Implications of Autonomous Vehicles to Airport Terminal Planning and Design

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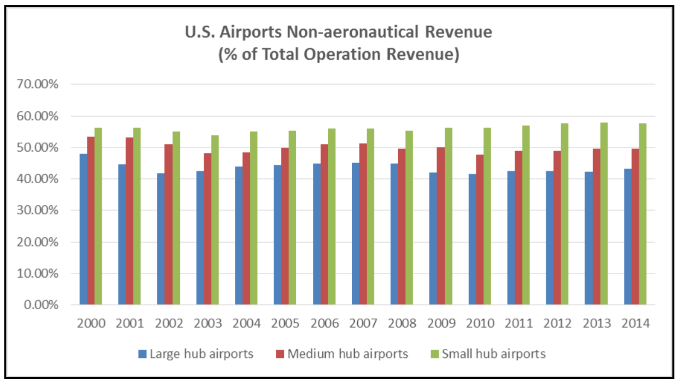
Abstract*— Incomes from parking and rental car facilities, for most of commercial airports in the U.S., are significant components in their revenue. Current design of parking capacity and parking fees are based on historical passenger throughput, travel mode splits, and projected future air traffic demand. With the emerging Autonomous Vehicle (or driverless vehicle, self-driving vehicle), the fundamentals could change. This paper describes the potential impacts of AV to airport parking and ground access and designs a simulation platform for quantitative analysis. Statistical methods are used to provide inputs for simulation based on airport historical aggregate level mode split and parking information. The results in this study show the impact of AVs to the private car dependent airport is detrimental. Airport planners and designer need to consider how to accommodate the future needs in dynamic strategic and master planning and flexible terminal design.

Keywords- Driverless Vehicle; Self-driving Vehicle, Airport Planning; Airport Design; Airport Parking; Simulation Framework

I. Introduction

According to 2015 Airport Council International (ACI) Airport Economic Report, in average, 56.7 percent of the airport revenue comes from aeronautical activities, while 38.8 percent from non-aeronautical and 4.5 percent is non-operating revenue. The report shows that although airport revenue enjoys sound growth from 2013, overall 69 percent of airports are still operated under a net loss[1]. With the commercialization trend of airport operation, non-aeronautical revenue has become a primary target for airport planners and operators to enlarge profit [1]. As for U.S. airports, non-aeronautical revenue mainly comprises of parking and ground transportation revenue, rental car revenue, and terminal concessions revenue. Figure 1 shows the percentage of non-aeronautical revenue in total airport revenue (left) and revenue from only parking and ground transportation in the non-aeronautical revenue (right) from Year 2000 to 2014, in the groups of large, medium, and small hub airports. The percentage of non-aeronautical revenue in total airport revenue dramatically increased after 2008, especially for small and medium hub airports where the air traffic demand was affected more because of the economy recession. The percentage of revenue from only parking and ground transportation in the non-aeronautical revenue were stable in last 14 years, with medium hub airports the highest around 50 percent. Airports provide parking revenue enhancement programs to improve travelers' parking experience at the airports, such as valet parking, remote economic parking, and internet-based parking [2]. These incentive programs have been successful in accommodating the increasing parking needs under limited parking supply at many hub airports [3], meanwhile enhancing the parking revenue generation [4].



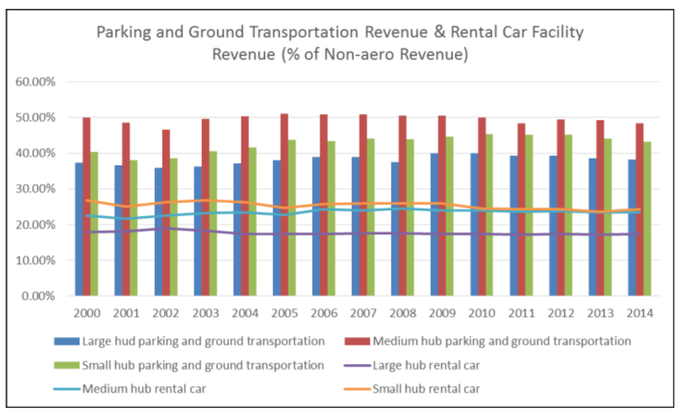


Figure 1. Airport Revenue Data source: Airport Financial Reporting Program Web Site (CATS)

The statistics shown above demonstrated that airport revenue is sensitive to parking and ground transportation that could be affected by the change of general transportation system. Emerging shared mobility services, such as Uber and Lyft, change people's lifestyle and their transportation mode decisions. Those services cause substantial controversy because of the insurance liability and because how the drivers and operators pay the fees of accessing transportation facilities,

[1] http://www.aci.aero/News/Releases/Most-Recent/2015/06/03/ACI-Releases-the-19th-edition-of-the-Airport-Economics-Report--Paradox-Overall-industry-is-in-the-black-yet-most-airports-lose-money

e.g. airport, train stations, and port. Because of the convenience and low cost of ride-sharing, a portion of passengers who used to choose private car, taxi, or other commercial vehicles shift to share-ride services. This shifting could affect the airport income derived from parking and taxi access charges. Thus, airport authorities are seeking ways to remedy the revenue loss. In November 2015, Metropolitan Washington Airports Authority added $4 dollar surcharge to the fares on rides to and from Dulles International Airport and Reagan National Airport facilitated by car-hailing apps like Uber and Lyft [17]. Other airports like Boston Logan Airport and Los Angeles International Airport have also enacted policies to charge share-ride companies.

