Date: 4/26/2019

Memo to: Dr. Betsy Aller, EDMMS

From: Team AVID

Subject: Memo of Transmittal

Introduction

The purpose of this memo is to inform you of Team AVID’s Senior Design Project. This Interim Project Report serves to provide information about the design process and the completed aspects of the project.

Project Information

Autonomous vehicles are growing in popularity. Many car companies are researching and developing self-driving systems. Our team was tasked with producing the interior of a self-driving car. Various technology and design requirements will be incorporated. The project will be developed by completing concept sketches, 3D renderings, scale modeling, and manufacturing of a full-scale model.

The team has completed each task to date. Research has been completed to complete the TRR report and Oral Presentations. Our experience with the Design Thinking activity opened the pathway for a creative design process. Each team member will contribute their opinions and talents into each aspect of the project.

Conclusion

Team AVID has met each assignment with ambition. The team has gathered important information and data to complete the interior design. This project has pushed the team to work hard and open our minds to the creative possibilities. We look forward to completing the next steps in the design process.

Autonomous Vehicle Interior Design

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Senior Design Interim Report
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Abstract

While many automakers are pushing for autonomous technology to achieve self-driving vehicles, there is a shortage of consideration for the interior. For decades, it sounded like a pipedream to sit inside a transportation vehicle that has a mind of its own - a vehicle that could travel to any destination with zero driver input. This senior project will deliver a focus on an autonomous vehicle (AV) interior that focuses on comfortability, technological luxuries, and safety. The design will be conceptual, and theoretically will be applicable to any size vehicle. A project plan details all of the tasks needed to complete these objectives, and a Gantt chart illustrates the timeline for the completion of this plan. Research on automobiles and their interior designs of the past, present, and future concepts has been completed. Collaboration with another design team was conducted to prompt ideas for both groups. Project activities will be executed within an agreed upon budget and deadlines.

Introduction

The current state of the automotive industry is undoubtedly approaching the fully electric and autonomous. With the prospect of a "green future," many automotive giants such as General Motors and Ford have sought to keep up with smaller companies like Tesla Motors who have pushed for this change. Companies such as Uber and Lyft are looking at replacing drivers with autonomous rideshares. In recent development, modern automobiles have features including assisted parking, braking, and auto-pilot driving. The trend of including features like these points to a future where cars become self-driving on a computerized and sensory system. The goal of this project is to provide an understanding and visual representation of what the future of automobile transportation may be like.

Deliverables, Criteria, and Constraints

As for deliverables, the team will use market research and surveys to brainstorm ideas, create concept sketches, and develop models. Using information from research, the team will create a CAD model with details of the car interior and a small-scale model (about 1/12th scale). This project will also deliver a full-sized model of the interior for autonomous electric vehicles and will demonstrate what new things automotive companies can consider incorporating themselves. The full-scale model will seat 4-5 passengers with two rows of seating. There will be a finite element analysis of any applicable component, and documentation of results. Drawings – both digital and hand-sketched – will be provided.

One constraint for this project is the presentation deadline on Tuesday December 3, 2019. The full model will be delivered one month before the final presentation. This project will not require any of the students' personal budget. There is an allotted $1,000 for cost of supplies. Lightweight and affordable material will be used to maintain ease of transportation and low costs.

Project Objectives

The objective of this project is to deliver a clear representation of what the interior of future autonomous vehicles may look like. The team and advisor will set specific criteria for the design. After analyzing research data and homing in on the target market, the aim is to provide a feasible depiction of an autonomous interior. The design process will be the fundamental framework over the course of the project.

Another objective is to find an industry mentor. Professor Middleton is working on bringing in someone to advise and guide the project from Adient, a company that focuses on automotive seating. Testing of the final model and necessary adjustments will be made based off consumer feedback. Finally, a presentation and poster board will illustrate the team's efforts throughout this project.

Summary
Because the automotive market is shifting towards an automated drive system, it begs designers to question what the interior of an automobile could offer passengers. The team aims to answer this question in this capstone project. We will utilize the engineering design process of defining the problem, researching the market, designing and selecting solutions, and redesigning as necessary.

Section 1: Background

In today's society, automotive vehicles are used to transport passengers and goods millions of times a day. It's a universal fact that every large country depends on transportation for their economic prosperity. As populations increase and urban areas expand, the need for fast, reliable transportation continues to grow. Conversely, if there is not an efficient method of transportation, people's time, money, and safety could be at cost. One option to fill this need would be the implementation of self-driving cars.

To establish an understanding for the development of self-driving cars and their interiors, the team examined several main topics: history of the autonomous vehicle; development of information systems in vehicles; safety standards and laws; interior designs of the past, present, and future; and concept designs and their costs. This technical research explores the vast possibilities for the future of autonomous interior designs. This exploration delves into topics regarding past, present, and prospective future designs that people have envisioned for this industry.

