Electric Autonomous Vehicle Case Study Analysis

#SMARTCOLUMBUS

AEDE 4567 Capstone Research
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1 - Executive Summary

The purpose of this report is to outline the research conducted by the EAV Benchmark/Case Study group as part of a collaboration between The Ohio State University's Environment, Economy, Development, and Sustainability Capstone course and the City of Columbus' Smart Columbus Project. The City of Columbus wishes to deploy a fleet of connected Electric Autonomous Vehicles (EAVs) in Easton Town Center in order to eliminate travel issues for first mile/last mile commuters and shoppers, increase efficiency of business logistics within the commercial district, and reduce the negative environmental impacts that result from the use of traditional transportation modes.

In order to help the city achieve these goals, we created a set of research objectives aimed at informing Columbus of the best practices and key challenges learned from global leaders for EAV frameworks. Our first objective was to establish a list of cities that have already tested or formally inaugurated projects with similar parameters and goals. We then refined our list by limiting our consideration only to projects with a high quantity and quality of information. This allowed us to ensure the data and insights we gathered would be accurate and useful. Our final list of benchmark cities included La Rochelle, France; Trikala, Greece; Lausanne, Switzerland; and Rotterdam, Netherlands, all of which are thoroughly analyzed and outlined in this report.

Because the global leaders are almost exclusive to Europe, including all of our chosen benchmark cities, some of the information we provide needs to be understood with certain considerations. For instance, we believe that one of the most important next steps for Columbus will be to create an exhaustive local transportation policy. However, it is difficult to use what benchmark cities have done as perfectly transferable examples because European laws are very different from laws in the United States. With that said, the recommendations we provide are not exclusive to one region of the world and we believe are essential to the effectiveness of Columbus' plan.

Along with creating an exhaustive and transferable legal framework, Columbus should establish updated, uniform physical and digital infrastructure around Easton Town Center for the EAVs. This digital infrastructure includes the monitoring of real-time data and information, by a third-party, in order for the shuttles to run most efficiently. The city should also implement training and certification programs in order to secure the operating environment and minimize the potential for risk and injury. Finally, public acceptance must be addressed with educational programs and marketing campaigns to illustrate the benefits to potential riders and ensure them of their safety. The results of our research suggest that these recommendations will speed up the process of the Smart Columbus Project by a number of months as well as ensure the highest social, environmental and economic benefits.

2 - Introduction

The Smart Columbus Project plans to implement six EAV shuttles on three separate routes within Easton Town Center in Columbus' Commercial District. The key objectives of these shuttles are to solve first mile/last mile challenges and offer alternative mobility options in an area dominated by conventional personal vehicles. This report is in response to USDOT Project 3, option (a) for the Smart Columbus - EEDS Capstone course RFP and serves as a benchmark and case study analysis on the deployment, usage and adoption of autonomous shuttles around the world.

In order to comprehend the objectives of our research and the motivations behind our methods, it is necessary to understand the area in and around the Easton Town Center. Therefore, the first part of our research consisted of analyzing the area and conversing with essential contacts and stakeholders in Columbus. This analysis was then used to compare potential case studies based on their similarity to the Smart Columbus Project. A list of case study cities was then compiled based on information from a number of reputable contacts including the CEO of Urban Systems, Wilfred Pinfold, and the Director of Coast to Coast Smart e-Mobility, Peter van Deventer. Furthermore, ongoing research projects in Europe and the U.S. were analyzed, the most significant of which being the EU's CityMobil2 Project.

Our next goal was to gather all the information we could on each relevant case study including but not limited to: how the EAVs were being coordinated with other modes of transportation in each program, the lengths of fixed routes, and obstacles such as damage, maintenance, charging, weather, pedestrian interaction, public acceptance, legal barriers etc. Our recommendations for Columbus were ultimately drawn from the case studies that were the most similar to Columbus, had the most data available, and had the longest program lifespan.

Although each case study varied in structure, they all remained consistent in a number of areas. The main findings of our research showed that:

1. The best investment cities can make is educating technical staff involved with infrastructure and transport planning on the automation technology.

2. Local engagement leads to a higher acceptance rate and therefore increased socio-economic impacts.

3. Comprehensive public policy is necessary to the implementation of an EAV system.

4. Effective frameworks require some form of signage or updated infrastructure.

5. Full implementation of an EAV shuttle system requires a minimum of one year, with several examples taking fifteen months or longer.

3 - Research

3.1 - Overview of Project Area and Goals

The Easton Town Center consists of 1.8 million square feet of mixed-use space with over 180 retail locations and 500 residential units. The area has approximately 25 million visitors annually and is the provider of over 30,000 jobs. All of this activity is limited to 8,000 parking spaces (Easton Town Center, 2017).