Moreover, merging car-sharing companies, such as Flighcar and Turo (previously RelayRides) are offering car rental using long-term parking vehicles of flight passengers. Passengers who offer their cars can get free parking, car wash, and payment dependent on the length of their parking. It is estimated that on an average five-day trip, members can save $100 in parking fees and make $30 in rental. Such program usually use off-airport parking facilities conveniently and closely located to the airport.

Besides the on-going programs, full version of Autonomous Vehicles (AVs) that can drive by themselves with no need of a human driver are predicted to enter into the market in seven to ten years (see http://www.driverless-future.com/?page_id=384 for different predictions from manufacturers, media, network companies, and mobility service providers). Major car manufacturers and technology giants have demonstrated significant progress in advancing and testing these technologies in real-life traffic conditions. As of today, four U.S. states – Nevada, Florida, California, and Michigan – and the District of Columbia have passed laws permitting the testing of AVs on highways. In addition, other eight states are under consideration of permitting the testing. Although there are unresolved obstacles, AVs might be commercialized sooner than many of us have expected.

Transportation researchers and economists have begun to analyze the possible impacts of AVs to transportation industry from a general point of view. Littman [5] studied the implications of AVs for transportation planning, and indicated that affluent drives could enjoy the independent mobility of AVs in the 2020s or 2030s, however, other benefits like reducing congestion, increasing safety will be realized when AVs are affordable to low-income people. Bengler, et al [6-7] studied the evolution of new technology in driver assistance systems in the past decades, and analyzed the trend of past and future towards automated cooperative driving. In their study, they estimated that the technology would be readily available in 2030s. However from the market perspective, consumers show concerns on safety and the high cost of AVs. Fagnant et al [8] estimated that AVs might be available to the mass market by 2022 or 2025 assuming a five-year interval for the price drop.

Also there are many studies [9-14] have estimated and evaluated the benefits of AVs from safety, congestion, operation, car ownership, and parking perspectives. Obstacles for AVs to get into the market, besides remaining technical difficulties, are legislation permission and insurance issues. Thus some researchers focused their studies on these problems and [15-16] carried out suggestions to policy makers. Most recently, the National Highway Traffic Safety Administration (NHTSA) told Google that the artificial intelligence system piloting a self-driving Google car could be considered the driver under federal [2]. Such statement is a major step of removing legal obstacles and help move toward ultimately approval of AVs on the roads. Nevertheless, due to the uncertainty of technology development and policy actions, it is hard to predict the time table of the market penetration of AVs.

As for now, studies specifically focus on the impact of AVs to airports are limited. AL Kornhauser [25] gave a presentation at the Passenger Terminal Conference in 2013 on the topic of impacts of driverless cars to future airports. He mentioned that driverless car could make short-haul travel (less than 500km) more uncompetitive, ultimately would lead to continuous consolidation of hub airports. He also stated that from the airport design and operation point of view, e.g. requirements on parking efficiency for self-driving cars, demand reduction for on-site rental car facilities, etc. However, his presentation is descriptive and macroscopic, no detailed explanation or analysis was provided.

This study will focus on developing a simulation framework to evaluate AVs' impact to the parking and grand access of air transportation, and discussing how airport planners and designers should pro-actively adjust airport terminal building planning and design to provide flexibility in preparing uncertain future. Section II discusses in details of how AVs could affect airport operations. Section III describes the simulation framework. Section IV implements the simulation framework for the case study, Tampa International Airport (TPA). Section V presents the simulation outcomes of the case study, followed by conclusions and insights.

