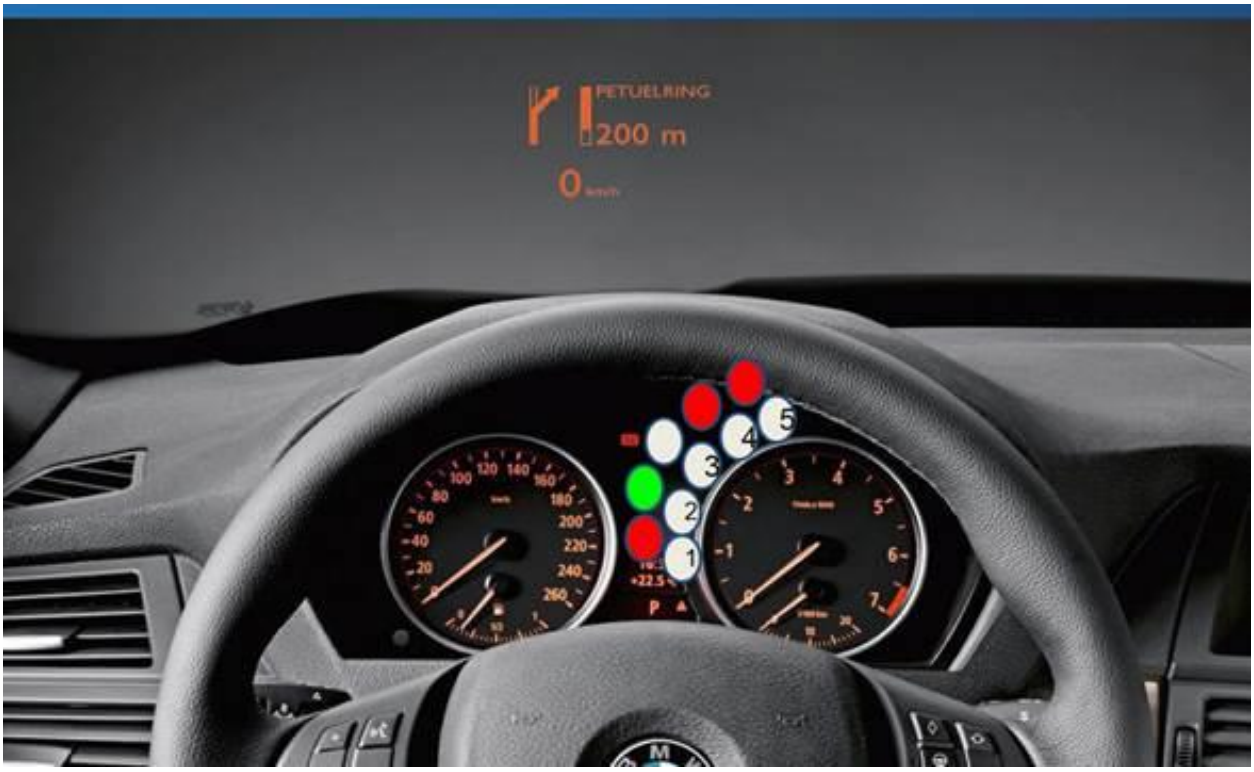
Optimal Shift Zone

Display System



Elias Frantz, Justin Williamson, Taylor Young

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Professor Kisenwether

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Executive Summary:

The goal of the project was to design an innovative technology that makes automobiles safer, greener and more connected as defined by Delphi. Three very distinct ideas were generated that met these requirements. After careful consideration and research as well as the determination of customer needs and wants, a single concept was selected. From here, the group identified six ways to implement this concept. These concepts were scored based on a weighted scale and a final design was chosen, which includes a heads up display that informs the driver of any manual transmission vehicle of the optimal time to shift gears. This will minimize gas consumption, and will help drivers who want to learn or improve stick shift driving.

Introduction & Problem Statement:

The overall objective of this project is to generate a design that will increase safety, greenness, and/or connectivity in future automobiles. Delphi defined these "megatrend" concepts as follows:

Green: create a world with zero emissions[1]

Safe: make zero accidents, zero injuries and zero fatalities a reality[1]

Connected: allow seamless connectivity between the vehicle and the driver[1]

The design developed will specifically address problems with safety and greenness concerns. Improving shift timing in manual transmission vehicles will reduce gas consumption and eliminate stalling and jerking. The final design must solve these issues without degrading from connectivity.

