Author: Bharani Kumar Depuru
Co-Author: Raghava Ram Tavva, Shirish Kumar Gonala

Title of the Paper: Survival Analysis of Automobiles

Theme: Project Management Leadership > In a Rapidly Changing World

Keywords: Predictive Modeling, Vehicle Breakdown, Internet of Things, Survival Analysis, Automobile

Abstract:

Business Problem Statement:

Goods transportation is the lifeline of automotive sector. Four wheelers used for transportation have the tendency to break-down due to the exceeding loads beyond a threshold, frequent long journeys without breaks, pathetic conditions of the roads, utilization of the vehicle beyond its life, etc. Such breakdowns during the transportation of goods create a dent in the brand image of the company and reduced customer satisfaction levels, among others. Increased avoidable claims are another huge problem for the Insurance firms.

High Level Project Management Plan:

Hybrid Agile Project Management methodology was selected, considering the uncertainties and additional scope, which might creep in continuously throughout the project.

Step one / Sub-Project one: Collecting and Forecasting 196 vehicle components using on-board device (OBD) as well as Telematics Controlling Unit (TCU)

Step two / Sub-Project two: Predicting on which key component of the vehicle will break down during transportation. Also, used survival analysis to effectively determine the number of days the components would work well before leading to failure

Techniques used:

Survival Analysis, Forecasting, Machine Learning (Decision Tree), Internet-of-Things (IOT), Cloud (AWS)

Key Stakeholders Impacted:

Automobile Manufacturers - Building trust for customers who purchase the vehicles, by predicting the vehicle breakdown because of key component failures and sending proactive alerts to get the vehicle maintenance done.

Insurance Firms - Unscheduled breakdown of vehicles will trigger insurance claims thereby eating into the profits of insurance firms. Proactive maintenance based on component breakdown alerts will counter such losses.

Introduction:

This project included multiple sub-projects, each having its own unique risks and challenges. This paper will speak about the innovative techniques used to help the identified senior executives to brainstorm and prioritize the business problems. We will understand about the challenges encountered in the emerging technologies from project management perspective and how to empower people to build robust solution. We will understand about the unique procurement management challenges in dealing with separate stand-alone entities in each sub-project and how we ensured that the overall project management is not impacted and how we had seamless integration among the suppliers. We will understand on how simulation has been used to determine the optimum resources required on the project. In short we will understand about the perfect blend of technology and project management application in solving the business problem like never before.

Main body of the paper:

- <u>Key challenges</u>
    1. Scope Management – Things, which were out-of-scope, soon became in-scope. For example, project scope was for the truck manufacturer to reduce the warranty costs, however, various stakeholders (e.g., Insurance firm) got involved to sponsor the project in lieu of sharing the vehicle breakdown prediction results with them. Initially it was a huge challenge to accommodate the insurance firms' requirements because it was causing a huge scope creep. This forced our thought process to embrace the changes and we started adapting Hybrid Agile methodology instead of a pure traditional waterfall project management methodology. Change requests log was used as a product backlog and prioritization of the changes were done based on NPV (net present value) and CARVER (Criticality, Accessibility, Return, Vulnerability, Effect, Recognizability)

    2. Time Management – Scope creep has extended the timelines by approximately 30%. We then applied SWOT and TOWS analysis to look at how to use the threat and convert it into opportunity. Then we converted the insurance firm, which was threatening our timelines to pay as

on a Time and Material contract basis for the requirements, which will directly benefit them and agreed to have their requirements prioritized by giving way to the OEM (Original Equipment Manufacturer) first. Adding the buffer was a challenge because of uncertainty in sea transportation and delay in custom clearance of 5000 IOT devices. Once again transporting the devices to the appropriate service/installation/assembly centers across 21 cities in India had a lot of uncertainties leading to a huge challenge in assigning the appropriate buffer.

3. Cost Management – The traditional project management forecasting techniques (EAC) gave results, which were far away from reality. The forecasted versus actual values were having a high error rate and hence we resorted to data driven forecasting techniques such as Holt Winters technique. Error rate (Root Mean Square Error) then reduced to approximately 4%, which is very less and hence we were able to effectively take actions with confidence. We have used the results of these forecasted values to add contingency and management reserve effectively with confidence.

4. Quality Management – Given that this is a niche implementation-involving culmination of IOT (Internet of Things), Deep Learning and Predictive Modeling, identifying the quality metrics based on which project success is evaluated was a huge challenge. We had to dig deep into the research articles and we have taken help of subject matter experts (mechanical experts) from developed countries to identify the right metrics.

