To my beloved aunt, Neela, whom I lost recently. To my dear parents, Uma Jagushte and Vaijanath Jagushte, who continuously supported my dreams. Also, to my dear elder brother, his wife and all my cousins for their relentless encouragement to take on new endeavors.
ACKNOWLEDGMENTS

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I cannot complete my acknowledgement without thanking all the survey respondents who graciously participated in the survey. Thanks to Ms. Cindy Orr, Mr. Stan Orr and the entire team of Association of Equipment Management Professionals (AEMP) for their valuable contributions in reaching out to professionals with sound background in telematics.
Also, thanks to Mr. Tom Jackson and Mr. Tim Truex for helping me reach out to the professionals via their network to expand my survey population and make it more comprehensive.

Last but not least, thanks to the entire academic fraternity who will read this thesis and take it forward with the objective of learning and earning knowledge. Telematics is a topic with great research potential and possibilities, and I would sincerely encourage all readers to take it as their next research endeavor.
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Construction equipment, especially heavy equipment, is a major component of construction projects, and with increasing magnitude of projects and growing technology, replacement of labor work with heavy equipment is a major future trend in the construction industry. For equipment fleet size of thousands or more discrete pieces of equipment, management becomes a seriously challenging task. “Construction Equipment Telematics” is a tool designed and developed with an objective to mitigate the issues in fleet management and optimize its efficiency.

Construction companies from across the United States and around the world are considering construction equipment telematics as a major tool to counter problems related to an equipment fleet. This research focuses on the analysis of usability of telematics from the end user’s perspective. The method of analysis used was a comprehensive Web-based survey questionnaire. Only construction industry professionals such as Equipment Managers, Fleet or Asset Managers, Project Engineers, Superintendents, Project Managers and others with experience in using telematics were included in the survey, so the survey population was limited and
specific. The survey questionnaire was designed and distributed through the online survey design software, and the appropriate approval was obtained beforehand.

It has been observed that the use of more than one service provider and the use of Original Equipment Manufacturers (OEM) and third-party service providers simultaneously is a common practice amongst construction companies. The overall approval rating by these industry professionals on telematics as a fleet management tool was 8.14 with 97.87% of the respondents having recommended its use.
CHAPTER 1
INTRODUCTION

Equipment Fleet Management in Construction

In construction, large and complex projects often require various heavy construction equipment to work simultaneously on a site that spans over several acres of area. The intricacy of the project site, scale and number of equipment involved in the operations, and number of employees who are in constant proximity to the equipment make the management of the overall equipment fleet a troublesome task. The use of heavy equipment has increased significantly in the construction industry with the continuous advancement in technology and increase in the requirements for larger projects. Many activities have replaced manual labor work with equipment. Large fleets often require efficient fleet management to increase overall project productivity, so efficient equipment fleet management has due importance. Telematics is one such tool for fleet managers to ensure that their fleet is working in the most efficient manner.

Concept of Telematics

Telematics is an integrated use of wireless telecommunication and informatics. In the construction industry, it is used to gather data about the equipment fleet. Based on this processed data, optimization of fleet and execution of the project per the plan can be worked out (Jackson 2016). This concept has been in the American construction industry for over two decades, and despite the construction industry’s conservative approach to the use of any kind new of technology, telematics is increasing in popularity and gaining widespread acceptance as a form of a productivity-enhancing tool. Protection of equipment value, clarity in liability and increase in equipment uptime are some of the benefits for which its popularity is growing (Simons 2016).
Research Structure

The research structure consists of five chapters and four appendices (IRB approval, survey questionnaire, definition of terms and list of companies mentioned); five chapters are categorized per the objectives addressed by each:

Chapter 1 is an introduction to the concept of telematics, equipment fleet management and use of telematics in the construction industry. In addition, this chapter discusses the research objectives.

Chapter 2 is a literature search and review on telematics. Analysis of the past research related to the use of telematics in equipment fleet management. This chapter itself has several sub-topics:

1. Inception of Telematics as a Technology
2. Current Working System of Telematics
3. Necessities of Using Telematics for Fleet Management
5. Telematics as a Safety Measure
6. Issues with Using Telematics
7. AEM/AEMP Standards

Chapter 3 is description of research methodology, which includes scope of research survey and details of survey questionnaire. This section discusses the process of obtaining the necessary permissions and the protocol of the research. In addition, the population dynamics of the target population and method of contacting the participants are discussed.

