SYST 542: Decision Support System Engineering

Vehicle Recommendation System

Project Progress Report

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Problem Statement:

The surge of science and technology has given the ability for companies to create a different types of car purchasing service. In order to make sure our Decision Support System is up to par and also competitive within the realm of helping end users find the right vehicle, we want to make sure our decision support system will be able to capture the most important criteria when searching and purchasing a car.

A working professional fresh out of college may want a completely different vehicle compared to a family of four that just welcomed a new-born on this beautiful planet. Thus, the benefit of using our car recommendation system, or our DSS, it will provide our users with a list of vehicles based on their inputs on budget (economy), reliability, and power (specifications).

1. The Decision Support System Concept:

1.1 Decision Problem:

With the ever increasing cutting edge technology in today's world, it is expected for one to be able to leverage technology and decision support systems to maximize value against their respective objectives. Every year, new car models are designed, manufactured, tested, and pushed into production for individuals, families, companies, etc. to purchase vehicles that best suits their everyday needs. While most think this is a relatively simple and hassle free purchase, we understand the importance of implementing a decision support system to maximize our value of the car one would like to purchase. A family of four may need a vehicle that best fit their appetite for fuel efficiency, comfortability, and large storage space whereas a working professional individual may want something more performance based with little storage room to increase their said performance. As vehicle manufacturers produce newer models faster than ever, we as vehicle buyers are faced with the problem of not only which car best fit our agenda, but making sure our hard-earned cash is being used efficiently and effectively leading to maximizing our value of our decision.

1.2 Benefits:

One of the main benefits of using a vehicle recommendation decision support system model is that we're able to input our needs and possibly wants given our constraints (in this case, constraints will mainly be the monetary value of the vehicle). We anticipate the system will not only educate our end users on what they actually need, but also filtering out what they don't need. The second benefit is our end users do not need to understand the back-end computation as everything will be a hosted on a front-end graphic user interface application. This will alleviate non-tech savvy individuals and encourage similar users to go out and do their primary research and to help paved the way to understand the granularity of the process of purchasing a vehicle.

2. User Requirements:

2.1 Stakeholders/ Target User:

Although we do not have very specific target demographics in regards of end users utilizing our tools, we anticipate the list below provides the most value for our end users that will be utilizing our decision support system.

- Families who need to purchase a new/used car due to additions to their family
- Working professional individuals seeking to upgrade from their cars used during high school and/or college
- Corporations/Organizations seeking to purchase cars due to their business model (e.g. Uber, Lyft, Hertz, Enterprise)
- Business owners who needs vehicles explicitly for business purposes
- Individuals seeking to buy cars solely based on their taste

2.2 User Input

- When customers decide to purchase a vehicle, the first factor to consider is budget. In our case, we aim to provide our customers the best purchasing experience and help them minimize cost. Our goal is to maximize customer satisfaction and their hard earned dollars. (ECONOMY)
    - Our graphical user interface/DSS will provide the ability for users to scroll for a min and max range of their dollars at work
- How reliable is the vehicle? (RELIABILITY)
    - Users will probably want a reliable car if they are driving across the United States. How important is this factor? We found that after budget, reliability is the next deciding factor when a customer is searching for a car/vehicle.
- What are the user's specifications? (POWER)
    - The end users/customers are imperative in keeping this model alive and in order to serve them properly, we must be able to extract certain information, such as the car model, type, engine power, interior design, efficiency of the transmission, and new technology