History of Autonomous Vehicles

The first known self-driving vehicle attempt was built in 1977 by the Tsukuba Mechanical Engineering Laboratory in Japan. This vehicle worked by following white street markers and could reach speeds of up to 20 miles per hour on the lab's test course (Kruger et al., 2005). The first major breakthrough, however, came in the 1980s by Ernst Dickmanns and his team at Bundeswehr Universität München. Their prototype was able to achieve 60 miles per hour on the roads without traffic. Another important milestone in the history of autonomous vehicles was the Automated Highway Systems' (AHS) revolutionary demonstration made in 1997 that included more than 20 fully automated cars (Kala, 2016). The demonstration was carried out on a California highway and completed without glitches. This event stands as gaining the most media coverage of any Intelligent Transportation System activity in U.S. until the 2005 DARPA Challenge.

During the 1990s, the basic capability for car automation systems was demonstrated in Europe, Japan and the United States respectively by the PROMETHEUS program, Advanced Cruise-Assist Highway System Research Association (AHSRA) and AHS program. The European projects were completely based on vehicle intelligence, while the Japanese developed systems that were highly vehicle-highway cooperative. The U.S. projects made use of both techniques in their autonomous vehicle systems (Fu et al., 2008). The 1990's projects were unique and showed promise with the United States. The project was abandoned after this demonstration because of the timeframe patrons were willing to fund. In recent years, around 2000 smaller and more private attempts emerged. These smaller projects are largely short- scoped and more safety based. Currently there are many small and mid-sized projects in progress which show great potential for future development of autonomous transport.

Information Systems in Self-Driving Vehicles

Information systems in automobiles have developed rapidly with the evolution of vehicles. They have moved from simple tactile button systems for radio and air conditioning to high-tech touch-screen tablets that are able to display everything about the car. In order to narrow concept designs, it is important to understand this development, as well as the direction it is heading in.

One research paper, titled *Information Systems in Automobiles - Past, Present, and Future Uses,* written by Tobias Brandt, discusses the different information systems within cars and how they interact with electric vehicles and their electrical efficiency. Brandt describes the systems found in a vehicle as convenience, communication, entertainment devices, and vehicle monitoring systems. The first development on these was mostly to the audio system. There was significant development early on for the AM/FM radio, moving to cassette players, then moving to CD players. These used analog display systems at first, then transitioned to LED displays in the 1990s and 2000s. The radio system now is usually a full entertainment system with Bluetooth, CD, DVD, and many other options depending on the vehicle (Brandt, 2013).

Vehicle monitoring systems categorize all the information that is used to keep track of the functions of a car. Moreover, their systems use indicators that measure aspects of the engine and its overall function. This includes a display for GPS, collision detection, maintenance information and settings through the entertainment system (Brandt, 2013). This information will be integrated into the project for concept designs. The cars will contain mandatory displays for the speedometer, odometer, safety information, air conditioning, audio, DVD and GPS maps. Each function requires the user to interact with them, by way of either a physical button, touchscreen, or voice command.

One method to gain an understanding of what consumers want is by way of a survey. This will yield the best interior design due to considerations coming directly from average users. The team is currently developing the survey and will begin distributing it. The information gathered from the survey will influence the team's design concepts and will be included in the interim project report.

Current Safety and Regulations

Safety and regulations for autonomous vehicles are important to consider because the interior design may be directly influenced by government laws. The commonalities of today's automobiles makes one wonder whether or not there are laws that must be obeyed when designing those interiors. By delving into the topic of safety standards and establishing more criteria, the team can further refine design ideas.

Only a handful of states have implemented laws that are specific to autonomous vehicles. Many of these laws aren't too detailed; for example, some define what it means to be an autonomous vehicle, or simply mention the state's legal stance on autonomous vehicles, as mentioned by Weiner & Smith (2017). According to US Legal (2016), the majority of vehicle laws are currently listed under the 1968 Vienna Convention on Road Traffic and apply to vehicles that must be fully operated and controlled by a human. Therefore, much framework needs to be updated. Considering this, for example, government agencies such as the Department of Transportation have put out documents for guidance and voluntary procedures that autonomous automakers should obey. However, these are simply guidelines and not laws - they were written to remove obstacles and to streamline innovation (NHTSA, 2018). Government laws that govern autonomous vehicles are few and far between, but as technology advances these guidelines may make it into legislature.