5. Risk Management – Dealing with emerging technologies puts the project in 'Complex Spectrum' of Stacey Matrix. Risks identified were umpteen in numbers and manually prioritizing the risks was mayhem. Manually applying Probability and Impact was a huge task and hence we resorted to Oracle Crystal Ball for performing Simulation to get Sensitivity Chart to prioritize the risks. This has helped us greatly in planning for management reserve.

6. Human Resource Management – Given the niche technologies, acquiring human resources from advanced technologies to work from the same location was a Herculean task. Co-location being the core of agile methodology, we could not discount this option. We hence tailored this principle of collocation by replacing it with virtual teams who were constantly connected through video-conference. So we had to hire people from other countries, who have already worked on such projects, and whose working times overlap with India time. We also resorted to electronic dashboards for the daily standup meetings.

7. Procurement management – IOT is very new concept in India and we hardly found any vendors who can provide us with the IOT devices meeting our specifications. So we evaluated the proposals based on time-to-ship, import duty clearance time, bulk purchase discount, size of the TCU (Telematics Controlling Unit).
   Also, since we had to install this TCU on 5000 trucks, sending data on hourly basis for 196 components of the trucks over telecom network would mean a lot of data being transmitted, which means a lot of cost. This triggered a lot of negotiations for the special leased lines to transport the data packets for an affordable price.
   Saving such high-volume streaming data on premise would mean a lot of cost and hence used cloud service (pay as you use) and finally Amazon Web Services was selected based on thorough make-or-buy analysis.

8. Stakeholder Management – With introduction of insurance firm as one of the key stakeholder, the interests of multiple parties conflicted often. Using Power-interest grid did not help much because both OEM and Insurance Firm were in the same quadrant. Used product backlog and ordinal scale so that again there is no tie-up between the requirements. Project scope was to implement IOT devices on 5000 trucks, which means we had to install these devices on newly manufactured trucks as well as the newly sold trucks. Synchronizing the installation of devices with the newly sold vehicles service dates was a huge challenge and convincing vehicle owners about the delay in service and educating them about the advantages and getting their buy-in was yet another task.

9. Communication Management – Convincing the customer business representative from OEM and Insurance firm and having them sit along with the team in India throughout the project was a nightmare. We had to apprise them about repercussions if their participation falls down below certain threshold. Despite that there were lapses and we resorted to an escalation management process by raising alarm to appropriate decision makers as and when their involvement fell below a defined threshold.

These were a few important challenges highlighted from the project inception to project closure.

Methodology/process followed:

Currently 5000 buses enabled with automotive telematics devices with data packets sent over to the back end analytics setup

- Document and assess current state telematics and analytics solution
- Identify gaps in current state and define target state technology landscape
- Develop real time prediction and forecasting analytics model of possible 'faults' to reduce breakdown and maintenance time

- Knowing where your vehicles are at all times is important. But knowing how they're performing on the inside and on the road is key. An in-depth look into key performance and safety metrics through intelligent data dashboards can give you all the insight you need

- Knowing your fleet's next service date, maintenance history and costs is important to maintain a healthy, strong and efficient fleet, no matter the season. Maintenance reports provide an itemized view of each vehicle's service need—crucial for planning ahead and a great way to prevent high overhead which can burn right through your budget

Hybrid Project Management Methodology:

We resorted to managing the project using Hybrid Agile methodology and the phases used in the project from technical perspective was based on TOGAF (The Open Group Architecture Framework).