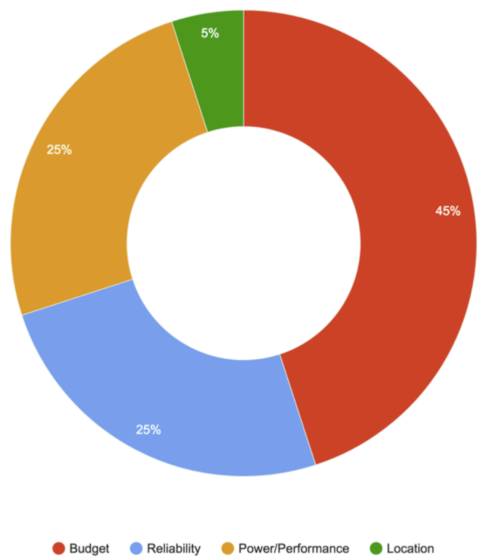

Fig: 1. Pie Chart of Factors for Purchasing a Vehicle

- *Other thoughts our team plans to implement after version 1 of our DSS*

- Where are our users located? (LOCATION)
    - We expect our end users to be located all over the United States, and it is imperative our DSS can provide the ability for an end user to simple enter a zip code and connect them to the nearest dealers and private dealers to make a purchase

- Account creation to provide narrowed search results based on their previous searches (ANALYTICS)
    - In order to stay competitive and provide additional features, we plan to implement analytics on individual users and provide a set of recommendation list once a user creates an account to make their visit worthy
    - As part of analytics, we plan in the future to provide additional features, so as long as users are willing to accept our feature of having dealers contact them directly when we find a suitable match. We believe a threshold match of a greater than 90% will have to meet in order for dealerships and private dealers to contact our customers directly.

3. Project Management Plan (PMP):

3.1 Constraints:

Time:

The development of our decision support system will require approximately two months' time of development, of which 1 week will consist of intense quality assurance and testing from our development team.

Personnel:

Our team will comprise of 4 technical individuals where two of our team members have extensive development skills in VBA Macro, Python, Java and our other two team members having skills in JIRA and testing. Ultimately our team has a various backgrounds.

Scope:

Due to our limited manpower and bandwidth of personnel, our project scope is limited to what our end users initial requirements are. We will, in the future, provide technical support and additional features so as long as the requirements are not only possible, but well worth the opportunity cost of doing so.

Costs:

The project will be utilizing open source and free platforms (Excel, Google sheets)

3.2 Assumptions:

Assumption 1

- Our vehicle recommendation system (DSS) will be created and developed using an Excel model

Assumption 2

- Our DSS will be used to help aid car buyers to purchase the *right* vehicle for their everyday needs and wants given their constraints

Assumption 3

- Our DSS will output a very specific cars based on the our end users inputs of their budget, car type, zip code, and vehicle's specifications

Assumption 4

- Our vehicle recommendation system (DSS) will be created and developed using an Excel model

3.3 Project Scope

Our final working product will be Excel based that will include a user friendly simplistic tool that captures all the necessity of what has been stated in the overview of our decision support model (see User Requirements).

3.4 Project Timeline and Deliverables

Our project timeline will have constant meetings with our stakeholders to redefine current and upcoming requirements for our web based decision support system. We expect to complete all design, development, and testing within two months' time and expect to be on target.

Time Required	**Time taken**
Beta testers- for the tool usage and reporting findings	20 days
Beta test analysis	10 days
Implementations, corrections, and updates	1 month

Fig: 2. Project Timeline and Deliverables

3.5 Accomplishments

The team will complete collecting user requirements from a customized survey of over 3000 individuals ranging from families, working professionals, and corporations. We will have our product up and running after the completion of developing and testing within two months' time and expect to be the one stop shop for all vehicle purchases.

4. Technical Description

4.1 Model Overview

The main aim of our model is to provide the user with car recommendations that best fit their needs and wants when choosing and purchasing a vehicle. Our model will have a GUI on which the user can interact and input various parameters to yield results that are based on their input. A user will be posed with a variety of parameters to determine their preferred specifications (i.e. color, engine, displacement, power and fuel tank capacity etc.), purpose of vehicle purchase (example: utility, loading, cargo flexibility, room for passengers etc.) and other constraints that might limit their choice. The DSS will display a list of cars based on the user's inputs of our four main criteria: budget, car type, location, and car specification.

The system architecture is provided below as figure 4.1. The system architecture is self-explanatory and will be very responsive given the reliability of our servers and IT equipment.

