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We are concerned with global warming and have seen evidence that this phenomenon is actually taking place through various inclement weather conditions worldwide. There have been many conversations on a national and worldwide level as to how to prevent its escalation. One school of thought as identified the autonomous vehicle (AV) as one solution to the issue. The development and usage of autonomous vehicles presents fundamental technology which will not only improve transportation safety but will also help the environment by conserving energy consumption, decreasing air pollution and the expense of congestion. The National Highway Traffic Safety Administration (NHTSA), have presented a 5-part gamut which outlines the technological benefits of AV and have documented the benefits of each level:

- Level 0: Functionality is completely controlled by the human driver
- Level 1: Automation of 1 function
- Level 2: Simultaneous automation of more than 1 function (e.g., navigation and deceleration); however, the human driver must remain engaged
- Level 3: Functionality of the vehicle is satisfactorily automated to afford engagement of other activities by the driver.
- Level 4: Complete automation, that is, there is no need for a human driver

Level 3 autonomy or above in commercial vehicles is currently an unsatisfied feature in a niche market within the commercial vehicle industry. According to the SAE (Society of Automotive Engineers), levels of autonomy in vehicles are a measure of how much influence or action is required by a person in order to do normal driving function and techniques such as (but not limited to) merging to another lane and high speed cruising. Level 0 autonomy vehicles are defined to be vehicles with automated system warning systems but no automated system control. Level 1 autonomy is when a driver and automated system share control over driving a vehicle but a driver is still required to perform normal and emergency driving techniques, an example of level 1 autonomy is adaptive cruise control. Level 2 autonomy is when a driver and automated system share driving functions and the automated system can control accelerating, braking and steering features. A driver is required in level 2 autonomous vehicles so they may perform emergency driving techniques in case of an emergency. Level 3 autonomy is when a automated system has control over all driving functions of a vehicle in addition to few emergency features such as emergency braking, a driver is required to activate all other emergency features. Level 4 autonomy is very similar to level 3 autonomy, however the vehicle would be able to operate in different environments and adjust accordingly, such as self parking. Level 5 autonomy is when a vehicle can perform on its own without any human intervention.

The principle of autonomy in vehicles is a fairly old topic within the commercial vehicle industry but recently have regained some attention. Militaries and space programs across the world have developed several unmanned vehicles, such as UAVs (unmanned aerial vehicle) and space probes (Luna programme; USSR 1959). The autonomous systems used in the 20th century were systems that required a person to take command of the vehicle. In more recent times,

people are innovating on those past systems. Processors and detection equipment are all improving. During the 1960s, cameras and infrared sensors weren't reliable enough to feasible create a detection system. Processors used during the 60s that would possibly be able to process such data in a short period of time were probably too expensive to develop. Advancements in processors and the components of detect systems (camera, infrared sensors, light sensors) have made it possible to achieve higher levels of autonomy. In July 2017, European automobile manufacturer Audi has announced their new Audi A8 luxury sedan is the first commercial vehicle to achieve a level 3 autonomy.

There are several companies working on a fully autonomous car to be dropped within the next few years. One of the leaders in autonomous car technology is undoubtedly Tesla with Elon Musk heading the efforts. On April 28th of 2017, during his TED talk, Elon stated that, *"November or December of this year, we should be able to go from a parking lot in California to a parking lot in New York, no controls touched at any point during the entire journey."* However, a level four experience, where the driver could fall asleep at the wheel, is thought to be two years away. Tesla is employing an all camera based system that they believe will lead to full autonomy due to the complete 360 degree visibility the car's computer system will be taking advantage of for decision making on the road. Tesla's website states that, *"All Tesla vehicles produced in our factory, including Model 3, have the hardware needed for full self-driving capability at a safety level substantially greater than that of a human driver."*

Other major companies, including BMW, Mercedes, and Volvo all have models on the market with self-driving capabilities. Mercedes-Benz has a system they call Drive Pilot that can safely guide the car in a lane with traffic while maintaining spacing between other cars but can only switch lanes with driver commands. BMW's 5 series can park itself in both parallel and perpendicular spots without the driver in the car. However, their Traffic Jam Assistant still requires driver interaction when in traffic though it can follow lane markings and the car in front of it. Volvo has a model that can be equipped with most of the top of the line features available today for self-driving cars such as steering assistance and controlling acceleration, and braking. Their models all require the driver's hands to remain on the steering wheel, ensuring they are still active participants in the drive and that complete autonomy is a ways off still.

Google is one company early to the scene in their development of a fully autonomous ride. Beginning their research as early as 2009, their project has from the start aimed at level four automation and has since taken the name, Waymo. Earlier this year, 500 Chrysler Pacifica Hybrids were released to the public in Phoenix, AZ integrated with the fully automated technology provided by Waymo. Their testing with the public rides still requires an engineer behind the wheel in case of emergency, but their rides offer a complete disengage from driving in ideal situations. The cars can sense and differentiate pedestrians, bikers, animals and other cars from each other then adjust appropriately and safely. With sensors that offer vision for 200 feet in all directions, Waymo is one of the closest projects to commercialization and fully autonomous driving for the public.

Numerous companies and entities have their separate approaches and designs for implementing autonomy to their desired level with nuances distinguishing them. The general market will not have automated vehicular technology for consumers for several years. Luxury car manufacturers will be the first to offer AV, however, these models do not qualify as autonomous as the human driver is required to be actively engaged in some capacity. Tesla is employing an all camera based system which produces 360 degree visibility which proposed full

level 4 autonomy. Tesla and Google's Waymo has shown that 360 degree visibility is one attainable in a vehicle and for that matter a key component in automation , as Team AutoMoe has proposed. What is variable between our proposed designs is our implementation for attaining a full 360 degree of vision. AutoMoe's current proposed design implementation does not seem to directly emulate any AV system in development. With inspiration from the BMW's 5 series , some form a parallel and perpendicular mechanism could be a possible addition to our design to refine our capabilities so that our system is more flexible. With the use of primarily ultrasonic sensors and an arduino microcontroller for detection we hope to at the least reach level 3 autonomy however the goal of team AutoMoe is complete level 4 autonomy where a human driver isn't required during any step of navigation.

Presently, most prominent car manufacturers have adopted an evolutionary approach towards AV and are relying heavily on step-by step industry development. There is an industry goal to make available level 3 vehicles by the year 2020. This will require buy-in from the government and software companies. Despite the concentrated efforts to bring about AV, it is will not happen overnight. The general market will not enjoy automated vehicular technology for several years even after policies and regulations have been established. Luxury car manufacturers will be the first to offer AV as is witnessed with models from Tesla, BMW and Mercedes-Benz. However, these models do not qualify as autonomous as the human driver is required to be actively engaged at all times. Additionally, these high-end automakers now have to contend with Google, Uber and Baidu who are making strides with AV technology.

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