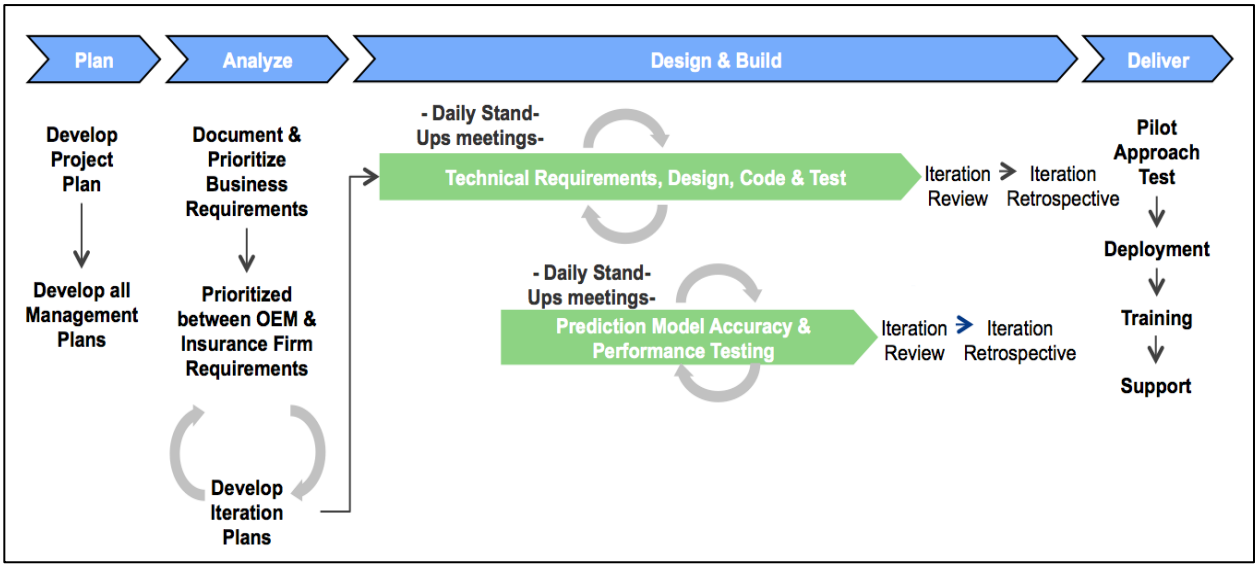

Figure 1: Project Management Methodology

- Got a clear project charter prepared at the very start of the project, which was updated as soon as we onboarded insurance firm

- All the management plans for all knowledge areas, configuration management plan and change management plan were prepared at the very start of the project, which were constantly updated as and how project progressed based on approved change requests
- High level business requirements gathered at the beginning of the project with prioritization and modifications throughout by considering the 2 key stakeholders – OEM and Insurance Firm
- Cross-functional teams were used to pull the top most requirements as part of iteration planning
- During the Execution phase, the technical requirements were worked upon as planned, with the goal to complete the requirements in the fullest (design, code/construct, test). The prediction model has a slightly different approach of technical criteria (compare accuracy)
- Daily standup meeting was done during the overlapping time between India and Germany team members
- Iteration Review was performed with all the stakeholders including the PhD scholars who were during research in the field of IOT
- Iteration Retrospective was performed with the cross functional teams to determine the good, bad and ugly of the iteration process and fix the top issues during the next iteration
- Piloted the solution as opposed to big bang roll out because of the much needed learning curve, given that this is one of its kind innovative solution
- Deployed it in a big way and trained all the stakeholders on the end-to-end usage through multiple forums, workshops, formal trainings and provided complete support (including on-job support for slow learners). Also prepared small CBTs (computer-based training modules) for new joiners
- Most interestingly planned for a periodic up-gradation of the prediction model as and how new engine is rolled out or if new vehicle manufacturing processes are introduced or if new regulatory norm is passed (BS III vehicles prohibited to be sold in India post 1st April 2017)

The 5 Step Approach of the Project:

Based on our experience/market research on similar engagements we proposed a five-step approach to achieve your objective.

	Plan Project Execution	Assess Current State	Define Target State Tech. Landscape	Prepare Roadmap	Develop Analytics Soln.
Input	• Statement of Work • Stakeholder Catalog	• Current state solution arch. • Current state tech. landscape	• High level CSA for Telematics and Analytics Solution • Gap Assessment	• High level target state architecture • Gap Assessment	• High level target state architecture
Activities	• Develop detailed project plan including milestones, key deliverables • Prepare cadence plan • Onboard resources	• Conduct workshop and meetings with key business and IT stakeholders • Document high level current arch. for Telematics and Analytics setup • Identify current business and IT gaps and issues	• Define overall high level target state Technology architecture for telematics & analytics solution • Identify solution building blocks • Identify telematics data packets • Develop conceptual data architecture	• Identify initiatives based on gap assessment and target state arch. • Discuss with key business, IT stakeholders and incumbent vendors to create implementation roadmap	• Based on the historical data, build a prediction model, from the 'data feed' from the telematics platform forecasting survival analysis at regular intervals to study the possibility of breakdown • Implement analytics solution
Outcomes	• Detailed Project Plan	• High level CSA (current state assessment) for Telematics and Analytics Solution • Gap Assessment	• High level target state architecture	• Implementation Roadmap	• Analytics Solution