II. IMPACTS OF AUTONOMOUS VEHICLE TO AIRPORT OPERATIONS

It is predicted that in a very long range, there would be mixed traffic (conventional vehicles and AVs) on the roadways. Author's previous work also shows that the household with single vehicle ownership is comparably less willing to give up their car but it is possible for them to replace conventional car with an AV. Previous study on air passenger ground access segmentations [21-22], classify air passengers who need access to and from airport into three groups based on their travel cost and preference: inexpensive public transit users (e.g. metro and bus), comfortable transit users (e.g. shuttle, taxi and ride-share) and private car users. From the point of view of flight passengers who used to drive their private vehicles (either by themselves or dropped off and picked up by family members or friends), AVs would provide significant benefits to them, e.g. no family member needs to drop off and pick up the passenger at the curbside, the self-parking functions can be used for shortening the ground access time by directly dropping off and picking up the passenger. In addition if the passenger drives by himself/herself to the airport, he/she can send AV back home so that it can be used by other family members. Thus, if more passengers own AVs, it is foreseeable to have more curbside pick-up and drop-off

[2]http://www.reuters.com/article/us-alphabet-autos-selfdriving-exclusive-idUSKCN0VJ00H, accessed on Feb. 10, 2016.

instead of parking at airport. Such phenomena would decrease the airport revenue from parking, especially for medium and small hub airports where parking incomes are critical.

Furthermore, if passengers who took comfortable transit did so because of restricted car ownership of the household or the concerns of high cost of airport parking, the functions of AV will encourage them switching from comfortable transit to driving to airport and sending the AV back to the household afterwards. Also, if the cost of AV ride-share is acceptable for inexpensive public transit users, these passengers may shift to comfortable transit users to take advantage of the convenient door-to-door service. In contrast, passengers who used to drive to airport by themselves have the possibility of joining the group of AV rider-share if the cost of the service is reasonable, especially for those who take multi-day trips. Dependent on the purchase price of AV, business models of AV transportation services, and the charges of different AV services, there are many possible mode shift of airport ground access with the emerging of AVs. Furthermore, the release of driving burden offered AV would encourage the shift of air travel to ground transportation short to medium distance flight trips (e.g. the flight trips between under 1000 miles, which represent 1-3 hours of air travel (access and egress time excluded) [23]). This will reduce the air traffic demand at airport and affect not only aeronautical revenue but also non-aeronautical one.

In summary, the usage of AVs could affect airport parking and ground access in the following formats: 1) Flight passengers purchase AVs and use it similarly as conventional vehicles; 2) Mobility service providers use AV fleet to offer on-demand single or ridesharing services; 3) Mobility service providers use AV for car rental/sharing. Overall, with the emerging of AVs, airports are going to face challenges of less parking demand, more pick-up and drop-off needs, loss of rental car tenants, and less air traffic demand.

In this study, we develop a simulation framework (focusing on airport parking) and apply it to a case study to understand how the future trends would affect airport operations quantitatively.

III. III. RESEARCH APPROACH

The simulation process in this paper can be generally summarized into sequential processes to answer the following questions: 1) Where the passengers using the airport originated from the airport's service area? 2) What is the travel mode choice of that passenger to airport? 3) What is the on-airport activity of the passenger (i.e. curbside drop-off or parking and parking choices and duration? Because individual travel and parking information of enplanement passengers are usually not available at the airports, based on aggregate level statistics of airport parking and ground transportation and the understanding of the distribution format of the variables, we apply reverse-fitting to obtain the parameters in those distributions and then use the distributions for microscopic simulation.

As Figure 2 indicates, first, passengers are generated from the draw area of the airport based on population density. Dependent on if the airport is isolated from other large commercial airports or not, it could have primary draw area or both primary and secondary draw areas. We assume that all passengers generated from the primary draw area will take that airport as their origin airport. While for airport in a regional airport system where two or more large commercial airports serve the same metropolitan region, the passengers in the secondary draw area may choose other airports as well. So it is assumed that the probability of passengers in secondary draw area choosing the airport reduces with the increase of the