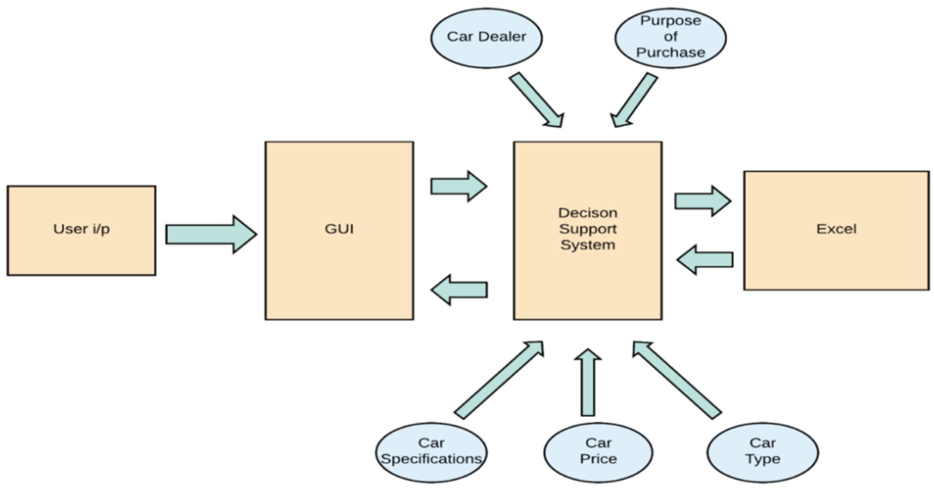

Fig: 3. The System architecture

The Hierarchy diagram is created to have a better understanding of the main goal of the project. This diagram is drawn based the information from fig: 7.3 and from the weights calculated.