Figure 2. The 5 Step Approach of the Project

Solution Implementation Steps in a Nutshell:

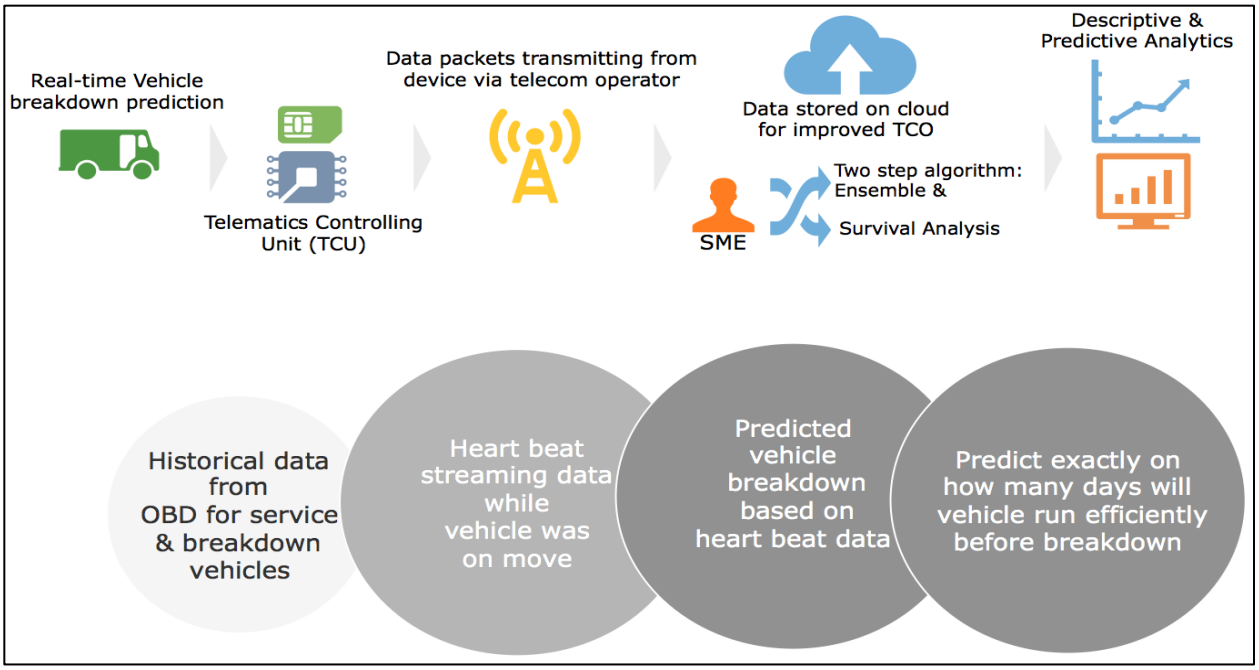

Figure 3: High Level Solution Implementation Snapshot

- 5000 trucks were installed with the TCU devices, which will on a frequency of every hour, capture the health statistics of 196 components of the truck using OBD (On-board diagnostic) devices
- Data generated every hour was transmitted over telecom provider network and it was stored in the cloud environment – AWS (Amazon Web Services)

- Connection was established with the AWS to the statistical tool (RStudio) and generated automatic Descriptive and Predictive reports, which were then used by various departments who contacted truck owners over phone to convince them to get their vehicle serviced. Also SMS and Email alerts were triggered to the truck owners
- Reports were automatically shared with the logistics department to have the components which might breakdown based on the predictions
- Logistics department would place an order for just-in-time manufacturing to maintain the Lean inventory, thereby achieving significant improvements in terms of effort and thereby cost

Critical Success Factor:

Based on the above problem solutions, the efforts put on the implementation of Hybrid Agile was worth our hard work. Below are a few of the Critical Success Factors:

- Reduction in number of vehicle breakdowns by preemptive maintenance alerts rather than static time bound alerts ~ 8%
- Reduction in number of warranty claims ~ 8%
- Reduction in number of insurance claims ~ 22%
- Reduction in inventory cost ~ 4%
- Improvement in turn-around time for replacing failed/'will soon fail' components ~ 8%
- Increased customer satisfaction leading to improved brand building – Subjective based on positive versus negative sentiment analysis of feedback collected in descriptive format. This is provided in figure 4

