviation Administration. Retrieved from https://www.faa.gov/airports/planning_capacity/npias/reports/

U.S. Department of Energy. (2013). Guide to FEMP-Designated Parking Structure Lighting For Federal Agencies. Retrieved from https://www.energy.gov/sites/prod/files/2014/02/f7/parking_structure_lighting_guide.pdf

U.S. Environmental Protection Agency. (2016). *Social Cost of Carbon.* Retrieved from: https://www.epa.gov/sites/production/files/2016-12/documents/social_cost_of_carbon_fact_sheet.pdf

Zhang, Y., & Wang, Y. (2017). Implications of Autonomous Vehicles to Airport Terminal Planning and Design. Information Technology and Intelligent Transport Systems 1, 23-24. DOI:10.1007/978-3-319-38789-5_11