ASCE Blue Sky Competition 2020

Smart Mobility for Smart Cities:
Transforming the Way We Live

Smart Pilot Technology

University of Houston

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1.Executive Summary

Smart cities are defined by various characteristics which include sustainability, safety, well-established infrastructure, and efficiency, among other things. Smart cities are able to perform their daily operations effortlessly with only minor inconveniences. Due to these traits, we believe that major cities in Texas such as Houston, Austin, Dallas and San Antonio have the potential to be smart cities. However, they all face similar issues that prevent them from reaching that point: high traffic congestion and numerous car accidents create a cycle that has even greater side effects. All these effects point to an underlying cause; continuing the use of non-autonomously operated vehicles poses a great expense to cities which seek to improve their functionality.

To solve these issues, we believe that autonomously operated vehicles are the solution. Currently self-driving vehicles are an emerging market, but they are still not accessible to many people. Applying Smart Pilot Technology (SPT), a compact system installed in the head unit that connects with the vehicle and converts non-autonomous vehicles into autonomous ones, has the potential to solve the issues these cities are facing and help them become the next smart cities.

2.Challenges of Non-Autonomous Vehicles in Future Smart Cities

As it is, there are thousands of crashes on Texas roads every year. There were 3722 deaths on Texas roads in 2017 despite the multiple safety measures meant to effectively decrease this number (U.S. Department of Transportation 2018). There is still a large disparity between our goals and the statistical numbers of injuries caused by vehicle crashes. Drunk driving is also one of the biggest issues these cities are facing: 1468 of those 3722 deaths on Texas roads in 2017 were alcohol related and 944 (Burke 2018) of those 1468 deaths were from Houston alone. (U.S. Department of Transportation 2018, Burke 2018) Also, due to the amount of car accidents, car insurance rates rise and for that reason some people choose to forgo car insurance.

The growth of the city of Houston only creates more burden onto the existing transportation network, creating a domino effect that impacts everything from government resources to personal expenses. Currently, Houston is a city with more than 6200 miles of roads (Begley and Barnel 2018) as well as city wide coverage of LTE, Wi-Fi, satellite systems, and other necessary network systems that would be utilized to ensure the connection between cars is adequate and allows the communication necessary between vehicles. The established infrastructure of Houston makes it a candidate for addressing the problems its currently facing using the application of Smart Pilot Technology.

3.Application of Smart Pilot Technology

3.1 Goal

The goal of this design is to offer an affordable alternative to the current self-driving cars in the market. The primary benefit is a safer roads, which in and of itself has many positive effects such as decreased car accidents, decreased deaths, decrease insurance costs, reduced traffic congestion, and limited car purchases.

3.2 Definition and Execution

To better understand how this design works, we must first define what an autonomous vehicle is and give some examples. As defined by Wikipedia: “A self-driving car, also known as an autonomous vehicle (AV), connected and autonomous vehicle (CAV), driverless car, robo-car, or robotic car, is a vehicle that is capable of sensing its environment and moving safely with little or no human input” (Wikipedia 2018). Some examples of this type of car would include Google’s Waymo, Tesla’s Model X, and Uber’s outfitted Volvo SUVs. Our design would give all

people access to the same systems these 'self-driving cars' have without requiring the purchase of a brand-new car.

Smart Pilot Technology will be installed into traditional vehicles without certain autonomous capabilities allowing that vehicle to perform the same operations as other 'self-driving' vehicles on the road. The SPT unit would replace the head unit (where the radio is located) and the car would be modified at the pedals and steering wheel to react to the commands of the SPT unit. Sensors, cameras and radars would be used to collect real-time data and feed it to the command unit so that the car can perform the correct maneuvers. The application of this technology would require a team of trained technicians who understand how to modify various model vehicles and have the skills to install the SPT unit.

3.3 Reduced Collisions

The main benefit of this design is that death rates caused by roadway crashes would severely decrease. Since there is a computer in place communicating with other SPT integrated vehicles to recognize a potential collision -- when a human might not, whether due to distractions or extreme weather, or being intoxicated -- it could take the necessary steps to avoid the collision.

3.4 Insurance Costs

Another benefit to reduced collision rates is the potential for a decrease in insurance costs. "Insurers may place more emphasis on losses that aren't caused by crashes, such as damage from wind, floods, hail, other natural elements, and theft. That comprehensive coverage may not be so bad if the potentially higher costs to repair or replace damaged vehicles are more than offset by the lower accident frequency rate." (Notte 2020). Insurance costs could decrease enough that more drivers would be willing to purchase insurance and with less accidents, these insurance companies would also be benefitting.