Current NHTSA standards

The National Highway Traffic Safety Administration (NHTSA), under the U.S. Department of Transportation, released a thrice-revised policy framework for Automated Driving Systems (ADSs) in 2018, which is the most up-to-date on legal guidelines that autonomous vehicles should follow. This framework, titled *Preparing for the Future of Transportation: Automated Vehicles 3.0,* emphasizes their prioritization of human life and safety on the road, which serves as the main purpose for passing this policy. Since 1966, there have been 2.2 million fatal automobile crashes. Human error is the leading cause (94%) for these fatal accidents (NHTSA, 2018).

The NHTSA established a Level scale from 0 to 5 defining the levels of autonomous vehicle integration, where Level 0 has no automation with full driver responsibility, and Level 5 has full automation and human control is optional. Regardless of their level, autonomous vehicles are encouraged to have redundant safety systems, provide feedback to the outside world like visible sensors for pedestrians and other drivers, and have the option for the driver to take complete control of the vehicle at any given time. They should have robust cyber security algorithms in their software as to avoid hacking, become accessible to the elderly or people with disabilities, and support the ease of port facility maneuvering. To expand on the last point, when technology permits, autonomous vehicles in processing shipments should be assisted with tasks that rely on pure human intervention, such as unloading containers and pulling up to ports (NHTSA, 2018).

As mentioned earlier, the NHTSA has mostly offered only recommendations for autonomous vehicle makers, but hardly any laws concerning the general design considerations for them. They say in their policy that they are in full support of adapting old regulations and ignoring them when the situation is irrelevant. For example, if a former law under the Vienna Convention was specific to vehicles dependent on total human control, they would obviously disregard it. The goal for the NHTSA is to provide support to this growing industry without stifling creativity (NHTSA, 2016).

Google's safety standards for autonomous vehicles

On February 4, 2016, Google submitted a letter to the NHTSA requesting that they interpret some of these safety regulations as they would apply to what they considered to be their Level 4 autonomous vehicle (a vehicle with nearly no human input necessary to travel to a destination). These regulations, titled Federal Motor Vehicle Safety Standards (FMVSS), are laws that have been passed in Congress and are enforced by the NHTSA. FMVSS apply to components and features of vehicles for safety. They range from air brake systems and child restraint systems to head impact protection to occupant crash protection.

Google beseeched the NHTSA to interpret these FMVSS which didn't exactly apply to their vehicle. The first regulation was Light Vehicle Brake Systems (FMVSS No. 135), which describes the activation of brakes using foot control. Google's vehicle would apply the brake itself using the ADS, so this regulation was irrelevant. Another null regulation was Rear Visibility (FMVSS No. 111) which requires external and internal mirrors to give a field view around the vehicle to the driver. Google instead proposed that the field view be provided first to the ADS. Theft Protection and Rollaway Prevention (FMVSS No. 114) requires the brake to be pressed in order to shift into the parked position. However, Google's vehicle wouldn't have a brake pedal and they had the confidence their driving system would select the most appropriate transmission position (Urmson, 2016). These were among several items which Google sent to be revised by the NHTSA.

These regulations are relevant to design considerations and design scope limitations which may not currently be considered. Furthermore, since tech giants like Google have asked these questions to interpret the law, it's feasible that the interpretations will become the new standard for autonomous vehicles in the future.

Current Automotive Interior Design

The design engineering approach to automotive interior design has changed tremendously over the past 40 years. While the car exterior body still hooks consumer drivers, the interior has been redefined as a way of interacting with an automobile. Drivers and passengers demand a luxurious, aesthetic look and feel to their cabin, while also being offered logical and functional ways to control and interact with the systems.

Materials and existing designs

Improvements to engineered materials and processes have introduced new way of thinking about a car's interior design. Fortunately, because of the advancements in polymer blends and manufacturing processes, low-cost plastics can be made to look and feel like premium material. Additionally, synthetic leather is becoming a popular choice among car makers because of its cost efficiency, aesthetic appeal, and close resemblance to real leather (Grand View Research, 2018). Because of less developed processes and materials, older generation cars took a simplistic approach to the interior, focusing on comfort and performance. However, new models are able to deliver a more luxurious feel to the average consumer, emphasizing comfort, ergonomics, functionality, and aesthetics.

Manufacturers must rethink the relationship between a car's cabin and the passenger. There's been a shift of attention among millennials regarding the cars they buy. They're geared more towards the interaction with the interior as opposed to the engineered capabilities of the exterior and motor. This doesn't suggest that millennials don't care about the driving capabilities, just that these engineering advancements are being taken for granted (Hung, 2017). Regarding the seats, current designs are focused on comfort, adjustability, and luxury. There are high demands for heated and ventilated seats, power adjustment, and comfortable cushioning. To no surprise, the most luxurious cars have rated best in class when it comes to their seating. For example, the 2016 Bentley Bentayga has a 22-way power adjustment. The head rest can be moved up and down, forward and backward, and even has side features that can be pulled around the head for a cocoon-like experience. They also use multi-density foam for higher rigidity in some areas and more cushioning in others. It's common now to see the softest cushioning protruding off the edge of the seat to ease the transition getting in and out of the vehicle (Hung, 2017).