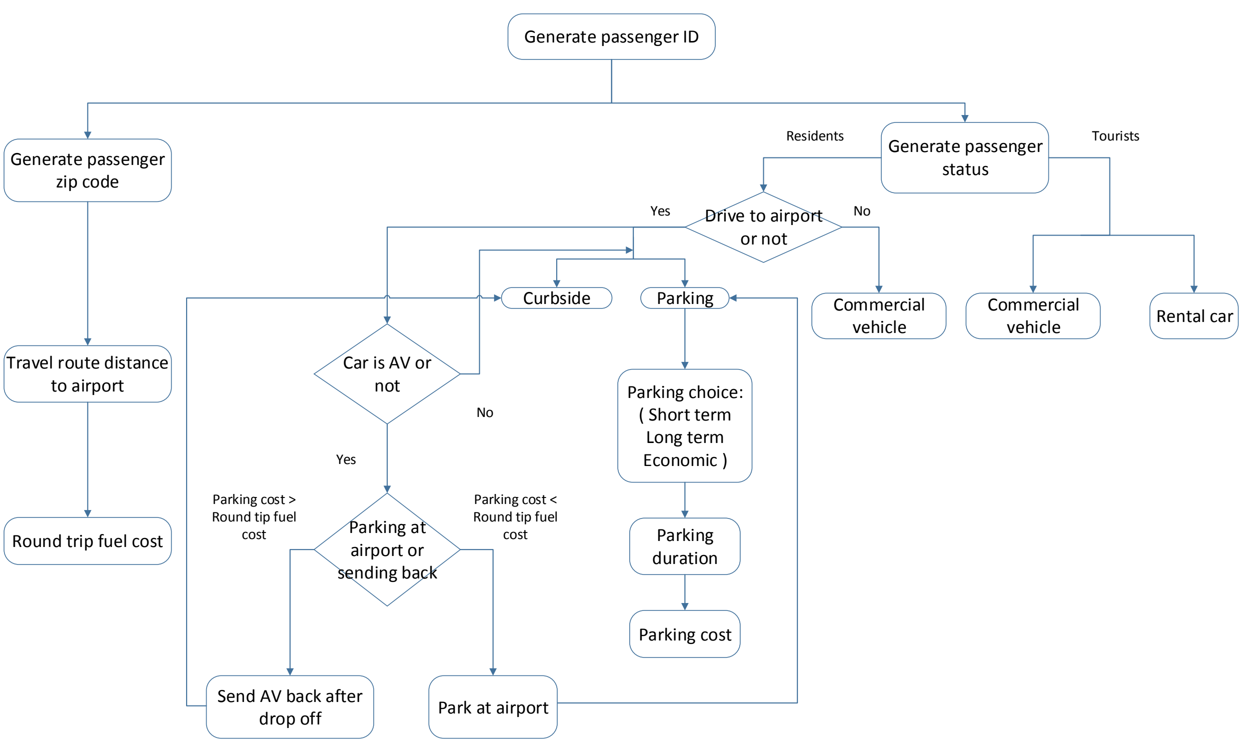


Figure 2. Simulation Framework

distance from the airport. Note that we simplify the process assuming that passengers are distributed based on population density of zip code level in the draw area. Actually, the passenger distributions should also be dependent on the social-demographic characteristics of the different zones in the draw area. This will be refined in future study. Passengers generated in the same zip code are assumed to have the route from the centroid of the zip code to airport. Route choice and its corresponding distance used in this model are derived from google map recommended route without considering congestion.

Second, local residents and tourists have different set of transportation mode options. In the simulation procedure; passengers are simulated and labeled as either local residents or tourists before the mode choice simulation. We assume tourists either drive to airports or take commercial transportation services (public transit, taxi, shuttle, etc.). If they drive, they will use rental cars and return the cars before getting to the airport. While for local passengers, if they choose to drive, they may be dropped off at the curbside or park their cars at airport garage. There are different parking patterns, such as short term hourly parking, short term daily parking, long term parking, and economic parking. Parking durations of different parking patterns shows different distributions. Historical data shows the split of the parking patterns and average parking duration for each parking pattern. It may also give quartile information. Thus, we can reversely fit the data assuming parking duration follows certain distribution for each parking pattern. Given local vs. tourist passenger percentages, the mode split statistics, the split of the parking patterns and fitted parking duration distribution, we can simulate individual passenger’s ground access to airport and his/her parking decision. Note a caveat of the simulation is that we do not distinguish between individual travelers and group passengers. If there is information on the percentage of passengers traveling in different size of groups (for residents or for tourists), the information can be easily incorporated in the simulation.

As the first step of analyzing and quantifying the impact of AVs to airport terminal planning and design, we focus on local residents who may drive to airport and park at the airport without taking possible mode shifting into consideration. Given the assumed AV market penetration of the region, we first simulate the AV car ownership of the traveler. Assume under the new circumstance, the percentage of driving-to-airport-curbside-drop-off is the still the same (no matter if they are using conventional vehicle or AV. Certainly for AV owners, instead of having family member to drop them off, they may do it all on their own). For those driving-to-airport-parking, owning an AV is very likely to affect their decisions of parking, especially for those travel for many days, or with limited car ownership of the household. Those passengers may consider sending the AV back to home if the cost of doing so is lower than having cars park in the airport garage. In the simulation, parking cost (calculated with simulated parking pattern and parking duration) and cost of AV going back home and coming to airport (calculated with simulated distance and given fuel price) are compared. If parking is more economic, the traveler will choose parking at the airport, vice versa. Here we take the fuel price into consideration; however, AVs are more likely to be powered with renewable energy compared with conventional vehicles. But on the other hand, for the AVs being sent back home and coming to airport later, we do not take the maintenance cost, depreciation and other costs into account. Thus, the overestimated and underestimated effects could cross out each other.

With the simulation platform set up, we first simulate the non-AV scenario and use that as the baseline of this model. While simulating the impact of AVs by 2030, we use two approaches; one is static simulation and the other adaptive simulation.

Static simulation approach assumes the initial percentages of choosing short-term, long-term and economic parking in 2030 are the same as current situation. We simulate the parking revenue under different AV market penetration, from 0 percent to 100 percent with 5 percent as the increment step. Adaptive simulation procedure takes into account the gradual change of splits between curbside and parking caused by the emerging of AVs. At the end of each iteration, the split between parking and curbside usage will be calculated and used for the next iteration of the simulation.