With 1.5 million square feet of space for retail, food services and warehouse services, one of the main challenges for the area is providing better access for low-wage employees getting to and from their jobs, especially those currently using public transportation. Aside from the 8,000 parking spaces, commuters have access to the COTA Easton Transit Center that is situated on Stelzer Road, just past Morse Road. Taking this option into the area allows commuters to get within one to two miles of nearly any employment location at Easton, but this still requires these commuters to walk the remainder of the distance, which can take a lot of time and energy. A layout of all the COTA stops, including the Easton Transit Center, is shown in **Figure 1** below along with average daily on and off statistics for each. A lack of reliable transportation options can have negative impacts on these types of jobs, as employees may choose to avoid working in certain areas because transportation options are limited or inconvenient (Beyond Traffic: The Smart City Challenge, 2016).

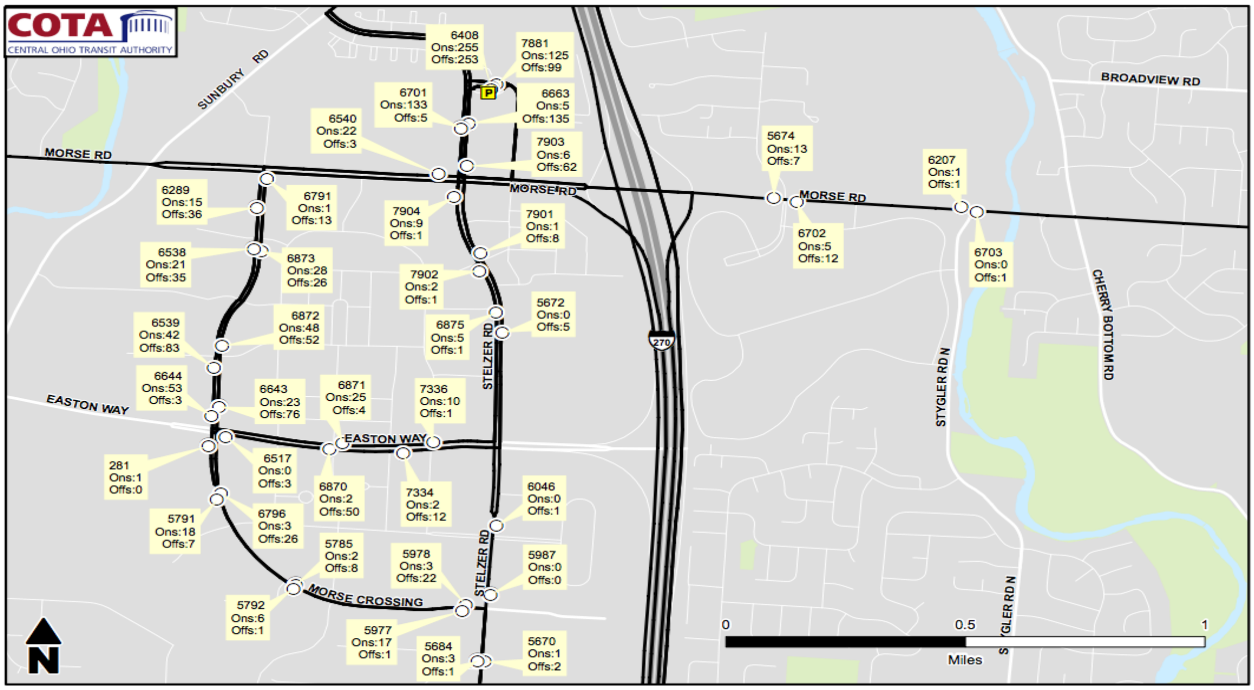

Figure 1. Average number of passengers getting on and off the COTA at each stop per day.

As outlined by the City of Columbus in “The Smart City Challenge” report, the goal of the project is to have six EAVs that can carry twelve passengers on upgraded public roadways. The plan calls for at least two work center shuttle routes that are designated for connection with the Easton Transit Center and will be synchronized with incoming COTA buses. There will also be a retail route serving commuters and shoppers from specified parking locations. The system will include a solar capable charging station, manual control options (physical and remote), and a comprehensive traffic monitoring software. All totaled, it is designed to meet social, economic, and environmental needs. The challenges anticipated by Columbus are realizing and making use of best practices by global EAV framework leaders. Our analysis serves to provide direct insight into how global models can be utilized to improve the implementation and effectiveness of an EAV program at Easton Town Center.

3.2 - Case Study Materiality Matrix

For our second objective, we compared case studies in order to determine the most relevant and useful examples for Columbus. Each study was analyzed based on two sets of parameters. The first set of parameters related to "Similarity to Columbus" based upon the information supplied from the city, and the second set related to "Usefulness to Columbus", based upon the amount and quality of information available. The breakdown of case studies and their ranking analysis are displayed in **Figures 2** and **3** below.