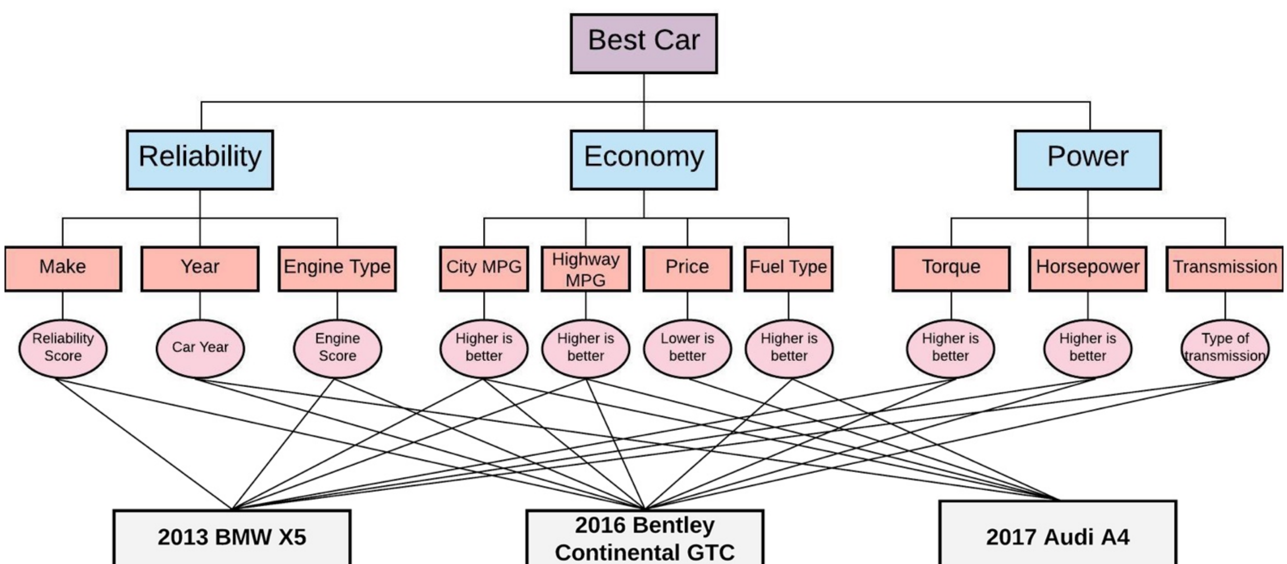

Fig: 4. The Hierarchy Diagram of Choosing Best Vehicle

4.2 Dialogue System

- A Google sheets page with no requirement for user login which can be accessed by anyone on the web
- The main page displays a set of questions regarding the vehicles and their specifications. The user can then select their preferred specs and type of cars.
- Result will show a list of cars based on user preferred selections. In addition to that a recommendations section at the end of page with some other vehicles that are closer to user preferences.

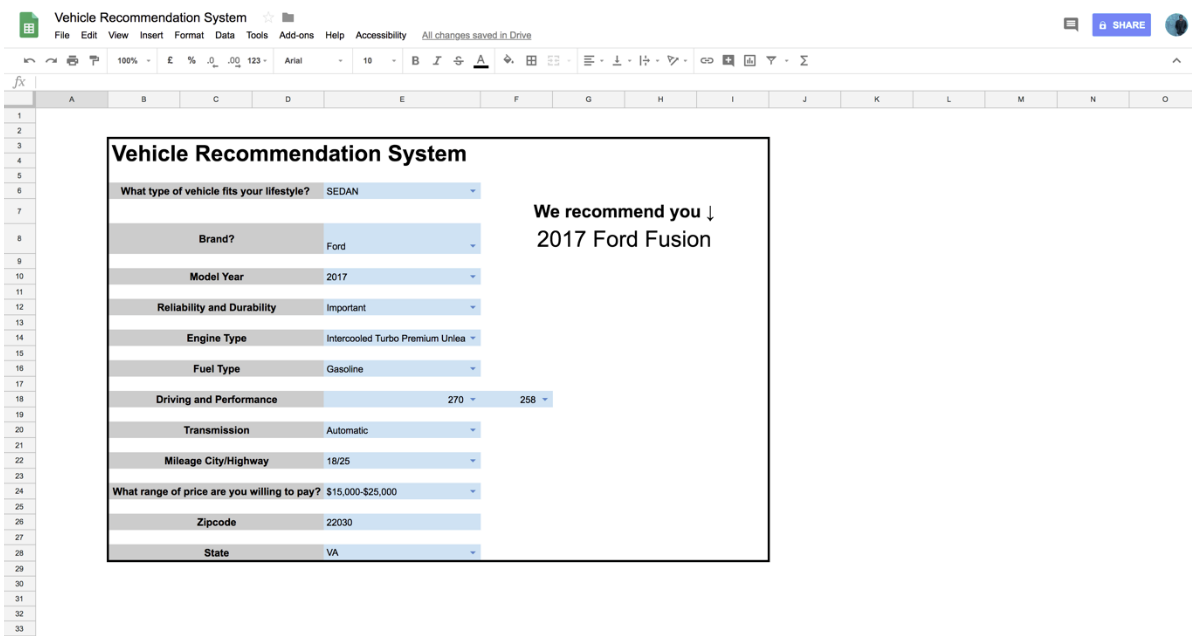

Fig: 5. Screenshot of Google Sheets Prototype

4.3 Data Subsystem/Required Data

- In order to display a set of questions on the user interface, data is required by the data store system i.e, LRS (Learning Record Store). The data is comprised of Car model number, specifications, price, user location and dealer's location.