We apply the simulation platform as well as the static and adaptive simulation approaches to the case study of Tampa International Airport.

IV. CASE STUDY OF TAMPA INTERNATIONAL AIRPORT (TPA)

Tampa International airport (TPA) is a medium hub airport, and a primary airport in Tampa Bay Area. TPA is located 6 miles from Tampa downtown. Florida's population has grown from 6.8 million in 1970 to more than 18.5 million in 2009. Federation for American Immigration Reform (FAIR) projects that if current trends in population growth continue — with no change in current immigration policy — Florida's population in 2050 may increase to 31.7 million (FAIR, 2010). Tampa Bay area is a region that leads the population growth in Florida. The increase of population has led to more air travel needs. From the year 2011 to 2015, the average annual growth rates of domestic and international passengers are 2.69% and16.91%, respectively, with the total of 3.16%.

Non-aeronautical revenue is critical for TPA, especially when the aeronautical revenue dramatically reduced because of the economic recession in 2008. Figure 3 shows TPA revenue distribution from year 2000 to 2014. Parking revenue keeps steady around 32 percent from year 2009. In the same time period, rental car revenue increased to about the 20 percent of the total revenue. According to 2012 TPA Master Plan, the increasing trend of rental car need is predicted to continue and make the current on-site rental car facility reach its capacity in 2016. To better accommodate the future needs of air traffic demand, aviation authority in Tampa plan to set up a three-phase airport expanding project in the long run. Phase 1 launched in 2015 intends to relocate rental car facilities from long-term parking garage into a new consolidated car rental facility next to economic parking garage, and using automated people-mover systems to connect with the terminal building. This project will accommodate the future needs for rental cars, meanwhile adding 1/3 more parking space for long-term parking [18]. However, the supply of long-term parking still cannot fulfill the need by 2031 based on the prediction of the master plan. After year 2026, a shortage of 1400 spaces will occur. Thus, planners are seeking effort to either provide better parking management, or construct more parking facilities at terminal complex and south development area in phase 2 projects [18]. Phase 1 projects are expected to complete in 2018, while phase 2 projects are anticipated to accomplish through the year 2023. The final phase will expand the terminal area by creating a new airside building.

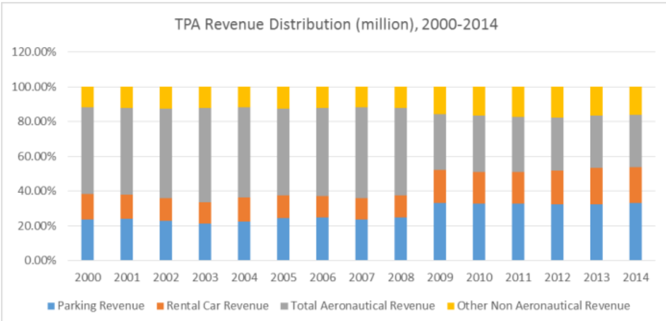


Figure 3. TPA revenue distribution Data source: Airport Financial Reporting Program Web Site (CATS)

Regarding flight operations and passenger enplanements, Tampa International Airport is ranked as fourth largest airport in Florida, and second largest airport in central Florida following Orlando International Airport (MCO). Different from MCO, TPA mainly serves domestic destinations, and international enplanements represent only 3.4 percent of all passengers in 2014 [20]. Also, most of passengers are origin and destination (O&D) passengers. Connecting passengers only takes 5 percent among all enplanements [18]. Furthermore, the air travel purposes of passengers are different in Orlando and Tampa Bay Area, which make the market share of these two airports stable over the years. TPA draw area is categorized into primary area and secondary area in its master plan (see Figure 4). Primary draw area covers eleven counties surrounding TPA which enjoy significant convenient ground access to TPA, so that travelers predominantly choose TPA. While secondary draw area covers the counties where TPA do not have the dominant advantage in terms of ground access compared to MCO. Thus the passengers may consider take either of the airports. In this study, in order to generate passenger more precisely, we use data at zip code level.

The forecasted baseline passengers' enplanement in 2030, as predicted by 2012 TPA master plan is used in this case study. Tampa Bay Area has comparatively underdeveloped public transit system, but well-developed highway system. Such situation makes the airport ground access highly dependent on private vehicle driving. Although there are other commercial services, for example door-to-door super shuttle and taxi, Only 7.2 percent of the passengers choose commercial vehicles to TPA. In this study, we use information from ground transportation survey conducted in 2009 by Tampa International Airport and also parking information in the master plane [16].Table 2 shows the percentages of passengers choosing different travel modes as well as their parking patterns, short term hourly parking, short term daily parking, long term parking, and economic parking. According to the ground transportation survey, the average duration of short-term hourly parking is 0.8 hour, and the average duration of short-term daily parking is 60 hours. Among all the short-term parking, 87 percent of the parking are less than 6 hours. As for long-term parking, the average duration is 84 hours, with 13 percent of which are less than 6 hours. The average duration of economic parking is 124.8 hours, with 5 percent of which are less than 6 hours. We assume that the distributions of parking duration follow truncated normal distribution. Given aforementioned information, we reversely fit the data and obtain the parameters of the distributions.