The cell color represent value with *green having the highest ranking value of (5), *yellow (4), *orange (3), *light red (2), and *red (1).							
Similarity to Columbus							
City	Area Type	SAE Level of Autonomy 4+	Updated Infrastructure	On Demand Features	Route Length Between 1-3 miles	Passenger Capacity	Number of Vehicles
Trikala	Downtown	4	yes	yes	2.4 miles	12	6
La Rochelle	Small City	4	yes	yes	1.9 miles	12	6
Lausanne	College Campus	4	yes	yes	1.5 miles	12	6
Rotterdam	Business Park	4	yes	yes	1.1 miles	12	6
San Ramon	Business Park	4	yes	yes	3 miles	12	2
Singapore	Business Park	5	no	yes	na	2	6
Boston	Business Park	5	no	yes	na	2	6

Figure 2. Similarity to Columbus Case Study Analysis Table. All data sources listed in appendix.

The cell color represents value with *green having the highest ranking value of (5), *yellow (4), *orange (3), *light red (2), and *red (1).					
Usefulness to Columbus					
City	Length of Program Longer than 3 months	Number of Total Passengers	Kilometers traveled	Report Available	Qualitative Analysis
Trikala	4 months	12,150	4,230	yes	yes
La Rochelle	5 months	14,660	3,778	yes	yes
Lausanne	4 months	7,000	6,970	yes	yes
Rotterdam	15 years	2,400 daily	na (assumption of a lot)	no	no
San Ramon	short demo	na	na	no	no
Singapore	short demo	na	na	no	no
Boston	short demo	na	na	no	no

Figure 3. Usefulness to Columbus Case Study Analysis Table. All data sources listed in appendix.

From these tables we were able to create a materiality matrix for all of the potential case studies. All of the case studies that ended up in the green area of the graph below were analyzed further so best practices and key insights could be realized for Columbus. The top case studies are from the cities of Trikala, Greece, La Rochelle, France, Lausanne, Switzerland, and Rotterdam, Netherlands.

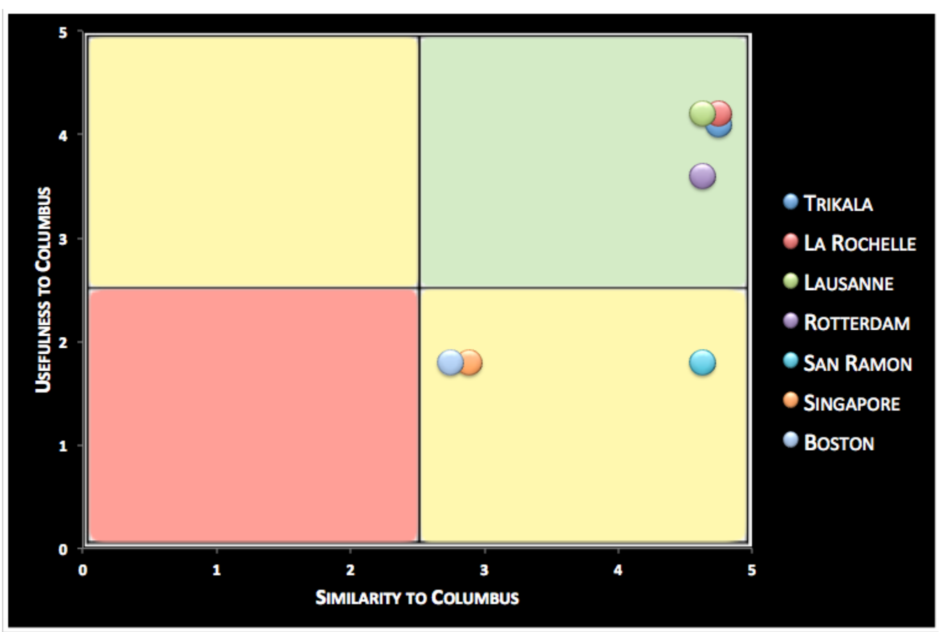

Figure 4. Case Study Materiality Matrix. Leading cities are Trikala, Greece; La Rochelle, France; Lausanne, Switzerland; and Rotterdam, Netherlands.

3.3 - Case Study: Trikala

Trikala is located in the plains of central Greece. The capital (also called Trikala) has a population of 80,000 and is located near the Litheos River. This city has well-kept, open squares, parks, and pedestrian zones and a highly functioning street layout, despite its high pedestrian, bicycle, and vehicular traffic with winding, narrow roads.