Reliability			Economy				Power			
Make	Year	Engine Type	City MPG	Highway MPG	Price	Fuel Type	Torque	Horsepower	Transmission	Model Year
Audi	2017	Intercooled Turbo Premium Unleaded I-4 2.0 L/121	27	35	$44,350	Gasoline	258	270	Automatic	2017 Audi A4
Acura	2012	Acura 3.5L 6 Cylinder 280 hp 254 ft-lbs	16	21	$12,347	Gasoline	262	280	Automatic	2012 Acura MDX
BMW	2013	BMW 4.4L 8 cylinder 555hp 500 ft-lbs Turbo	16	23	$22,639	Gasoline	500	555	Automatic	2013 BMW X5
Chevrolet	2015	V6 Flex Fuel Vehicle	14	22	$22,295	E85	186	196	Automatic	2015 Impala
Nissan	2010	Nissan 3.7L 6 Cylinder 332 hp 270 ft-lbs	18	25	$14,630	Gasoline	270	332	Automatic	2010 Nissan Roadster
Bentley	2016	4.0 litre twin turbo-charged V8 engine producing 528 PS & 680 Nm of torque	15	25	$129,940	Gasoline	680	581	Semi Automatic	2016 Bentely Continental GTC
Volvo	2010	Volvo 2.5L 5 Cylinder 227 hp 236 ft-lbs Turbo	20	28	$14,456	Gasoline	236	227	Automatic	2010 Volvo C30
Mercedes-Be	2011	Mercedes-Benz 4.6L 8 Cylinder 335hp 339ft-lbs	13	18	$30,987	Gasoline	339	335	Automatic	2011 Mercedes-Benz SL-Class
Dodge	2010	Dodge 4.7L 8 Cylinder 310 hp 330 ft-lbs FFV	9	13	$25,213	E85	330	310	Automatic	2011 Dodge Ram 1500
Audi	2017	intercooled DOHC 24-valve 3.0-liter diesel V-6, 272 hp	21	30	$50,875	Diesel Fuel	249	272	Automatic	2017 Audi Q7
Ford	2011	Ford 2.0L 4 Cylinder 140 hp 136 ft-lbs	25	35	$13,598	Gasoline	93	140	Automatic	2011 Ford Focus Sedan
Honda	2012	Honda 3.5L 6 Cylinder 250 hp 253 ft-lbs	17	23	$10,134	Gasoline	240	250	Automatic	2012 Honda Pilot
Volkswagen	2016	Volkswagen 3.0L 225 hp 406 ft-lbs Diesel	20	28	$29,354	Diesel Fuel	210	225	Automatic	2016 Volkswagen Toureg
Toyota	2016	Regular Unleaded I-4 2.5 L/152	25	35	$19,208	Gasoline	170	178	Automatic	2016 Toyota Camary

Fig: 6. Screenshot of 15 cars with Selected from Dataset

- The data collected is acquired from many sources, where the collection of data is done manually through surveys from official websites of popular car companies and dealers.
- Some of the individual specifications like comfort of the vehicle, technology availability, car performance level can be determined from the answers provided by the other users in the feedback of a specific vehicle website.
- The dataset we are using is acquired from UCI Machine Learning Repository and Data.gov

4.4 Back-end Computation

- **A list of evaluation criteria**
  For taking any decisions regarding the vehicle recommendation, we are considering 3 important factors. The factors are Reliability, Economy and Power/Performance. Considering the users of all types and their most influential factors to buy a car importance to each attribute is assigned.

Mesurements	Attributes	Importance
Reliability	Make	3
	Year	5
	Engine Type	7
Economy	City MPG	6
	Highway MPG	5
	Price	9
	Fuel Type	4
Power	Torque	4
	Horsepower	7
	Transmission	3

Fig: 7.1. Importance of Reliability, Economy and Power

- **Calculating the weights based on the scores**
  The weights for each attributes is calculated using Rank Reciprocal Method.