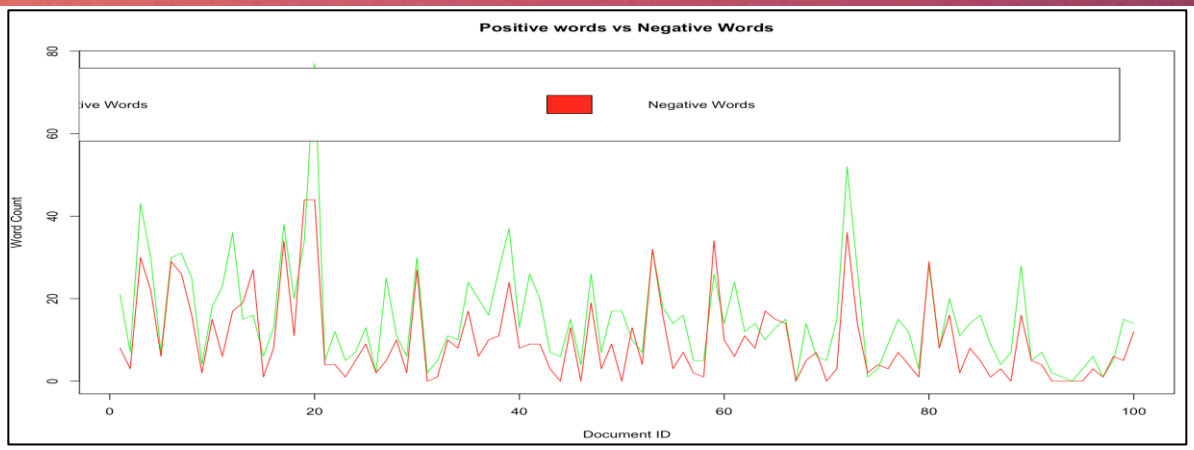

Figure 4: Positive versus Negative Sentiment of customer feedback

- Increased fuel efficiency leading to environment-friendly transportation
- The preemptive maintenance was a huge success, and the number of vehicles' breakdown has drastically reduced. Since Customer Satisfaction is the most prioritized attribute of a business, the automobile-manufacturing firm is delighted for all the feedbacks they have been receiving from their customers. This also helped them to establish healthy and sustainable relationships with their existing customers.
- Cost Saving without impacting the satisfaction levels of the stakeholders/employees associated with the organization is another important target. This state-of-the-art methodology, which was implemented, has garnered huge cost savings in the form of lower claims, to the Insurance firm. And all this, without impacting anyone associated with the firm.

Quantified benefits to business:

The innovative thinking and the solutions for the risks involved in the dynamic, out-of-scope conditions cropped up during the project implementation, has fetched great results and benefits to the business. Implementation of Hybrid Agile was phenomenal. Below are a few of the benefits to the Business:

- The number of vehicle breakdowns has drastically reduced, resulting in very huge improvement in the customer satisfaction levels
- Number of claims has shot down due to the prediction model. This has immensely helped the insurance firm to save the cost close to 1.2 Million USDs
- Inventory costs play a huge role in the operational costs. These costs associated with inventory are reduced due to the prediction of vehicle component failure in advance, which lead to better inventory management (Lean inventory)

- Improved brand image of the manufacturing company was achieved due to the proactive services provided to the customers in the form of preemptive measures. This is gauged using Sentiment Polarity Plot in figure 5