Due to increasing emission standards, weight reduction has become a popular demand for manufacturers. Design engineers are shaving off pounds with every new design through use of high-grade materials. Johnson Controls Automotive Experience - who designs seats for nearly every major automaker worldwide - has been focusing on seat mass reduction with the use of carbon fiber (Hung, 2017). Their CAMISMA (Carbon-Amide-Metal-based Interior Structure using a Multi-material system Approach) project has introduced a seat that is 40% lighter and just as strong as a conventional seat built around a metal frame. It combines steel, fiberglass-reinforced plastic, non-woven carbon fiber, and thermoplastic tapes with carbon filaments. Weight reduction is an important part in the design thinking of automotive interiors. It allows for less emissions and higher efficiency of the vehicle overall (Hung, 2017).

Design functionality and problems

The evolution of interior design has introduced many innovations for the way drivers interact with their vehicle while driving. These, however, present problems, distractions, and needs for fixes that drastically change how a driver manages their control systems.

The Volkswagen Golf is a great example of how interior design has evolved over the years. There are more than 30 million models of it on the road, and it has debatably set the tone for what a family hatchback should be. Many other car manufacturers have taken inspiration for their designs from it (Ozserin, 2018).

From 1974 to 1997, the Golf Mk1 through the Mk4 were released. There were general design improvements from model to model. The Mk2 introduced clustered control buttons and offered a more organized layout. The Mk3 used ventilation control knobs that replaced the more traditional sliding mechanisms. These were preferred as the driver could easily fine tune the temperature without the need to take their eyes off the road (Ozserin, 2018). The controls for the headlights, brights, and fog lights transitioned from separately spaced out buttons to a centralized knob to the left of the steering wheel. The most noticeable improvement was from the Mk3 to the Mk4. The buttons and knobs were made in different sizes and were labeled with icons, making it easier for the driver to memorize the layout. Released in 1997, the Golf Mk4 set the tone for the interior design of the models to come (Ozserin, 2018).

In 2003 the design became very complicated. Technological advancements in the early 2000s introduced problems when they were integrated in the control systems and the new infotainment center. The Mk5 presented the user with a screen as an interface tool. Buttons were then correlated with the infotainment system, and with that, drivers had to take their eyes off the road to make sure they were hitting the right button. Additionally, digital maps urged drivers to look at the screen, obviously a major distraction from the road (Ozserin, 2018).

In 2008, the Mk6 launched with the newest and latest type distraction: a touch screen. There is no tactile feedback in a flat glass panel, as opposed to knobs and buttons. The driver is forced to look away from the road for a significant period of time in order to find what they're looking for. Additionally, the screen had a much lower placement compared to the gauge cluster. Therefore, drivers had to look a considerable distance away from the road to use the infotainment center. This was especially dangerous because at this angle the road couldn't be seen well even from peripherals. One feature that eased the touch screen control was the utilization of a directional pad (D-pad) on the Mk6 steering wheel (Ozserin, 2018).

The 2012 and 2018 models of the Golf never addressed the major problems with the screen. Each one simply introduced a bigger and better looking screen with more touch functionality causing greater distraction. The air vents remained placed above the screen, suggesting a sort of legacy design hurdle (Ozserin, 2018).

The 2018 Volkswagen Polo addressed the problem of look-away distance by moving the infotainment screen at the same placement level as the gauge cluster, a much shorter distance from road to screen. The position of the air vents were then shifted below the screen. Many other manufacturers have followed suit with this design (Ozserin, 2018). The D-pad from the Mk6 still remained and had been improved on. The climate control button cluster was now at the lowest level, suggesting that it is of lowest importance and can be controlled with muscle memory (Ozserin, 2018).

Design fixes

Volkswagen is taking steps in the right direction with the Polo’s interior; however, problems still persist. A touch screen is undoubtedly the most distracting feature in most cars today. While it helps the center console remain organized with fewer buttons, it also demands too much cognitive and visual attention from the driver. Presently, automotive interiors need to be redesigned, as they are dangerous and distracting for a driver.