3.5 Traffic

Traffic decongestion is another benefit of a mass installation of SPT. "Autonomous vehicles have the power to regulate traffic and reduce road congestion so people can get to their destinations faster." (Notte 2020). By transitioning from traditional human-driven cars to self-driving cars, less collisions occur-- meaning less traffic from clearing a collision, people gawking at the collision as they pass by, and less traffic from transporting EMS vehicles to the scene. This will lead to a decrease in travel time and an increase in worker productivity for people who commute long distances.

Also, by reducing the amount of traffic congestion we are reducing the amount of carbon dioxide released by idle cars sitting in traffic. A study done in Delhi found that "idling CO_2 emission contribute 9% of the total emissions from transport sector in Delhi in 2004." (Bhandari, K., Parida, P., and Singh, P. 2013) *It should be noted that this study only encompassed cars sitting at stoplights; this percentage would increase if idling emissions from congested traffic were included.*

3.6 Concerns

There are also several valid concerns associated with self-driving cars: hacking of software being the main concern. This could be addressed by imposing an 'open-sourced' software. As such, it is open to all testers who can make improvements and corrections as mistakes and loopholes are found. At first it could be vulnerable to exploitation but as people study the code, they can strengthen any security issues found creating a stable system. Similarly, self-driving technology is still quite new, meaning that software development is not where it needs to be. Debris, unexpected road closures, jaywalking pedestrians, and extreme weather conditions are some examples of things current models of self-driving cars cannot identify when necessary, and as such have led to fatalities.

4.Integration of Smart Pilot Technology into Existing Technology

A fair amount of the technology needed for SPT has already been developed and is currently in use. Although, to be used at the extremities we intend, there would need to be upgrades to the technology (as discussed under "Resources Required"). Much of the developed technology and software is also private information of the companies at the forefront of designing self-driving cars, and they are interested in keeping their competitive edge. As such, it would be difficult to acquire the appropriate information needed to develop SPT.

The technologies used in SPT would include mostly sensors, radars, cameras. We would also need to use, if possible, data collections from other companies such as Google and Tesla to ensure our product is up to date with all available information. We are already at an advantage in that we understand some of the negatives associated with self-driving software. One such concern is that vehicles could get hacked—but a potential solution to this is making the software 'open-sourced'. As such, it is open to all testers of software who can make improvements as mistakes and loopholes are found. More problems can be found in the community effort of supporting the software to ensure it is safe enough for all uses of life.

Fortunately, this is an established industry that still has much room for growth. As the market continues to grow, so will the technology used in self-driving vehicles.

5.Public Appeal

This design is meant to mainly appeal to the public: it allows for an affordable, resource friendly way for cars to be upgraded so that roads become safer for all users. This is only applicable for noncommercial vehicles, such as family or personal use cars. This would not apply to any 18-wheelers, commercial vehicles, RVs, etc. This technology would only be implemented in vehicles that run a standard load out of engines and axis. It would be a more economic way for people to upgrade their car to self-driving capabilities without buying a brand-new car just to access those features.

5.1 Public Survey

In order to analyze the reception of this solution, we conducted a survey to student members of our university, the University of Houston. Some of the questions included:

1. If there was a possibility to switch your car to an automated one would you do it?
2. If the government reimbursed the cost of the switch through taxes, are you willing to switch?
3. Would you feel safe in a self-driving car? Why?

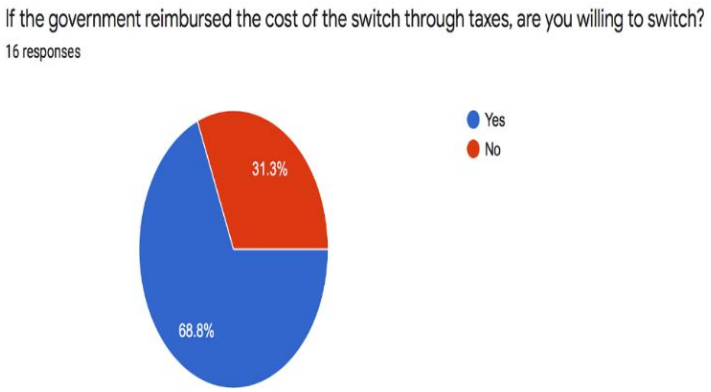

Figure 1. Survey of University of Houston Students. 2020

Some of the people who answered “No” to question number 3 wanted to see how efficient the car and the technology behind it was before accepting to convert their vehicle to an autonomous vehicle.