	Reliability			Economy				Power		
	Make	Year	Engine Type	City MPG	Highway MPG	Price	Fuel Type	Torque	Horsepower	Transmission
Score	3	5	7	6	5	9	4	4	7	3
	0.375			0.400				0.225		
Smarter	0.111	0.278	0.611	0.270	0.146	0.521	0.063	0.278	0.611	0.111
Rank Reciprocal	0.182	0.273	0.545	0.240	0.16	0.48	0.12	0.273	0.545	0.182
Rank Sum	0.167	0.333	0.5	0.3	0.2	0.4	0.1	0.333	0.5	0.167
Average of Score	0.2	0.3333333	0.4666667	0.25	0.217391304	0.3913043	0.173913	0.2857143	0.5	0.214285714

Fig: 7.2. The final weights each attribute

  The reliability scores of all these brands are given by the average of many consumer reports. This website ranks the most reliable cars based on the number of problems occurred on an average per year. [1]

- **Quantitative value function**
  The data from the sources or the websites are not in numeric form i.e, make, engine type, fuel type and transmission. For the sake of calculating the data more easily,

everything is converted to numeric form. The scores for engine type are calculated using horsepower and referring from Wards Auto website.

The attributes and their scores are calculated by single dimensional linear value function

X=(X-Xworst)/(Xbest- Xworst)

Reliability			Economy				Power			
Make	Year	Engine Type	City MPG	Highway MPG	Price	Fuel Type	Torque	Horsepower	Transmission	Model Year
6	2017	3	27	35	44,350	5	258	270	1	2017 Audi A4
2	2012	4	16	21	12,347	5	262	280	1	2012 Acura MDX
9	2013	8	16	23	22,639	5	500	555	1	2013 BMW X5
10	2015	7	14	22	22,295	3	186	196	1	2015 Impala
8	2010	5	18	25	14,630	5	270	332	1	2010 Nissan Roadster
10	2016	9	15	25	129940	5	680	581	2	2016 Bentely Continental GTC
2	2010	2	20	28	$14,456	5	236	227	1	2010 Volvo C30
5	2011	6	13	18	$30,987	5	339	335	1	2011 Mercedes-Benz SL-Class
1	2010	5	9	13	$25,213	3	330	310	1	2011 Dodge Ram 1500
6	2017	4	21	30	$50,875	4	249	272	1	2017 Audi Q7
4	2011	1	25	35	$13,598	5	93	140	1	2011 Ford Focus Sedan
7	2012	3	17	23	$10,134	5	240	250	1	2012 Honda Pilot
3	2016	2	20	28	$29,354	4	210	225	1	2016 Volkswagen Toureg
9	2016	2	25	35	$19,208	5	170	178	1	2016 Toyota Camary
		1								
H scale by luxury company (1-5)	H	H scale (1-9)	H	H	L	H	H	H	H	

Make	Year	Engine Type	City MPG	Hghway MPG	Price	Fuel Type	Torque	Horsepower	Transmission	Model Year
0.555555556	1	0.25	1	1	0.71440495	1	0.28109029	0.29478458	0	2017 Audi A4
0.111111111	0.285714286	0.375	0.388888889	0.363636364	0.98152847	1	0.2879046	0.317460317	0	2012 Acura MDX
0.888888889	0.428571429	0.875	0.388888889	0.454545455	0.89562292	1	0.69335605	0.941043084	0	2013 BMW X5
1	0.714285714	0.75	0.277777778	0.409090909	0.89849423	0	0.15843271	0.126984127	0	2015 Impala
0.777777778	0	0.5	0.5	0.545454545	0.96247266	1	0.30153322	0.43537415	0	2010 Nissan Roadster
1	0.857142857	1	0.333333333	0.545454545	0	1	1	1	1	2016 Bentely Continental GTC
0.111111111	0	0.125	0.611111111	0.681818182	0.96392501	1	0.24361158	0.197278912	0	2010 Volvo C30
0.444444444	0.142857143	0.625	0.222222222	0.227272727	0.82594361	1	0.41908007	0.442176871	0	2011 Mercedes-Benz SL-Class
0	0	0.5	0	0	0.87413819	0	0.40374787	0.385487528	0	2011 Dodge Ram 1500
0.555555556	1	0.375	0.666666667	0.772727273	0.65994191	0.5	0.26575809	0.299319728	0	2017 Audi Q7
0.333333333	0.142857143	0	0.888888889	1	0.97108659	1	0	0	0	2011 Ford Focus Sedan
0.666666667	0.285714286	0.25	0.444444444	0.454545455	1	1	0.25042589	0.249433107	0	2012 Honda Pilot
0.222222222	0.857142857	0.125	0.611111111	0.681818182	0.83957398	0.5	0.19931857	0.192743764	0	2016 Volkswagen Toureg
0.888888889	0.857142857	0.125	0.888888889	1	0.92426089	1	0.13117547	0.0861678	0	2016 Toyota Camary
0.0566	0.094333333	0.132066667	0.12231	0.0660474	0.23593735	0.028539	0.087912	0.132	0.044088	