Design engineers should focus their attention on minimizing the effort and cognitive attention that touch screens demand. Research and development should go into controllers like the D-pad seen in the Golf Mk6. Consumers would prefer a tactile interaction between them and their screen that doesn’t require reaching forward and touching it. European and luxury car manufacturers have been working on a system like this for years. Specifically, in 2001 BMW introduced their iDrive system; a physical knob control that removed the need to reach out and touch the screen (Ozserin, 2018). It was a huge hit right away. Consumers liked it for its simplicity and intuitive control. Its placement was such that a driver could rest their arm in a normal position and still control their infotainment center. Over the years, iDrive has been updated and improved on. Today, users can click it, rotate it, and even push it like a joystick in four directions. This approach to a controlling device has been so well-received that other European manufacturers are adopting it in their designs (Ozserin, 2018).

All things considered, design engineers must rethink their approach to the way drivers interact with their vehicle’s interior. Contrary to the trend in computers and cell phones, touch screens can complicate input control. It’s cognitively demanding and clashes with the core necessities of driving. Engineers should focus their attention on solutions that are simple, intuitive, and versatile regarding input control.

The Future of Autonomous Interiors

Looking at past movies, such as *Back to the Future Part II*, people had grand expectations of the future and technological growth. Flying cars and hoverboards are just a few examples of evolutions presented that have yet to be accomplished. Although technology has not progressed as far as some would have expected, engineers continue to make strides and push towards greater innovations.

One such innovation is the development of fully autonomous vehicles. Steady growth and development of technology has allowed for continued steps toward self-driving vehicles. Despite this, self-driving cars, especially those available to the public, are not yet fully self-governing. This does not stop companies from researching and continuing to develop their own ideas and concepts into what future vehicles will be like. The race for perfecting autonomous technology and AI continues, and car manufacturers are looking to get ahead of the competition.

Examples of future concepts

Every car manufacturer has their ideas and designs that differentiate them from other automakers. However, themes can be identified within the majority of current concept vehicles. One of the most important and prevalent design themes is luxury. When it comes to self-driving vehicles, automakers are pushing the envelope in terms of comfort and luxury features. One example is Bentley's 2036 autonomous concept vehicle presentation, in which the company representatives envisioned traditional seating replaced with rows of luxury leather sofas (Wong, 2016). Many other automakers are redesigning and enhancing the comfort and mobility of their seating options, but not outright replacing them with other forms of seating.

The inclusion of tables is another common feature found in future designs. This development enhances the ability to complete work, as well as make use of it for entertainment purposes. The additional room within the cabin also allows for great flexibility on what manufacturers can and would like to include. Volvo's 360c concept vehicle uses versatile seating that can be used like a traditional seat or as a bed for lounging and even sleeping during travel (Savov, 2018). This concept represents a more comfortable cabin with less luxury. This could be appealing to more consumers, considering the number of commuters present on the roads every day. The option to work during a morning or afternoon commute would be enticing to the many that have extended commutes. The 360c represents a possible replacement for short or overnight flights, while remaining an ideal option for daily commuters.

The Mercedes F 015 opts for a design that could also appeal to career-driven individuals, continually flashing points of luxury and versatility. A unique set of rotating leather seats, wood flooring, along with metal and glass surfaces highlight this interior design (Oagana, 2015). This concept also contains space large enough for four adults and provides plenty of room for discussion and work opportunities. This design shows an appeal to a variety of potential customers. Both Volvo's and Mercedes' designs include glass touch screens built into the panels on the inside of the doors. Heads-up displays on the front windshield as well as the passenger windows display estimated time of arrival, directions, and a variety of other options and functions for the passengers to customize.

Cost of future designs

Appealing and luxurious designs show great potential for the future market; however, the one vital question remains "how much will these vehicles cost?" At this point it is hard to pinpoint exact figures for potential cost. Although, given the amount of technology and premium materials that will potentially be used, it can be assumed vehicles like these won't come cheap. Estimates can stem from the cost of services being provided to areas that have begun the adoption of autonomous vehicles. On December 3, 2018, the Rhode Island Department of Transportation (RIDOT) announced they had "awarded a contract to May Mobility to deliver a limited and controlled automated vehicle service to help fill a transportation gap between downtown Providence and Olneyville via the Woonasquatucket River corridor" (RIDOT, 2018). The cost of this service for the first year of operation was $800,000, covered by a $300,000 federal grant and a separate grant awarded by the State's Attorney General's Office. The services of these shuttles are free to the public over the first year of operation. The costs per shuttle/vehicle in other instances have been within the range of $140,000-$200,000 per year, depending on the length of service (Waddell, 2018). Some believe that current costs of hiring these services do not accurately represent future costs; however, this is purely speculative.

The goal is to maximize the comfort, flexibility, and appeal of designs to consumers. Following the path of current automakers, it is important to have the option of creating a premium and luxurious interior and also attempting a functional and broadly appealing design that limits the cost. Through continued research on current manufacturers conceptual designs, along with modern vehicles, there is great potential for a unique interior that fits the current and near-future market.