Classified as a large scale demonstration (four to six months) and a medium size operation compared to other CityMobil2 project areas, the automated bus system in Trikala is composed of six, ten to twelve passenger busses that circulate the heart of the city on a 2.4 kilometer route. The initial phase of the project launched on November 10, 2015 and ended February 29, 2016. The busses ran with no human supervisor and in normal traffic, however, they operated in a lane dedicated only to the EAVs. The busses drove the circular route without the capability of changing lanes or navigating around obstacles. Although the dedicated lane was marked with signage indicating that it was meant for only the autonomous busses, other motor vehicles and bicycles frequently used this lane illegally. Using radio frequency, traffic lights communicated with the EAVs to secure all crossings in order to eliminate risk of collisions with pedestrians and vehicles. The radio frequency indicated the status of the busses, allowing motor vehicles to clear crossing areas before the busses were authorized to cross. The fleet was managed with a remote system allowing monitoring and instruction from a single control center. In an area with such high traffic, it was important for the busses to be well connected to and in cooperation with existing traffic functionality.

The Trikala project was noted as highly successful as the world's first truly integrated automated transport system. As opposed to some other regions taking part in the CityMobil2 program, the autonomous vehicles in Trikala operate within the city's urban fabric.

3.4 - Case Study: La Rochelle

La Rochelle is a small town on the western coast of France that has been a pioneer for alternative mobility testing over the years. Along with incorporating bike-share programs, electric shuttle systems, and even hosting France's first "car-free day," the city has also hosted a number of pilot programs for autonomous vehicles through various EU framework programs (CityMobil2, 2016). The most recent program was considered a large-scale demonstration and lasted from December 2014 to April 2015. La Rochelle's EAVs connect the city's train station to other relevant destinations such as the harbor and the university. The program details consisted of six shuttles with ten to twelve passenger carrying capacities traveling along a designated 1.2-mile route.

La Rochelle's successful autonomous vehicle framework can be accredited to its exhaustive engagement of local stakeholders with both educational campaigns and expert workshops. In total, ten educational sessions were held in local schools and a national newspaper, Le Petit Quotidien, was specially published as an educational tool for children ages six to ten to learn about the driverless shuttles. The mayor of La Rochelle has explicitly stated that there has been a positive correlation between the amount of local engagement before and during the demonstrations and the amount of participants and people who accept the technological changes in the city (Experience and Recommendations, 2016).

Another major insight from the large-scale demonstration in La Rochelle, along with from a few other demonstrations in the CityMobil2 Project including Lausanne, relates to the public acceptance and preference of EAV frameworks. The first key insight is that, on average, over 60% of EAV users say they would rather ride in an EAV than in a conventional shuttle or bus given the two options were the exact same price, time variable, and frequency and size (Experience and Recommendations, 2016). Secondly, despite a high acceptance rate among users, the users have strong preferences on how the EAVs should be implemented. For instance, in La Rochelle, which has had three EAV demonstrations to date, 92% of users believe the shuttles should never share the road with other motorised vehicles (Experience and Recommendations, 2016). This data can highlight necessary considerations for Columbus as they plan to merely "upgrade" current infrastructure around the Easton Town Center to accommodate EAVs (The Smart City Challenge, 2016). **Figures 5** and **6** below visualize the user acceptance data.

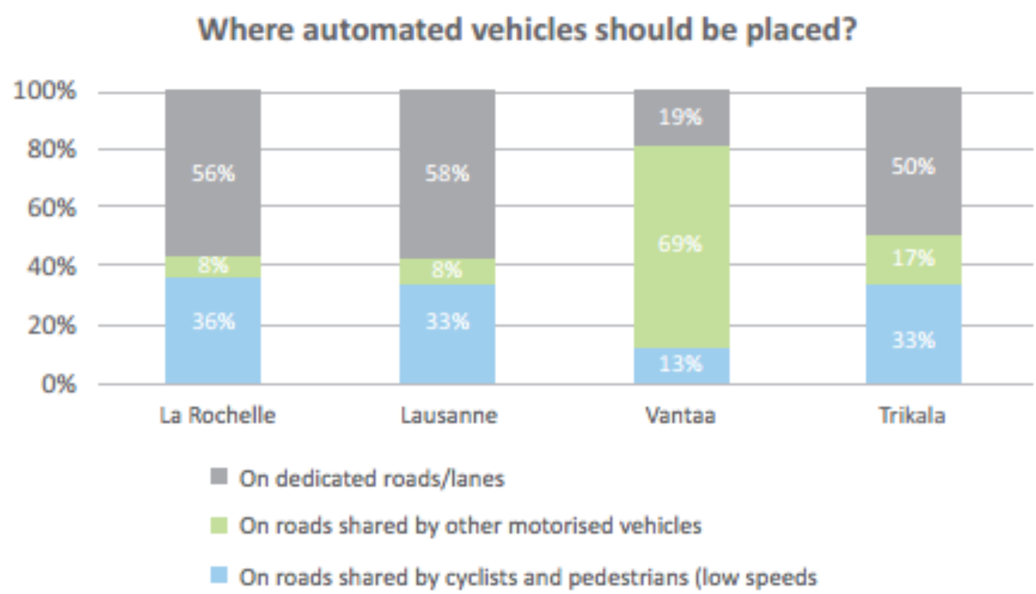

Figure 5. User preference for where EAVs should be placed.