Fig: 7.3. Table 1: Table of data after transformations; Table 2: Value score of attributes

- **Utility of Alternatives**
  From the weights table in fig. and value score of attributes in fig. the utility of each alternative is calculated.

Audi	2017 Audi A4	0.60786843
Acura	2012 Acura MD	0.481681763
BMW	2013 BMW X5	0.708906464
Chevrolet	2015 Impala	0.526703732
Nissan	2010 Nissan Ro	0.546836435
Bentely	2016 Bentely C	0.638858664
Volvo	2010 Volvo C3	0.44599665
Mercedes-Benz	2011 Mercede	0.481983645
Dodge	2011 Dodge Ra	0.358653817
Audi	2017 Audi Q7	0.540727378
Ford	2011 Ford Focu	0.464764853
Honda	2012 Honda Pil	0.501500887
Volkswagen	2016 Volkswag	0.485041602
Toyota	2016 Toyota Ca	0.591956699

Fig: 7.4. The utility and rankings of 15 cars is calculated

5. Implementation Plan:

5.1 Prototype Implementation

- Implementation of our prototype is simple, because we are going to be working exclusively with an Excel model. The prototype will have an interactive user interface and an excel model using a database comprising all the principle factors needed for an algorithm which will output the users' best next vehicle purchase given the parameters inputted.
- After creating and deploying a web page, feedback of the website can be obtained from the people who accessed it. A set of 1-3 questions with a rating based input can be implemented at the end of the page to every user who accesses the website.

5.2 Approach

Based on the implemented model of our prototype, the approach will be agile development process in our system applied to the website for user to optimize their decision. Our 4 man team will be split into 2 teams, where two will work the front end and two will work the back-end. The back-end administration is crucial as this will be the heavy database work. We will make sure that our database will properly and accurately import data from our various data sources as we will be using that to narrow and yield the best results for our end users utilizing our DSS.

System testing will be required, like any software and/or DSS, and will be one of our main important components before releasing into production. We will release a prototype/beta version in order to re-evaluate and identify errors and issues from our selected end users.

Furthermore, we always put customers first and care about privacy and security of users. Our technical support team is available 24 hours a day, 7 days a week to help customers whenever they need it.

6. Evaluation Plan:

6.1 Introduction:

The evaluation plan is mainly generated to satisfy the needs of the customers and make their investment worthy. This is a crucial plan in regards of critically examining our DSS/model. This plan consists of the management procedures and describes the functionality of our program and what needs to be done in order to enhance and make our DSS better in comparison of our competitors.

6.2 Purpose:

The purpose of our evaluation plan will allow our end users/customers to be able to find and purchase vehicles based on our parameters and their specifications. The DSS will provide recommendations and provide the best results based on the users' needs. The ultimate plan will outline how we are to evaluate and as to who, what, how and why we are evaluating the decision support system.

6.3 Target Users:

The evaluation plan will concentrate predominantly on the system developers, project management team, and the prototype/beta testing team.

6.4 Sample Size:

The beta test user groups consists of at least 3,000 total users. The user groups are generally divided into two with 1,500 users in each of the groups. There will be a statistical formula that calculates the margin of error in statistical analysis. Based on this formula decisions are made for using large sample sizes.