Technology of future autonomous vehicles

Along with currently available vehicle features essential to autonomous vehicles, companies must create a foundation for future technology. To achieve 100% vehicular autonomy, there are several critical technologies to be solidified: network infrastructure, sensor technologies, and AI. These technologies would need to operate seamlessly together in order to successfully operate in a large-scale traffic network.

An interconnected database and communication system between vehicles will be essential to autonomous road traffic (Coben, 2016). The inter-vehicle network has numerous potential uses for passengers including: saved preferences for the screen interface, allowing the vehicle to understand gestures, and creating an accessible environment for disabled passengers. These functions would provide maximum comfort, privacy and security for users, offering a tailored ride. Connected vehicles could also provide passengers with multiple views of current traffic in real-time to give an accurate assessment of route delay and navigation by using the data exchange with surrounding infrastructure.

Several sensor technologies have been explored to accomplish such a large-scale system and reduce concerns for error. One prospect would be to use light detection and ranging (LIDAR) and radio detection and ranging (RADAR) to allow vehicles to create frequencies of emission and “perceive” the world around them in ways that the human mind could not (King, 2015). Another method would be to equip each unit’s perimeter with individual cameras and physical sensors for emergency stopping, parking and other proximity features. By gathering data using these sensory tools, the vehicle can put together sources of pattern-recognition. It will then not only be required to log the data obtained and adjust accordingly, but also share this information with all connected vehicles (Khaksar et al., 2016).

Conclusion

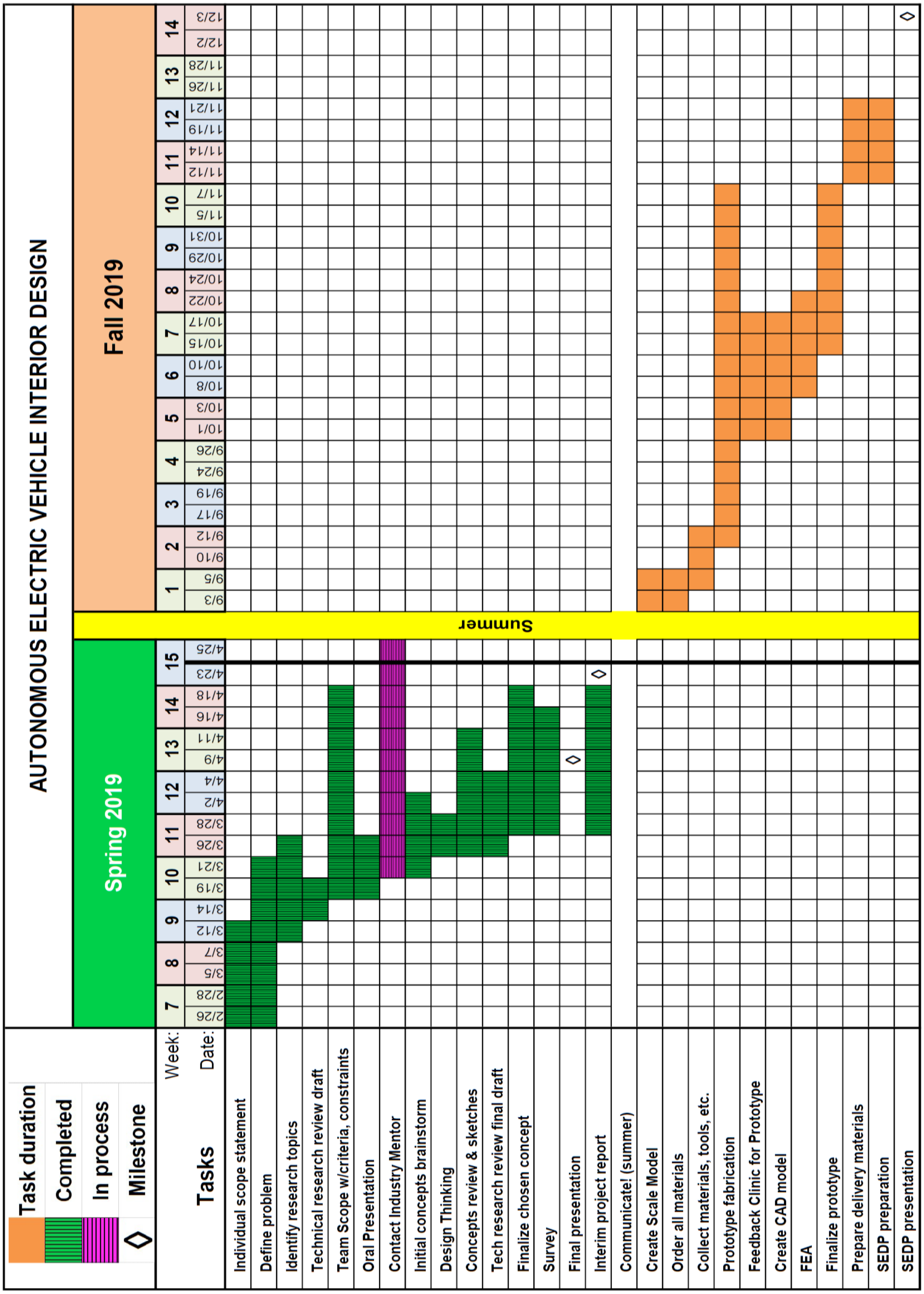
This technical research establishes an understanding of autonomous vehicle interiors by examining topics including: history of the autonomous vehicle; development of information systems in vehicles; safety standards and laws; interior designs of the past, present, and future; and concept designs and their costs. It also explores past, present, and future designs that people have considered. By investigating all of the above topics, the team is more likely to produce a comprehensive and imaginative design.