One of the responses stood out and the person said “As technology and neuroscience improves and becomes more advanced, I’ll feel safer. If all cars were autonomous, there would be no reckless drivers. The chance of getting into a crash would be decreased substantially with less human drivers on the road. I think that because we want to have control over our lives, many people are wary of new technology. Sure, ethical dilemmas could arise, but just looking at the numbers of crashes by self-driving cars per year, comparatively, self-driving cars are safe and less prone to accidents”.

There is public concern for the safety of autonomous vehicles which cannot be dismissed but a majority of the sampled people are still willing to consider automating their cars which demonstrates an interest in this approach to solving the challenges stated earlier.

5.2 Government Appeal

A benefit to installing city-wide SPT is the vast amount of data that could be collected. The collection of this data could be used to further improve this technology which could then provide more accurate results of traffic flow. Government agencies could then target their focus on certain infrastructure projects and decide what projects have higher priority and which don't and how to best manage their assets.

6.Necessary Resources

6.1 Technical Resources

The resources required to construct a SPT prototype are mostly already available – and already in use. Products such as Google's Waymo, Tesla vehicles, and others use this technology already in their systems, so there is already a growing manufacturing industry to produce the parts in the scale necessary for the implementation of this solution. Since these companies have not made their technology public, it would be necessary to develop our own programming. Development of the necessary technology will be possible with the help of computer and electrical engineers as well as with the help of mechanical engineers to develop and test SPT. The next most important step after developing and testing SPT is training technicians to install it. Installation methods would differentiate slightly depending on the vehicle and as such the crew tasked with installing SPT would need to be skilled in various types of vehicles. They must also be able to install SPT without damaging any of the previous functions of the vehicle prior to SPT's installation.

6.2 Cost

Money is the biggest expense behind any invention. It would be essential to receive the necessary funding from either private investors or government grants to develop a SPT prototype and implement the technology to the general public. It would also be beneficial to give the public financial discounts in exchange for implementing this technology in their vehicles to incite them to upgrade and thereby improve the usability of SPT network as a whole. The purpose of SPT is to be a cost-effective alternative to other self-driving competitors, and as such it would be necessary to be affordable to allow for every driver to install the upgrade.

6.3 Future Improvements

A few necessary improvements would be made to current technology before it could be implemented to the extent we would like; namely how well the system works in extreme weather situations. Most people have probably had the misfortune to drive through heavy rainstorms or snowstorms that limit visibility. Conditions like those are extremely challenging for humans to navigate, and even harder for sensors and machines that lack the same visual

adaptations that humans have. Other situations such as road closures and other occurrences that would require human problem solving are also issues, although it's one that could be solved by having all cars connected to a global system that monitors where each car is in respect to each other and any road closures or other issues are reported to the system that orders the cars to react in a certain way. Similarly, current models of self-driving cars lack the same human recognition & decision making and there have been several accidents which would have been preventable by a human driver's action. One such example of this is a jaywalking pedestrian. A car operated by a human who was paying attention would have slowed to allow the pedestrian to finish crossing the road, but self-driving cars lack the ability to identify such an obstacle in the road, especially if it is in a location it is not meant to be (such as a pedestrian crossing the roads at sections other than cross walks).

7.Engineering and Societal Values

The overall societal value of a mass installation of SPT would be immense: decreasing the number of driver-induced deaths would save not only millions of lives, but also immeasurable amounts of money and time through decreased travel times, decreasing insurance rates (also giving more people access to insurance) and improve the overall efficiency of the cities they operate in.

This would further promote research and data collection on sensors and other data assessing/collecting software and hardware, which could eventually be used to go as far as settling humans on other bodies such as Mars or the moon. It could also be used in medical applications such as surgeries to identify cancerous tumors and other health issues.

Ideally, this technology could be developed to include every car on the road; allowing them to operate on a hive-mind system of interlinking information. This would enable traffic to be reduced to absolute zero in cities with the necessary infrastructure and eliminate collision-caused deaths. The impact of this application has the potential to benefit more than just the transportation industry and holds many opportunities for a brighter future.

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