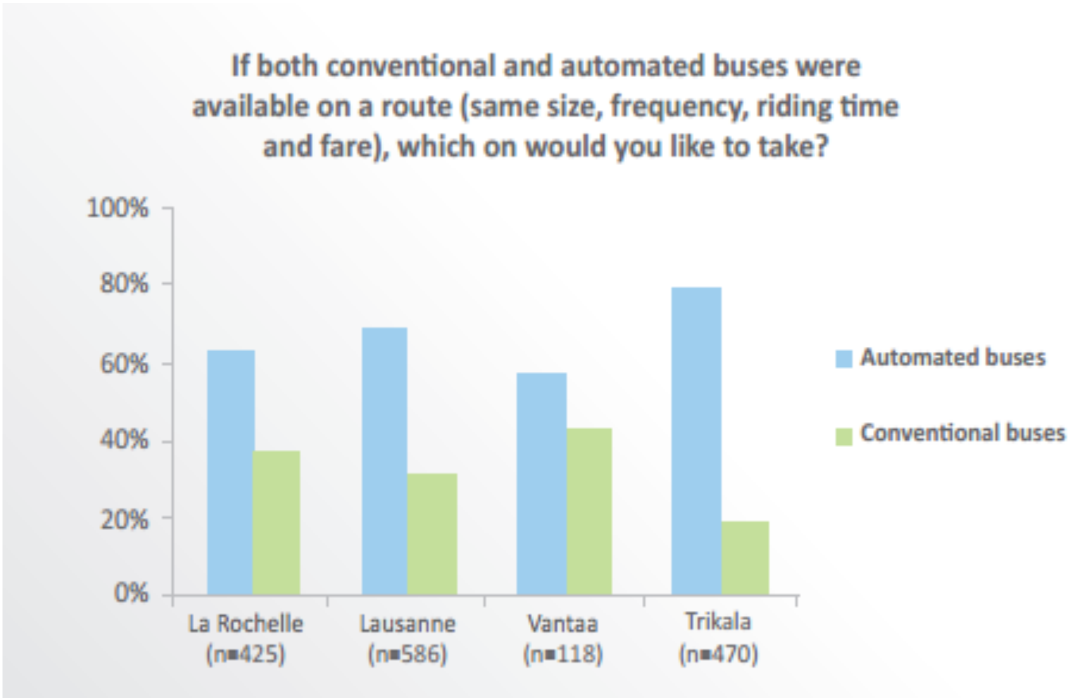

Figure 6. User acceptance of EAVs post demonstrations.

3.5 - Case Study: Lausanne

In Lausanne, Switzerland, The Swiss Federal Institute of Technology (EPFL) campus launched a large-scale autonomous shuttle demonstration from April to August 2015. The EPFL campus is a large campus that is serviced by Metro Line 1 and an electric bicycle sharing system. There are approximately 16,000 students, faculty and staff on the 136-acre campus (EPFL, 2016). The EPFL campus has been powered by 100% hydroelectric power since 2012, and was the first campus to receive the International Sustainable Campus Excellence Award (Sustainable Campus Index; EPFL, 2016). As an institution with strong sustainability goals and values, they partnered with the CityMobil2 project in order to solve their first mile/last mile transportation issue. Although there is a metro station on campus, it is difficult to get from the station to other areas of campus such as the Rolex Learning Center and the Innovation Park (EPFL, 2015).

To solve this transportation issue, EPFL, along with CityMobil2, introduced six EZ10 shuttles in the spring of 2015. This demonstration ran 7:45 am until 7:45 pm daily from April 16, 2015 until June 30, 2015 (EPFL, 2015). The "track" that these shuttles followed was approximately 1.4 miles long and stopped at six popular areas around campus. **Figure 7** below shows the track that the shuttles followed from the metro station throughout campus.

Figure 7. Map of EAV shuttles' route on EPFL campus.

The shuttles had a capacity of ten passengers and a “groom”, or student volunteer, was present on board to encourage users, answer questions, and conduct user surveys. They were also present in case any concerns were to arise during the demonstration (EPFL, 2016).

Along with the addition of grooms on board, traffic lights were added and routes were painted on the ground to increase safety and efficiency. These factors were included to make passengers feel as safe as possible when riding in these autonomous shuttles. The implementation of new policy however was not needed since the demonstration was completed on the campus’ private property, not public roadways.