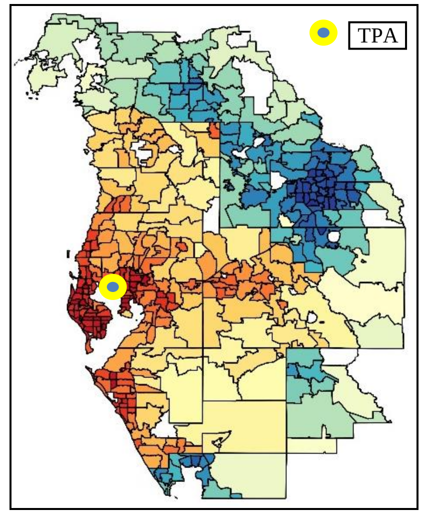


Figure 4. Study Area: TPA primary and secondary draw area indicated by population density Data Source: Tiger database (Primary: orange area; Secondary: blue area)

In the simulation, the current parking rates of different parking choices of TPA are used. This is another parameter that could be varied in future study for testing the impact of different parking pricing policies. Current parking rates at TPA are the follows: for short-term parking garage, free for the first hour, $4 for the next twenty minutes, and then $2 per twenty minutes up to the daily maximal $22. Parking charges in long-term parking garage is similar, with the maximum $18 per day. First hour free policy is employed whereby congestion at the curbside could be mitigated. Economy parking charges at $10 per day and the garage is connected with terminal building via a shuttle service.

Table 1. Travel mode splits at Tampa International Airport

Travel mode	Percent			
Parking	Short-term	5.82%	Short-term hourly	2.42%
			Short-term daily	3.40%
	Long-term	8.89%		
	Economic	4.79%		
Curbside	36.30%			
Rental car	36.90%			
Commercial Vehicle	7.20%			
Total	100.00%			

Source: ACRP Report 40 [19] and 2012 TPA Master Plan Update [18]

V. Simulation Results

This section describes the simulation results of TPA case study based on two approaches: static simulation approach and adaptive simulation approach.

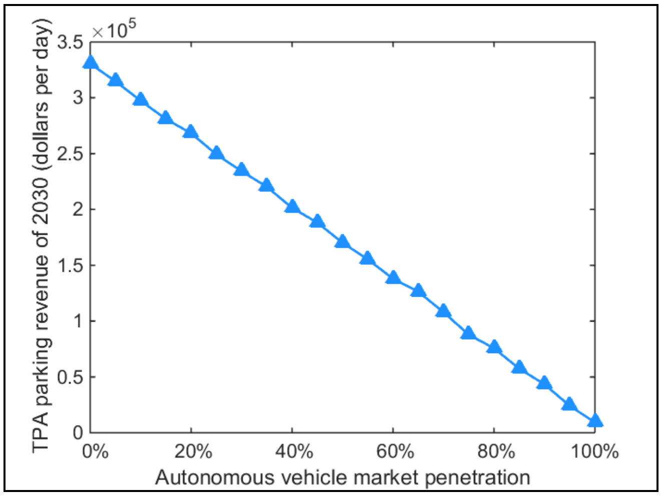


Figure 5. Scenario 1-Static simulation results

Figure 5 shows the forecast parking revenue of Tampa International Airport in 2030 under different AV market penetration in static simulation approach. The parking revenue is approximately linearly dependent on the market penetration of AVs. If the market penetration reaches to one hundred percent, 98 percent of the parking revenue will be lost compared to the situation where no AVs present. Because static scenario uses the current ground access modes splits, and assume there is no adaptive change between using curbside and parking, which means the acceptance of autonomous vehicle to a certain level is an instant event. This situation could only be true when major breakthrough of technology presents and the cost of AVs is not a concern of who are interested in purchasing.

Figure 6 gives the parking and curbside trend with the change of AVs under adaptive simulation approach. It shows that at the beginning stage when the market penetration is low, passengers who choose parking their cars at the airport decreases approximately linearly with the increase of AVs, meanwhile the curbside usage increases correspondingly. However, when AVs market penetration further increases, passengers who choose to park at the airport decrease more rapidly, and curbside usage increases faster as well. The trend slows down after 60 percent of market penetration. Ideally the market penetration reaches 100 percent (This situation probably will not be true), only 0.02 percent of passengers who drive would choose to park at the airport. Figure 7 gives the corresponding parking revenue, showing superlinear decrease when AV market penetrations are between 20 percent to 50 percent and then the decrease trend slow down when the AV market penetration gets higher.