Research:

Unfortunately, cars with manual transmissions are not as prominent in the market as they have been in the past due to the widespread use of cars with automatic transmissions. Many people falsely believe that driving cars with manual transmission is too much of a hassle and think that they are poor substitutes for new models with automatic transmissions. In fact, cars with manual transmissions have a 15% better fuel economy on average and are projected to increase gas mileage from 3 to 4 mpg[2]. They are also between $ 800 and $1,200 cheaper than automatic transmission cars[3].

Manual transmission vehicles do have certain downfalls. It is common for new drivers to attempt to downshift to break, or shift at the wrong times which causes the car to jerk or stall. Even experienced drivers can face these dilemmas. Providing easy-to-use technology to assist stick-shift drivers can meet both the green and safe design goals from Delphi.

Calculations:

Cost Calculations:

A. Total up all the retail costs of devices that are part of your Delphi Project design. Divide by 2.34 to get an estimate of the cost to manufacture these parts, and a better estimate of the price Delphi can acquire for the parts at high volume.

$148.00 for advanced heads-up display /2.34 (cost to distribute) = $63.25/HUD

B. The NRE cost that is added onto each new Delphi product is $328,000 / 20,000 = $16.40

NRE cost (given) = $16.40/HUD

C. The Assembly and QA labor is given by $25/hour (loaded) x.25 hr = $6.25

Assembly/labor cost (given) = $6.25/HUD

D. Total cost Delphi will charge the car manufacturer per accessory = (A + B + C) x 2 = OEM cost

(A+B+C) = Manufacturing Cost = 85.90

(A+B+C) x 2 = OEM Cost = $171.80/HUD

E. Total cost Car manufacturer will charge the car buyer = 3 x OEM cost = Accessory Cost.

(The multiplier of 3 includes profit, liability insurance, marketing, etc.)

OEM Cost x 3 = Accessory Cost = ***$515.40/HUD***

Customer Needs:

The most important needs of customers were identified and defined according to Delphi, members of the team and the customers themselves. *Table 1* provides these target design features. These needs were used to create a weighted scale, using the analytic hierarchy process illustrated in *table 2.* It is based on their relative importance in reference to the optimal shift zone concept that was selected. This weighted system allowed a variety of designs to be developed as illustrated in the next section of this report.

Table 1: List of the customer needs and their definitions

Customer Needs:	Design Specifications:
Safe	As defined in introduction
Green	As defined in introduction
Connected	As defined in introduction
Ease of Use	instructions must be clear, drivers should be able to use it fairly instinctually
Cost	future savings associated with design must be greater than the cost of the purchase itself
Ease of Manufacture	product should fit with existing technologies as to be added easily to current designs

Table 2: Creation of a logical weight system based on which needs are most important.

	Safe	Green	Connected	Cost Efficient	Ease of Use	Ease of Manufacture	Total	Fraction
Safe	1	2	2	4	1.1	5	15.1	0.333
Green	0.5	1	1.5	1.25	0.9	3	8.15	0.179
Connected	0.5	0.66	1	1	0.9	1	5.06	0.112
Cost Efficient	0.25	0.8	1	1	1	1	5.05	0.111
Ease of Use	0.91	1.1	1.1	1	1	3	8.11	0.179
Ease of Manufacture	0.2	0.33	1	1	0.33	1	3.86	0.085
						Grand Total	45.33	

According to the results demonstrated on *table 2,* safety is the most important by far. It is almost 60% more important than the next two most important features, green and ease of use. The least important feature is ease of manufacture. The relative importance of each feature helped the team generate and select the best concept and to finalize a design.

Concept Generation:

Early in the project, three original concepts were created. The concepts included a solar panel battery door, an under-the-car airbag braking system, and the optimal shift zone display system. The design options were into a survey in which more than fifty people voted on concepts they thought they would want to have in car. From our survey data, the under-car-airbag braking system was the most wanted item[4]. This feature would allow the car to recognize when a crash is imminent and deploy the airbags positioned under the vehicle.

After some thought, the under car airbag system was not selected. The system was very unsafe despite the fact that the original intention was to be a crash prevention system. The

system's objective was to create a high level of friction between the bags and the road which would rapidly slow the car down and lessen the impact or avoid it all together .Sensors would be installed on the car to detect when a crash was imminent; however, any sort of malfunction would be dangerous. For example, if a car were traveling too closely and the sensors detected this as an imminent crash, the airbag would go off causing a rear-end collision. As a whole, any glitch in the under-the-car airbag system would be a huge liability to Delphi.