Section 2: Methodology / Project plan

Every project begins with the identification of the needs of the customers. Therefore, our design project also starts with conducting a market survey and research on the functional requirements of the interior of self-driving cars. This will be done meet the ergonomic requirements of each person occupying the seat in the car. This will result into finding the problems or challenges faced by passengers or their demands about the kind of interior they want.

Next, preliminary design of the interior seats and accessories for the passengers in 2D concept sketches will be created. Ergonomics concepts will reflect the space needs for every occupant of the car. The following step will be the generation of 3D models of the concept AV interior on standard design software, such as Rhino3D or other design/computer aided design (CAD) software. Structural analysis of any applicable interior components will be considered. Thereafter, the team will work on the development of a physical full-size prototype of the interior space made from foam core, cardboard and other prototyping materials. The team would like to host a feedback clinic at the college to obtain critiques from students. In the end stage of the project, all the implementation of the design solutions came up with during the project journey will be executed. A full-scale AV interior model with aesthetic design concepts will thereby be the end product of our design project.

Timeline - Gantt chart



Budget

As per the course, the limit for the budget on design project is $1,000. Our team has made estimates based on tools and inputs that will be needed for the creation of the prototype. All the CAD design activities as will be carried out on the university computer systems which are free of charge. However, to approximate our spending, we have kept 10% of this budget limit on printing documents and developing the media. The rest of the cost (90%) is utilized for the development of prototype, which constitutes the major chunk of budget as there will be lots of rework that needs be done to achieve the final stage of prototype.

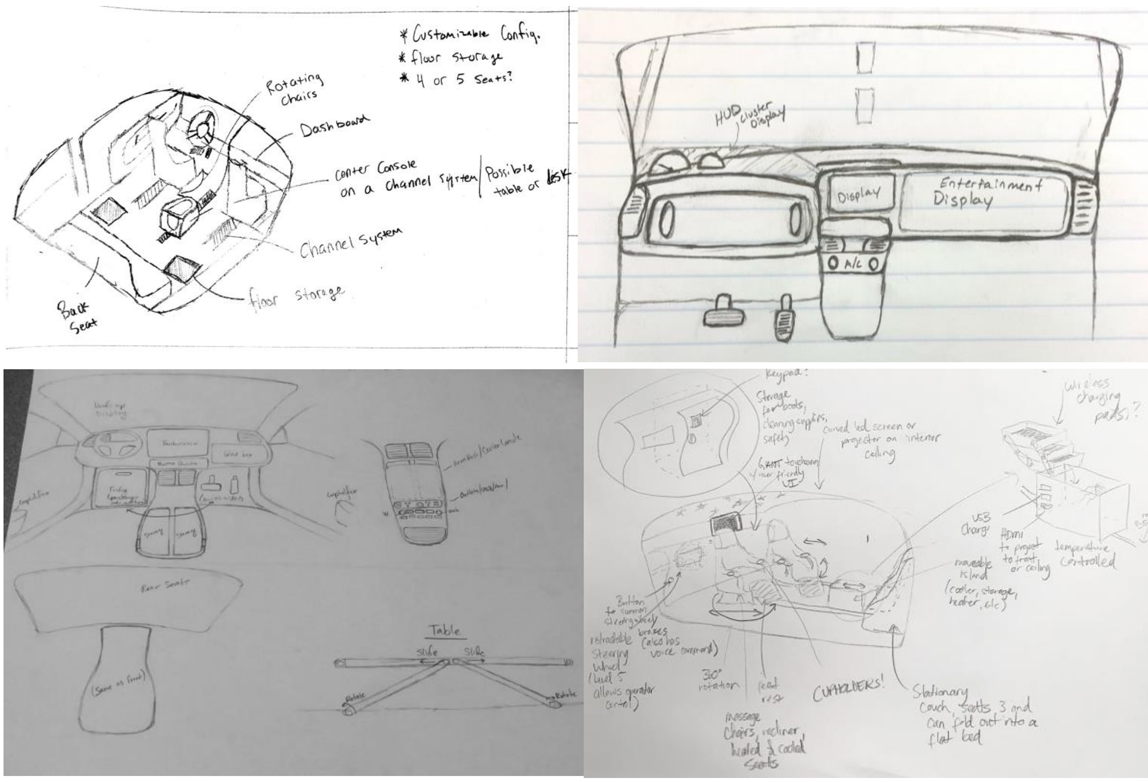
Activity	Cost ($)
Online Surveys	0
Printings, Media creation	100
Purchasing of foam core, cardboard, gluing agents, etc.	850
Total	950