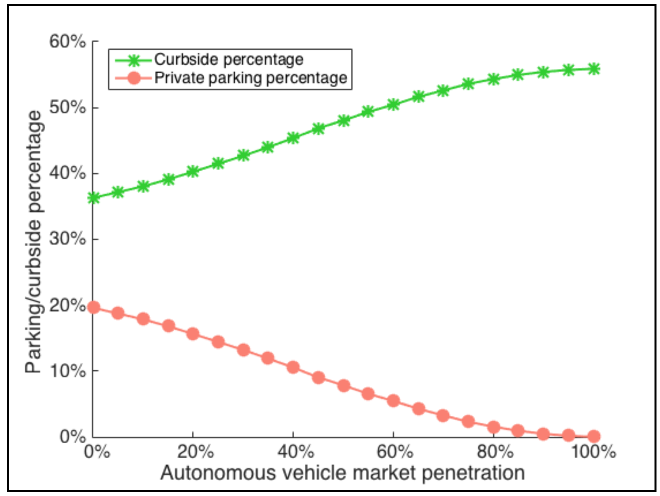


Figure 6. Scenario 2-Adaptive simulation results-Parking/curbside percentages

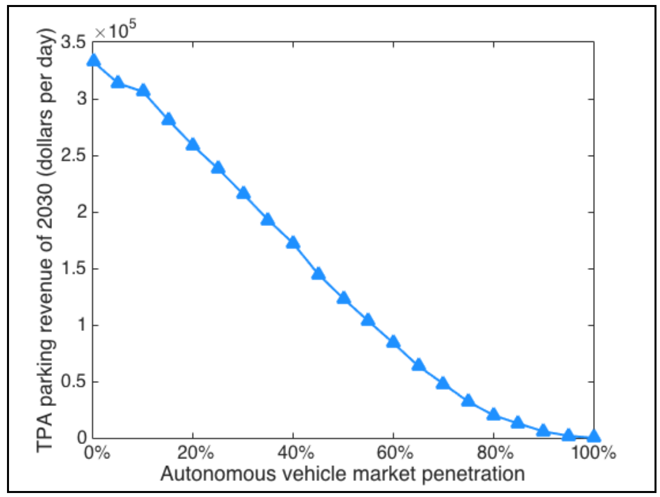


Figure 7. Scenario 2-Adaptive simulation results-TPA parking revenue trend

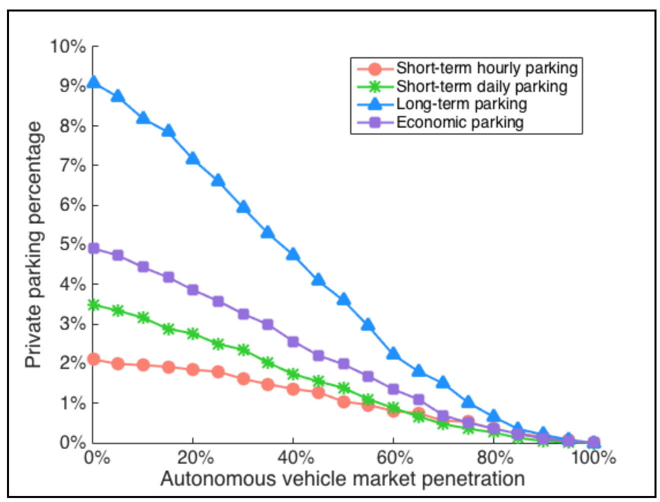


Figure 8. Private parking percentage: short-term hourly parking, short-term daily parking, long-term parking, economic parking under different AV market penetration

Figure 8 assembles the trends of different parking patterns with the increase of AV market penetration. It shows that long-term parking decreases faster with the increase penetration of AVs, following by economy parking. Short-term parking is not influenced dramatically at the beginning stage, but is so when the penetration reaches 20 percent.

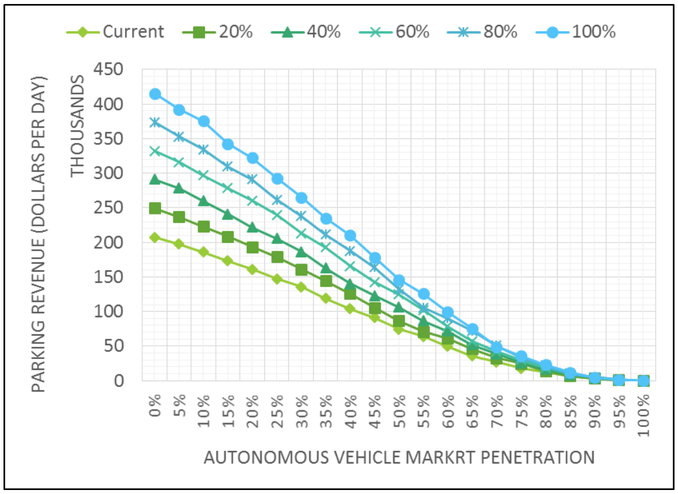


Figure 9. Adaptive simulation results-TPA parking revenue trend with increase of parking rate under different AV market penetration