After consideration, the solar panel battery door system was also not selected, even though it was voted as the second most popular choice from the survey results. Solar panel cars became a potential alternative for petroleum cars. In most electric cars, the battery is located under the car. The battery, connected to the solar panel, would have been placed directly in the door. Like the under-the-car airbag system, this concept simply had too many safety hazards. If the car were hit on the side, and there was a significant amount of damage to the vehicle, people in the car may come into contact with the battery acid. Hence, for these reasons, the solar panel battery door design concept was discontinued.

The optimum shift zone was the concept selected. Based on the weighted AHP matrix results, safety was the biggest concern. This concept met all safety concerns as there were few potential hazards associated with the system's failure. If the design did fail, the driver simply would be forced to drive a manual transmission without the aid and convenience of the optimal shifting guidance. It was also the most applicable for several markets. Optimal shift zone guidance has applications in the lightweight trucking industry as well as the consumer industry for inexperienced manual transmission drivers.

Concept Selection:

The team defined six unique ways to convey shifting information to the driver, as seen in *table 3*. The weighted scaling system allowed the team to determine the most viable option for the consumer and for Delphi. *Table 4* shows the scoring once the weights shown in *table 3* have been applied.

Table 3: Illustration of the design selection matrix without the application of weights.

	single light system	dual light system	light & sound	dual light and dual sound	HUD	vibration in stick	weight
safe	1	1.5	2	2.5	4	4	0.333
green	4	4	4	4	4	4	0.179
connected	1	1.5	1.5	2	5	5	0.112
cost efficient	5	5	5	5	3	2	0.111
ease of use	2	2.5	2.75	3	5	3	0.178
ease of manufacture	5	4.75	4.75	4.5	2	3	0.085

Table 4: Illustration of the design selection matrix according to the weighted scale determined by customer needs

	single light system	dual light system	light & sound	dual light and dual sound	HUD	vibration in stick
Safe						
Green	0.333	0.499	0.666	0.833	1.332	1.332
Connected	0.719	0.719	0.719	0.719	0.719	0.719
Cost Efficient	0.112	0.167	0.167	0.223	0.558	0.558
Ease of Use	0.557	0.557	0.557	0.557	0.334	0.223
Ease of Manufacture	0.358	0.448	0.492	0.537	0.895	0.537
Sum	0.426	0.404	0.404	0.383	0.170	0.255

	2.505	2.795	3.006	3.252	4.009	3.625

The heads up display design was chosen because it was the clear winner in the concept selection matrix. Above in *table 4* are several systems designs that were developed (seen in the first row). The requirements/needs are seen in the first column. Each design was rated from one to five per design requirement. Then the weighted factors for each design requirement from table 1 were multiplied across the rows. For example: safety had a multiplying factor of 0.33, so all the safety values assigned one through five are multiplied by 0.33. The numbers left in the matrix are the weighted values. These weighted values are then added together. The sum row shows the sum of the weighted values. These weighted values are compared and the highest value wins.

Final Description:

The optimal shift zone heads-up display (HUD) is a not too difficult to install. Once the HUD is fitted in a car (could be sold on site, or aftermarket), all that needs to be adjusted is programming for the HUD. This programming will involve sensors and computers (already in the car) which will detect when the driver should shift. Once the reprograming is complete, then the small indicator lights will shine when it is time to shift up or down. (See the pictures below) This relatively simple design, if used correctly, will save energy, and will also be safer to the drivers, and others on the road. *Note - This design may only be used for vehicles with a manual transmission. *Figures 1, 2 and 3* illustrate exactly how the optimal shift zone display system will look and work.

Figure 1: Color Indicators

The color indicates whether it is necessary to shift up, shift down or stay in the current gear.

F*igure 1* illustrates the possible colors. Red indicates the gear that should not be shifted into.

White indicates the gear the driver is in, and green indicates a safe gear to shift into.

Figure 2 & 3: Heads up Display Placement

There are two different placement or display options. One is an aftermarket option, and the other is a built in option. *Figure 2* shows the product as an aftermarket product that would plug into the on board diagnostic port of the car. It would connect to the vehicle's computer to gather the proper information, compute and display when to shift on a separate screen above the heads up display. *Figure 3* shows the product as a built in accessory. As presented, it would go above the RPM tachometer and would display the proper shifting information.