Section 3: Results

The research conducted was taken largely from internet sources. This is because the systems and design aspects considered have not been fully developed, so this is a study of new technologies and how they can be implemented. This research concludes that there were many factors to consider when developing an automotive design. The team investigated safety standards and laws that must be implemented, as well as design considerations for the comfort of the passengers.

Activities to Date

The activities completed are outlined in the current Gantt chart. The team has defined the problem and the approach to take in order to manufacture the final deliverable. After identifying research topics, the information was included into the technical research section. This research covered the implementation of systems for displaying the cars entertainment and status, safety regulations, autonomous integration, current car standards, material selections, and the functionality of design. The team applied this knowledge into the interim oral presentation to demonstrate the need for our project completion. With the guidance of the team’s advisor, Mr. David Middleton, the team participated in the design thinking activity along with the “mailbox team”. This gave much insight into the best practices in design thinking and the creation throughout the design process. This knowledge was incorporated into the preliminary paper designs that the engineering design technology (EDT) majors sketched up. Each EDT team member created their own design concept. The preliminary designs can be seen below.



Each design incorporated and highlighted different design corporations. The next step is to choose one design to focus on and create more sketches that investigate the different styles for the components. The team then developed a survey to distribute and collect results over the summer. This survey includes questions that cover demographics, technology selection, comfort options, and safety opinions. This data will impact our next round of sketches and designs for future models of the interior.

Section 4: Discussion

Throughout this first semester of senior design, our team has been successful in completing all of the tasks required for the beginning of the design process and conducted two oral presentations of our project and findings to date. We have concluded that our design will follow the 4th or 5th level of automation. These being full automation of the vehicle for short and long distance travel, that the driver/passenger can override if necessary. It will have to follow the similar guidelines for safety declared by the National Highway Traffic Safety Administration. The designs will go through a full design thinking process of designing each interior component, keeping safety, comfort, and entertainment in consideration. The team will complete sketches, small scale models, 3D renderings, and then the full scale prototype. Originally the team had difficulty working out the group dynamic, throughout this project the group has strengthened our communication and team skills.

Section 5: Conclusion

Many current vehicle designs still lack proper layout of interactive features. It is important to minimize the amount of time drivers take their eyes off the road, as well as the distance they must shift their vision to interact with buttons/touchscreens. This represents not only a design change, but also an increase in overall safety. Throughout continued research, manufacturer's current and concept vehicles show the potential for a well-rounded design that can fit the wants and needs of current and future customers. Despite the potential high costs of these vehicles, the continued development and popularity will drive down prices over time and be as affordable and modern vehicles. Given the safety regulations, or lack thereof when it comes to autonomous vehicles, there are few additional safety limitations to consider within the design. Differences in seating and whether a steering wheel and gas and brake pedals are included are a couple things to keep in mind when it comes to the overall safety of autonomous vehicles. Lastly, based on the results gathered from the survey, we will incorporate the preferences discovered to suit the future consumers wants and needs.

The implementation of self-driving vehicles would be an overwhelming benefit to society. With driver error almost completely out of the way, safety would already be much higher. Coupled with the network allowing for vehicles to communicate with each other, the number of accidents would greatly decrease. Taxis, ride-sharing services, and overall cost of transportation would also decrease. Introducing autonomous vehicles transforms transportation and travel. It cannot be stressed the number of benefits and how positively these changes can affect the world.

We have remained motivated and passionate about this project from the beginning. Being mostly EDT majors, we have made a concerted effort to continue with our own designs and experiment with various features and how to implement them. Up to this point we're remained on track and completed everything asked of us. We continue to meet our own goals and follow through with the tasks we've set forth for ourselves. Communication and teamwork have continued to grow stronger, and only further strengthen into next semester. Dedication is apparent within us all and we are all looking forward to completing and presenting this project in the Fall.

Section 6: Acknowledgements

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