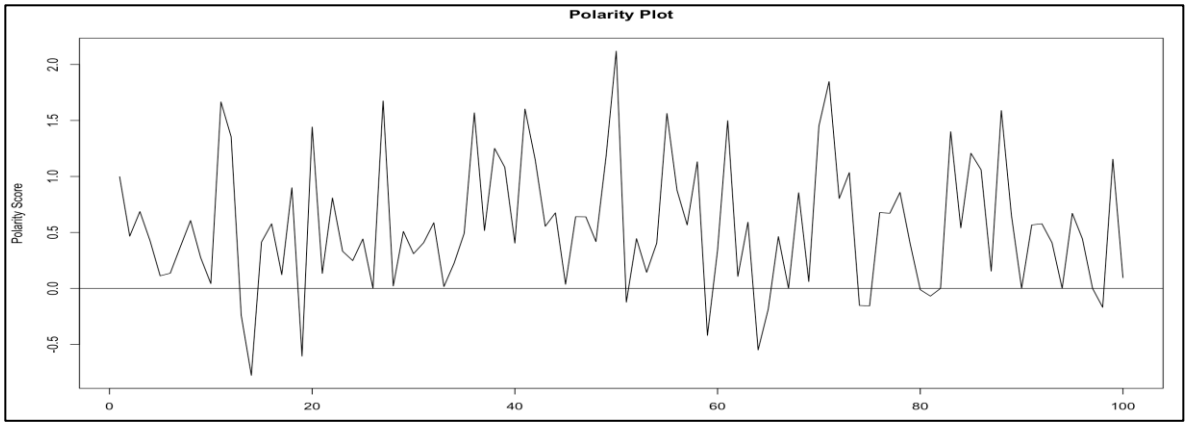

Figure 5: Sentiment Polarity Plot of customer feedback

- This critical implementation has not only helped firms to flourish, but also helped the Nation in saving the fuel, improved the fuel efficiency, which in turn lead to environment-friendly ecosystem

Cost Reduction (Various stakeholders)

- *Reduce the cost by predicting not just vehicle breakdown but also predicting on how many days will a vehicle operate before breaking down (can be extended to parts also)*
- *Reduce the warranty cost by proactive identification of part failure*
- *Reduce the number of insurance claims*

Accelerated Time to Value

- *Reduce the time in providing road side assistance*
- *Reduce the downtime of core operation due to vehicle breakdown*
- *Reduce the time for replacement parts to reach the repair site*

Human factor

- *Retaining the existing customers by providing proactive assistance*
- *Reducing the number of traffic / safety norms by proactive monitoring of vehicle, thereby reducing the wear and tear of parts, and improving fuel and engine efficiency*
- *Open new service centers based on high failure geographical regions*

Lessons learnt:

Implementation of this project has never been smooth. For us, the take-aways are not only the satisfaction of customers, but also the experiences gained due to many precious lessons learnt out of this challenging implementation.

i) People:

a. As there is a lot of dynamism involved in this project implementation, the utilization of human resources at times were very difficult. There was a gap in the requirements and the skills. We tried to use the certified professionals and that worked very well in the due course of time in project implementation

b. The stakeholders increased due to the capability of this project. Increase in the stakeholders resulted in increase in challenges. We had to invest lot of time in research and had to come up with the solutions so that escalation management is followed for raising alarm so that the decision makers are convinced with the solutions provided

ii) Process:

a. Having a watch on the drafts (pending bills) in the parliament would definitely help the organizations to design products in a more flexible manner. This would help the companies to cater to the changes that would come up in the near future. E.g. Is the recently scrapped BS-III model vehicles

b. Lack of effective planning on shipping of IoT devices has resulted in a lot of wastage of time. We should have had a near future vision as to what kind of problems may occur due to this project implementation

c. Initially, we should have considered those resources with knowledge/certification on processes like traditional project management as well as on Agile methodology

iii) Tools:

a. One of the crucial learning from the project implementation was the use of Oracle Crystal Ball for performing simulation. Else, applying probability manually would have been a very huge and time consuming task

b. Holt Winters technique usage is another important learning, which reduced Root mean square error, resulting in precision. We can increase the scalability and can utilize in other major projects
c. Resorting to Cloud (Pay as you use) has resulted in huge cost savings. Installations of 5000 IoT devices on trucks should have been planned in advance by taking 'time and resources' into consideration

Conclusion

Success of the business lies in the delivery of world-class products, which result in the greater customer satisfaction. This project implementation posed challenges, almost every day during the initial days of the project. The inclusion of various stakeholders into this project has only added to the already existing complexity.

With our management strategy, and resorting to Hybrid Project Management methodology (Traditional and Agile), we could clear a lot of problems, which arose due to uncertain inclusion of out-of-scope parameters. We are not only proud for accomplishing the customers' needs by successfully driving the amalgamation of Technology and Project Management, but also feel proud to be a part of a project that helped in fuel efficiency. This obviously led to environment-friendly ecosystem, eventually helping in Nation Building.

References

Majority of the research is done on paid research websites.

[1] Constandinos Mavromoustakis, George Mastorakis, Jordi Mongay Batalla, " Internet of Things (IoT) in 5G Mobile Technologies"
[2]https://www.forrester.com/report/Mobile+Edge+Computing+Will+Be+Critical+For+InternetOfThings+Success/-/E-RES132019
[3] http://www.computereconomics.com/article.cfm?id=2348
[4]https://www.gartner.com/document/3380746?ref=solrAllandrefval=185081784andqid=0392c5c5869f0023e140a719d88612a9
[5] https://www.gartner.com/document/3400818/meter/charge