Systems Diagram:

Figure 4: Systems Diagram

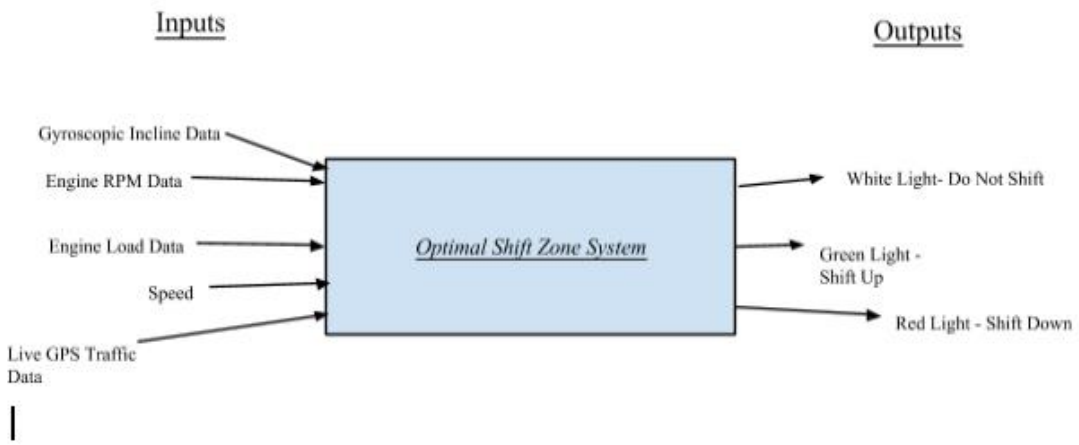

Figure 4 illustrates the systems diagram. The system requires all the data on the input side of the systems diagram to correctly calculate when to shift. Gyroscopic incline data was included in the input because driving on a hill influences shifting. This along with the other inputs allow the optimal shift zone display to determine when to shift. The lights, in this systems diagram, are the outputs that illustrate that information to the driver.

Scenarios:

If a vehicle had optimal shift zone technology it would save the owner money. Most cars on the road now are automatic cars, and manual cars are being phased out. The only available manual cars now are, more often than not, the baseline models. Tractor trailers and small shipping trucks still use manual transmission as well. If these drivers have little experience with manual transmission, they may not know the proper time to shift. Shifting at the optimal time can save up to 9 percent on average gas mileage, thus saving the owner money. (4) The optimal shift zone's job was designed to correct that.

The optimal shift zone display system lights up to tell the driver when to shift. If the driver is coming down a hill and there is a stop sign ahead, the display system will indicate when to shift down on the heads up display. It will also notify when to shift up and when not to shift at all. A green light on a specific gear indicates that the driver should shift into that gear. When the diver has shifted into that gear the light will turn to a white light which indicates the current gear and that he should not shift unless there is another green light which indicates another shift. The red light indicates a gear that the driver should not shift into. A driver should not shift into a gear with a red light because it would either put too much load on the engine or not enough. This could respectively lead to a blown engine,a stall or transmission trouble.

Below is a descriptive scenario of what exactly a driver would see and how they would react with system:

A UPS driver with a manual truck starts the vehicle. The system starts up with the vehicle. The lights flash three times to indicate that the system is functional and that it has located itself on a global positioning system (GPS). The driver then proceeds on his drop off route. When the driver comes to a stop sign the vehicle indicates when to shift down. Once the vehicle comes to

stop it will notify the driver to shift up. When the vehicle proceeds from the stop, the shift zone system will indicate to the driver when to shift up by lighting up a green light on the second gear or the gear the driver should shift into. Once the driver has completed the shift, the green light will turn white to indicate the gear the driver is currently in, second gear. Once the trucks engine's RPMs reeve to a certain level the system will turn the third gear light green. Then again, once the driver shifts into third gear, the third gear light will turn white. All the other gears will remain a red to inform the driver that they should not shift into these gears.

At the end of any time period, the UPS Company can check the driving statistics from the GPS of that particular driver or truck to diagnose if the driver is the problem of fuel consumption or if the truck is to be blamed. It could also sense if the shifts are smooth. An unsmooth shift could potentially damage fragile cargo. For a company such as UPS, this is very important knowledge and would allow the company to keep better tabs on their products, equipment and employees.

Total Cost Analysis:

(See cost calculations)

HUD Cost: The cost of $148.00 was obtained by researching prices of HUD systems. This particular HUD system was one of the most advanced, so this should be the highest price the optimal shift zone would ever be. 148.00/2.34 = Base price = $63.25

NRE Cost: The Non-recurring engineering cost describes the onetime costs that happen for a new design. This includes the labor cost for researching engineers, their benefits, and the change of arrangement of machines and new capital in manufacturing line.