One of the biggest obstacles to adoption of autonomous vehicles is a person’s fear of the unknown. Since EAVs are still up and coming, many people simply do not know enough about them to be able to trust them. That is where BestMile came in. BestMile is the fleet management component of the Lausanne demonstration. BestMile is the back end, operator, control center, and monitor of these shuttles. If an obstacle were to occur in the road or surroundings, such as a parked car, bicyclist, or construction, the BestMile operator would be able to remotely tell the shuttle how to handle the situation (Pessaro, 2016).

This demonstration in Lausanne did have some setbacks. During the time period of the demonstration, Lausanne experienced a heat wave, causing higher than normal temperatures and very dry weather. The combination of these two factors led to the need for air conditioning in the shuttles 100% of the time. Running the air conditioning consistently caused the battery life of the shuttles to decrease, which also impacted the shuttle’s operations. Dusty roads interfered with the laser sensors meant to detect obstacles and during the first month of the demonstration, two shuttles collided with minor damages (Pessaro, 2016).

Throughout the demonstration, roughly 6,000 passengers rode the electric autonomous shuttles around campus. These EZ10 shuttles were disability accessible, which was different from many other demonstrations done previously by CityMobil2 (Pessaro, 2016). Part way through the demonstration period, two of the shuttles were transformed into "on demand" shuttles, where the rider could request the shuttle via smartphone and it would drive to their location and pick them up. This system was possible through connection with BestMile's software. Around 1,000 people used the smartphone app to request he shuttles (Pessaro, 2016).

Overall, the demonstration of six electric autonomous shuttles on the EPFL campus in Lausanne, Switzerland was a success. Since the legal implementation was straightforward, the biggest challenge that had to be overcome was educating the potential riders in order for them to use the service. Furthermore, public outreach, adding signage, and painting the track on the route gave further assurance to riders for their safety. This demonstration was very important for the BestMile operating system, which could lead to further spread and development of the fleet management system in other areas.

3.6 - Case Study: Rotterdam

In 1999, Capelle aan den IJssel, a town in Rotterdam, Netherlands, along with many other stakeholders, piloted a public transportation program, which incorporated electric and autonomous vehicles to carry passengers through a single business park. The purpose of the initial project was to connect people in the Rivium business park to the public transport stations using a low- capacity, automatic, navigating vehicle that operates without any physical guidance (Pilot project ParkShuttle Kralingse Zoom, 2009). Their goal of solving a first and last mile solution is well aligned with the city's goals for Easton. Since its beginnings, the program has grown to a route that covers five stations over 1.1 miles. The shuttle currently runs on a track comparable to a horizontal elevator, making stops at Rivium Business Park, the residential area of Fascinatio, Brainpark III Business Park, as well as the metro and bus stations located in the city of Rotterdam (Advanced Transit, NA). A diagram of the system layout is shown in **Figure 8**.

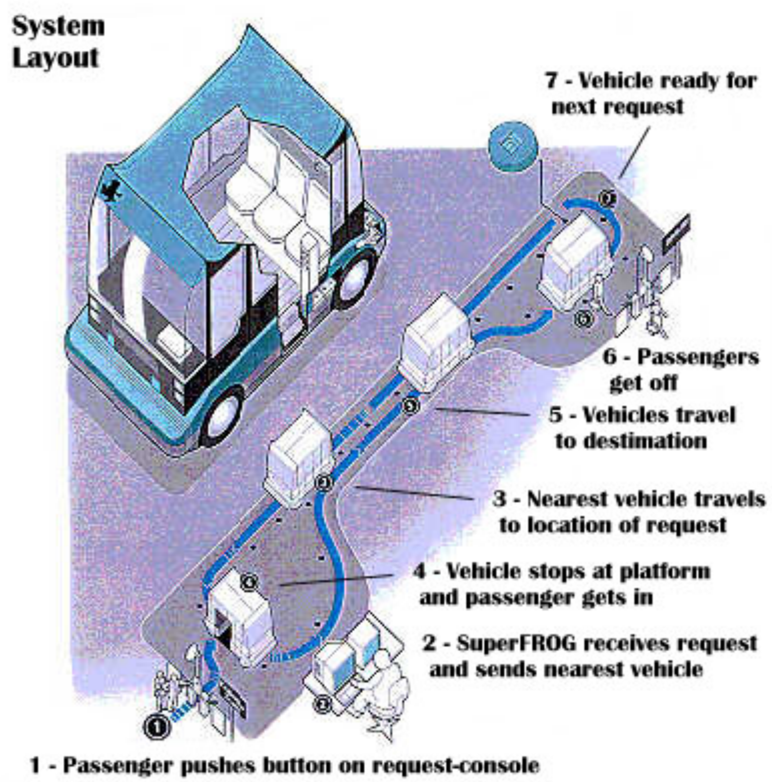

Figure 8. Diagram of EAV route and operations for on request transportation.