6.5 Limitations:

The evaluation plan can turn out to be impractical few times. In such case the expectations from the beta test results might be unrealistic which reduces the system scope. The generation of the beta test results will take large amount of time for the information collection and analysis. This is all required to compile the end-of-test surveys. Each of these surveys can provide more information in order to identify the major issues and shifting our focus and prioritizing on the more important aspect, per the surveys.

6.6 Logistics:

- **Configuration Manager:**
  - Process, modifications, coding and requirements gathering management
- **System Engineer:**
  - System design, requirements evoking, development, system test evaluation and analysis.
- **Project Manager:**
  - Design, implement, and manage project plan
- **System Developer:**
  - Unit testing
- **Beta Test Users:**
  - Testing and reporting of the system for evaluation

6.7 Timeline: The Gantt chart below shows the different phases of the project and the deliverable dates.

Project Timeline

VEHICLE RECOMMENDATION SYSTEM					
Task No.	**Task Title**	**Start Date**	**End Date**	**Duration**	**Timeline**
1	**Project Concept and Requirements**	**2/19/18**	**3/13/18**	**20**	
1.1	Decision Problem	2/19/18	2/22/18	3	
1.2	Benefits	2/23/18	2/25/18	2	
1.3	Research	2/26/18	3/7/18	11	
1.4	Analysis of the Requirements	3/8/18	3/11/18	3	
1.5	Project Initiation	3/12/18	3/13/18	1	
2	**Project Management Plan**	**3/14/18**	**3/26/18**	**9**	
2.1	Project Scope	3/14/18	3/16/18	2	
2.2	Deliverables	3/17/18	3/20/18	3	
2.4	Risk Management	3/22/18	3/26/18	4	
3	**Project Technical Specifications and Implementation**	**3/26/18**	**4/19/18**	**20**	
3.1	Process Model	3/26/18	4/5/18	9	
3.2	Interface Creation	4/6/18	4/11/18	5	
3.3	Database models	4/12/18	4/15/18	3	
3.4	Prototype Implementation	4/16/18	4/19/18	3	
4	**Project Evaluation Plan**	**4/20/18**	**4/25/18**	**4**	
4.1	Project Objective	4/20/18	4/21/18	1	
4.2	Sample Size of the database	4/22/18	4/22/18	0	
4.3	Limitations	4/23/18	4/24/18	1	
4.4	Logistics	4/24/18	4/25/18	1	
4.5	Timeline	4/25/18	4/26/18	1	

Fig: 8. Gantt Chart of Project Timeline

7. Conclusion

7.1 Summary

Selecting and purchasing a vehicle/car is a simple, yet a very complex decision. Our vehicle recommendation system is an automated system that helps our potential buyers select the right vehicle for them. Our DSS organizes multiple attributes that comes into play when purchasing a vehicle. We have taken our attributes and associated a weight for each one so that our results will yield the best list for our end users and based on their preferences.

Our vehicle recommendation system was designed to meet potential buyers' needs that really has no range due to the unique diverse user base we foresee. A prototype was developed to demonstrate the key functionality of our system. Using Excel, we were able to provide our end users with a list of vehicles that meets their preference based on our data that we have pulled, sourced, cleaned, and housed in to our database.

7.2 Lessons Learned

The major learned lesson is making sure our database is up to date with the most recent data from our data sources. We realized, when we did not update our database on a weekly basis, our data can yield different results and results that can really hinder the integrity of our system

It is imperative data imports are done on a weekly basis to make sure when our end users are using our system, the search results are based on the most up to date data.

7.3 Way Ahead

We plan to add other attributes in the next version of our system. The ones listed in our project includes the location of finding dealerships and private car dealerships, and using predictive analytics to narrow our users search results and provide recommendations before even entering their inputs in our decision support system. There will be many technical advances in many aspects like- safety systems, vehicle connectivity and the most crucial decision system for the self-driving cars. With the increase in the strength of the support system and the databases, there will be scope for concentrating on the smallest details which makes the system even stronger.