Labor Cost (manufacturing): One can assume the labor cost is $25.00 per hour. One can also assume that it will take ¼ of an hour to manufacture a HUD system. Therefore, the labor cost is $6.25.

Manufacturing Cost: Manufacturing cost is given by adding the base price of the HUD, the NRE cost, and the Labor Cost. 63.25+6.25+16.40 = $85.90

OEM Cost: The original equipment manufacturer cost explains how the price is marked up from a distributor to a retail business. The retail business generally buys in large amounts, resulting in a price double the manufacturing cost. (85.90 x 2) = $171.80

Accessory Cost: The accessory cost describes the markup when going from a retail business to a consumer. This markup is generally higher than the OEM price mark up because a consumer does not buy in great amounts. This generally multiplies the OEM cost by a factor of three. 171.80 x 3 = $515.40

Life Cycle Analysis:

The setup process for designing this feature may harm the environment, but in the long run, it will save natural resources, as well as cut back on pollution. The only use of energy in the setup for this device would be the rearrangement of machines in the manufacturing plant. These machines would likely need to be rearranged, and new machines would need to be developed and brought in so the HUD could be incorporated. It is likely that other construction equipment would be used to move these machines, all which use energy. Once this system is implemented, the results will greatly overcome this cost. First, the optimal shift zone would help a driver greatly cut back on energy, thus saving the driver/company money, conserving natural resources, and cutting back on pollution. In addition to this, driving a vehicle with a manual transmission would be safer, resulting in fewer crashes and fewer leftover remains of totaled cars in junkyards. Overall, the positive impacts of the optimal shift zone HUD system greatly outweigh the negative costs.

Conclusions:

Overall, there was a huge amount to learn from this project. The main concept learned is how complicated some of these processes can be. Our final design that was chosen would only be the initial idea in a real company and would be followed by many more. The selection process is complex and would take much more time than given. If there more time was allotted, the design process would be refined and advanced so every detail was perfect. Fail safes would need to be implemented, as well as maintenance and durability assurance. New ideas would also have to be considered throughout this process, and big parts of the project may be changed. The current design process gave the ability to develop an early stage design, without going into every potential scenario and without making sure the product works correctly.

Appendices:

Survey Questions and Results (45 responses):

1. What is your gender?

Female: 66.67%
Male: 33.33%

2. What is your age?

18-24: 26.67%
25-34: 8.89%
35-44: 15.56%
45-54: 35.56%
55-64: 8.89%
65-74: 4.44%

3. How many years of driving experience do you have?

Less than 3: 15.91%
3-5: 9.09%
10-15: 9.09%
15+: 65.91%

4. Have you owned a car?

Yes, currently: 88.89%
Yes, in the past: 6.67%
No, but I plan to in the future: 4.44%

5. Give details about your accident history.
(See link)

6. Which concept do you like best?
Solar Panel Battery Door: 34.21%
Under-the-Car Airbags: 52.63%
Optimal Shift Zone: 13.56%

7. Does your choice fit with our goals?
Safe: 65.79%
Green: 31.58%
Connected 23.68%

8. Would you be willing to spend more on a car with this feature?
Yes: 71.05%
No: 28.95%

9. Do you have any suggestions for improving our concept designs? Please indicate which one(s) you want to improve and how.
(See link)

10. In general, what changes in the automobile industry would you like to see in the next 10-15 years? Your answer may or may not be related to our current concepts.
(See link)

**Results based on online survey[5]

References:

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[3] "Manual vs. Automatic Transmission." *Manual vs. Automatic Transmission | Stick-Shifts Save Gas - Consumer Reports*. Consumer Reports, Oct. 2014. Web. 09 Dec. 2014. <http://consumerreports.org/cro/2012/01/save-gas-and-money-with-a-manual-transmission/index.htm>.

[4]Cohen, Zolton. "How to Drive Economically" 16 May 2006. HowStuffWorks.com. <http://money.howstuffworks.com/personal-finance/budgeting/how-to-drive-economically.htm> 14 December 2014.

[5] Young, Taylor, Justin Williamson, and Elias Frantz. "Delphi Project." Survey Monkey, 9 Nov. 2014. Web. 10 Dec. 2014. <https://www.surveymonkey.com/results/SM-Z7KRF9SV/>.