The vehicle used for this program is called the ParkShuttle. This vehicle was chosen based on its ability to be fully autonomous, work on demand, and simple infrastructure on the ground level. ParkShuttle carries twelve passengers per vehicle and can cover up to 100 kilometers on a single charge. During peak hours all vehicles are dispatched for use, but during off peak hours vehicles are swapped off the track in order to be charged. Vehicle maintenance occurs every Friday with one shuttle being serviced per week. The vehicle was designed to maximize passenger utility by allowing wheelchair access and all-around visibility, as well as having an information display. This display allows users to track their progress on the vehicle's route and be alerted when the vehicle is approaching a stop. In addition to passenger comfort, the vehicle is outfitted with a number of safety features. The ParkShuttle has an 800 kg weight limit and in order to monitor this limit, the vehicle is equipped with a weight sensor that stops the vehicle from departing if that limit is breached. Each doorway is also equipped with a motion sensor, which does not allow the door to close when there is motion detected. Each shuttle is connected to a supervisory computer system called SuperFROG, which keeps a record of vehicle location that is able to detect pedestrians, traffic lights and other obstacles. Access is controlled through a chip-card system. Passengers working in these businesses receive a chip-card to insert in a kiosk at the shuttle stop, allowing them to request a ride.

The program was introduced in four phases. Phase I consisted of running a technical test of the vehicle on a route without any passengers. They ran this phase for three months in order to get concise measurements for elements like the control, safety and security systems, and technical reliability. After the system was proven to be reliable, trained passengers were introduced. A trained attendant was on board during this phase in order to monitor safety first hand and collect information. This phase tested elements like waiting time, passenger acceptance and all the technical elements from Phase I under passenger conditions. The third phase was almost exactly the same as the second but instead of trained passengers, people working in Rivium Park were the passengers. In this phase, extra attention was paid to transportation needs. The fourth step continued to use regular passengers, however, the shuttle was then introduced to a public road crossing where it would have direct interactions with other vehicles as well as pedestrians. The fourth phase completed the pilot project and the shuttle was then ready for regular, operational use (Pilot project ParkShuttle Kralingse Zoom, 2009).

The passenger feedback for the ParkShuttle program has been overwhelmingly positive with little user reservation regarding fear of using a trackless vehicle. The previous bus line offered a fifteen-minute indirect connection for the business park but the ParkShuttle has been able to cut the commute time in half. The connectedness and autonomy of the vehicle allow it to respond in an on-demand fashion, which greatly minimizes the inefficiencies previously experienced with the bus line. Long battery range, accessibility, and comfort of the vehicle also allows for even more end-user benefits. The company that developed the operating system also expressed satisfaction with the system performance and service delivery. Operational costs are similar to that of a bus line but the electric vehicle service rate is over four times as fast. Personnel and energy costs for the owner are also substantially lower than that of a bus line.

3.7 - Research Challenges

The main limitations of this benchmark analysis include time constraints and a lack of existing data regarding EAV use in the United States. We were tasked with synthesizing a breadth of data, conducting numerous interviews of industry experts, and preparing to report to the City of Columbus in a limited amount of time. The newly emerging use of EAVs in the United States is cause for limited data in domestic use. Managing costs, determining the most efficient EAV hub locations, variability of traffic data, unwillingness of case studies to disclose information, and experiencing a lack of data availability due to the focused scope of our project and the novelty of EAVs were the most notable challenges.

Despite these challenges, the access to U.S. data on EAV programs is looking to increase drastically in the coming years. More and more cities are taking the leap into the world of autonomous vehicles and are being asked to disclose their findings and share their thoughts with the rest of the world. In a joint study by Polis and The Bloomberg/Aspen Initiative on Cities and Autonomous Vehicles, cities across the country are asked to partake in compiling all data on autonomous vehicle frameworks currently in place or in the planning phase (Van Deventer, 2017). We suggest Columbus keeps a close eye on this study as the Smart Columbus project continues to develop.

4 - Recommendations

Based on the case studies in which EAV implementation was most successful, the City of Columbus should first implement the necessary legal framework associated with adopting EAVs. With the Smart City Grant, Columbus has the opportunity to lead the way in American EAV transportation; thus, the policy implemented must be both comprehensive and transferable.

Next, establish secure infrastructure, both physical and digital. Providing secure infrastructure will involve the selection and purchase of the vehicle chosen for this setting. Implementing properly placed charging stations is also essential for an efficient operation. Some case studies, like those of the Netherlands and France, installed a small barrier between the regular traffic lane and the additional lane for the automated shuttle. Other infrastructure may include user access kiosks and request systems.