Figure 9 shows the parking revenue with increase of parking rate under different AV market penetration. Current parking rate is set as the baseline. 20% in the figure means the parking rate increase by 20%, so on so forth. From the results, we can find that when the market penetration reaches 15%, airport should increase the overall parking rate by 20% to keep the same average daily parking revenue with year 2014. When the market penetration reaches to 40%, TPA has to double the parking rate to keep even. When high level penetration rate presents (>60%), airport will lose half of the parking revenue if the increase of parking rate is less than 100%, compare to simulated current average daily revenue.

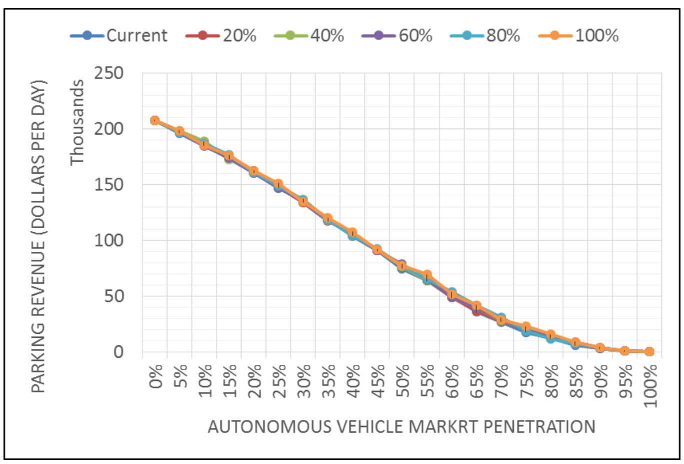


Figure 10. Adaptive simulation results-TPA parking revenue trend with increase of fuel price under different AV market penetration

The fuel price we use in the simulation is the current US national average, even when the fuel price doubled in the future, the parking revenue loss caused by the emerging of AVs will not change dramatically as shown in Figure 10. Furthermore, autonomous vehicle manufactures are focusing on cheaper and eco-friendly electronic power to support AVs. Thus, in the long run, fuel price would not be a big concern for AV users.

Proposed simulation framework is a straightforward way to evaluate the possible revenue loss due to the emerging of AVs. Outcomes show that the revenue loss could be severe for TPA with the increase market penetration of AVs.

VI. Conclusion

In this study, a simulation framework was developed to analyze airport parking revenue loss under different AV market penetration. Forecasted passenger enplanement, historical parking patterns and parking durations, regional population density, airport choices in regional airport system, and other factors are taken into the simulation procedure. Reversing fitting of historical data provides microscopic distribution inputs for the simulation. Results show that with the increase of AV market penetration, fewer passengers will choose to park at the airport. When the AVs are highly adopted, the number of passengers who choose to park will decrease rapidly, while curbside users will increase. If the market penetration reaches 100 percent, assuming no travel mode shift, almost all the passengers who used to park at airport will choose to be dropped-off and picked-up by AVs at the curbside (or designated areas). Although this study still has some caveats and limitations, the outcomes are worthy of the attention of airport planners and designers to consider adjusting strategic and master planning in order to better prepare for potential financial loss and accommodate the different operational needs of airports.

From airport planners' point of view, they need to 1) specify future demand for short-term, long-term and economic parking by taking the emerging of AVs into consideration. Note that long-term and economic parking could be highly compromised with high market penetration of AVs. 2) In the long run, as parking revenue plays a significant role in airport revenue, especially for medium and small airports, airports should adjust their financial strategies to cope with financial loss due to the emerging of AVs.

From airport designers' point of view: 1) Curbside could get more congested when passengers choose to be dropped off and picked up instead of parking at the airport. For the TPA case study, curbside congestion is already an issue because there is limited space around the landside terminal building. Thus, airport designers need to consider how to redesign the curbside and airport access road to better accommodate the future demand of more drop-off and pick-up trips. 2) When AVs are highly adopted, there would be a rapid shrink on the demand of parking garage; airport designers should consider the flexibility in parking garage design and make parking garage easily be adjusted into other types of functional space.

This study is the first step to evaluate the impact of AVs to airport planning and design. Ongoing efforts to refine this study include: 1) involve demographic information into the simulation framework to improve the passenger geographic distribution, 2) develop more comprehensive decision model for passengers ground access and parking decisions, 3) analyze possible emerging business models with AVs, explore travel mode shift due to the emerging of AVs and incorporate it into simulation procedure. 4) In depth sensitivity analysis regarding airport parking rate and fuel cost, select other representative large hub airport which have different parking patterns.

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