Implementing training and certification programs in order to secure the operating environment and minimize risk and injury will be crucial. All case studies included rigorous training programs for personnel. Investing in education for workers allows for a better connected system and greatly reduces accident risk. Having well-trained staff is also a great way to promote the users' attitudes toward the program, further advancing its success.

Finally, public acceptance must be addressed with a demonstration and pilot program to illustrate the benefits to potential riders and ensure them of their safety. When the public is engaged in the implementation and initial operation, successful adoption is much more likely. Case studies show that when riders are more engaged, they are less skeptical and, therefore, more likely to use the shuttles. Through pilot programs and public demonstrations, potential users are able to interact with the shuttle and see first-hand its safety features. Two great examples of local engagement that can be replicated by Columbus include running educational sessions at schools in the regions as in the La Rochelle case study, and having contests for young children to win a free ride on the shuttle before anyone else, as with San Sebastian's art competition (Experience and Recommendations, 2016).

5 - Conclusions

The City of Columbus must create a legal framework, train and educate a technical staff, educate and engage the public, and provide the proper infrastructure and signage to successfully implement EAV shuttles in Easton. Based on our research, the completion of an initial demonstration project will take 12-15 months, but potentially longer. In strategically introducing EAV shuttles throughout Easton, near COTA bus stops, parking lots, or throughout the shopping center, the City will provide better means for public transit riders. Successful implementation would reduce travel time for commuters and shoppers, reduce greenhouse gas emissions, and most notably reduce the traffic congestion issues in Easton. EAV shuttles in Easton will provide a basis for the further reaching goals of Smart Columbus, such as improving mobility for access to jobs, and providing accessible, as well as environmentally-sustainable public transportation.

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7 - Appendix

7.1 – Resources and Contacts

Paul Carlson (former City of Columbus and Smart City expert)
Our main advisor, helping us reach out to desirable contacts and also helping us focus our scope.
paulcarlson@columbus.gov

Andrew Wolpert (City of Columbus Transportation Engineer)
One of our main contact with the city of Columbus. He has helped us identify mobility references.
ADwolpert@columbus.gov

Wilfred Pinfold (Urban.Systems)
Collaborated to identify leading cities using EAV's.
wilfred.pinfold@gmail.com

Peter van Deventer (Coast to Coast e-Mobility and Netherlands EAV expert, OSU Alumnus)
Collaborated to identify current research on EAV's and ITS in the US and Europe.
petervandeventer@gmail.com

Robbert Lohmann (Chief Operations Officer, 2getthere)
Collaborated in the retrieval of data for the Rivium business park in the Netherlands
robbert@2getthere.eu

7.2 - Datasets

Dataset #1: Smart_Columbus_Volume_1_Technical.pdf
Source: Paul Carlson (former City of Columbus and Smart City expert); paulcarlson@columbus.gov
Description: This report provided an outline of all the Smart Columbus projects including the plan for EAV deployment at Easton Town Center. This document gave us detailed understanding of the parameters to look for in each case study and pinpoint similarities to the plan that

Columbus is trying to implement. The report also outlined some initial concerns that Columbus has already identified for EAVs.

Dataset #2: CityMobil2_Experience_and_Recommendations.pdf
Source: CityMobil2 - http://www.citymobil2.eu/en/upload/Deliverables/PU/CityMobil2%20booklet%20web%20final_17%2011%202016.pdf
Description: This report gave specific information and data on our 3 CityMobil2 case studies (La Rochelle, Trikala, and Lausanne). The report not only gave information on the details of each project including the number of vehicles deployed, length of routes, length of demonstrations, etc, but also provided information on key insights and challenges from each case study. Lastly, this report provided valuable figures that we used in our report.

Dataset #3: List_of_cities_with_EAV_studies_email.pdf
Source: Wilfred Pinfold (CEO of Urban Systems); wilfred.pinfold@gmail.com
Description: This email correspondence helped us narrow down our search of global leaders in EAV deployment. We were able to select three of our four main case studies from this list.

Dataset #4: EAV_global_studies_email.pdf
Source: Peter van Deventer (Director of Coast 2 Coast E-mobility and OSU alumnus); petervandeventer@gmail.com
Description: This email correspondence gave us new information on some on-going and brand new studies focused on data collection for EAV frameworks. Specifically, it introduced us to the study by Bloomberg/Aspen that will be a survey of US cities that have worked on EAVs.

Dataset #5: Easton_Area_Ridership.pdf
Source: Andrew Wolpert (City of Columbus Transportation Engineer); ADwolpert@columbus.gov
Description: This figure was used directly in our report to show the average number of COTA riders that are getting on and off at each bus stop around Easton Town Center. This information is not only helpful as a visual, but also helpful in understanding the high impact areas for public transit use in the area in order to conduct further analysis.