Chapter 4 is description of data analysis and interpretation methods. How the collected data answer or attempt to answer the questions posted under the research objective.
Chapter 5 explains limitations factored during the research and limitations observed during data collection. This chapter also concludes the research and recommends future studies and contributions of this research for telematics as a study topic.

Figure 1-1 shows various stages of this research as a flowchart. Including the contents from all five chapters, this research has seven stages.

Figure 1-1. Flowchart describing various stages of this research.
CHAPTER 2
LITERATURE REVIEW

Concept Introduction

Telematics is a concept that applies principles of information technology (IT) to the field of construction and provides management solutions to modern construction problems typically arising in large construction equipment fleets of complex construction projects. The cost and management of equipment account for approximately 15–30% of the total project cost, so deciding the management strategy and its implementation in the field to the fullest should be on the priority list of any project manager. In those regards, this technology is crucial. For timely project completion within the budget constraints, telematics is providing promising benefits, and those benefits have been realized in the industry. However, like most new technologies, telematics is not receiving much attention from the construction industry (Sener and Iseley 2009). Hence, this research attempts to evaluate past studies on telematics to identify the troubles in the adoption of this technology.

Research conducted in recent years by experts in the subject matter provided answers to some of the hurdles in equipment fleet management as well as reasons for slow adoption of telematics in equipment fleet management. Since the dawn of the new millennium, telematics has gained recognition in the construction industry, and despite the difficulties, the technology is on the verge of firm establishment.

This research reviewed the attempts to analyze the concept of telematics as a whole and strove to develop solution to the problems currently faced by the construction industry related to construction equipment fleet management. Moreover, the findings in
this literature search form the basis for the scope and methodology. The literature search and review are divided and organized into the following subsections:

1. Inception and Development of Concept of Telematics
2. Adoption of the Technology to the Construction Industry
3. Review of the Necessity of Telematics in the Construction Industry (which type of construction work is most suitable for the use of telematics)
4. Current Working System of Telematics and Data Collection Standardization

**Inception and Development of the Concept of Telematics**

Term: The Oxford Dictionary defined “telematics” as a branch of IT that deals with long-distance transmission of information. The term was coined in 1978 in France. The concept was initially implemented for vehicular tracking in logistic fleets and was gradually adopted in the construction industry after system installation on construction equipment became possible.

Figure 2-1. Total number of OEM embedded automotive units sold in North America (Source: Statista.com)

Figure 2-1 shows the total automotive units with OEM telematics systems sold during a period of 13 years. The sales have increased substantially in North America
from 2005 to 2016 with projections for 2017 and 2018. A slight dip was observed from 2009 to 2011 due to the great recession, which affected the overall automobile market of North America.

**Use in Automobile and Logistics Industries**

Telematics evolved from the integration of telecommunication and informatics. The use of GPS for location and informatics for vehicle (or equipment) data were integrated to form this technology. The technology is widely used in automobiles for communications, navigation, safety and security (Howard 2015). In the logistics and transportation industry, it is widely in use for driver assistance and vehicle diagnostic purposes.

There are two components in a vehicular telematics system: data acquisition module and remote service center.

**Construction Industry-Related Definition**

Telematics is an integrated use of any wireless technology and informatics. The use of telematics technology provides an assessment tool for equipment efficiency as well a baseline for productivity improvement. It is also a tool for long-term strategic organization and planning for operations (Aslan and Koo 2012). Since the inception of technology in the field of construction, significant improvement has been achieved, and equipment can be instrumented for data collection, transmission and archiving purposes in the most effective way (Monnot and Williams 2011).

**Difference Between GPS and Construction Equipment Telematics**

GPS services merely provide the location of equipment. Telematics, on the other hand, is broader concept in which data collection, transfer, processing, and reporting for every piece of equipment is possible. GPS services use satellites in orbit 12,550 miles
above the earth’s surface. Telematics uses satellites 248 miles above the earth’s surface. GPS satellites orbit every 12 h around the world; telematics satellites orbit every 90 minutes, which means that their frequency is much higher than that of GPS satellites. GPS uses three to six satellites at one time. Telematics uses one to two satellites at a time. GPS uses triangulation atomic clocks; telematics communicates via cellular telephone networks and Wi-Fi, and it obtains its location information from GPS as well (Jackson 2012).

**Current and Future Market Trends**

Holistic growth in the telematics market and implementation of the technology have increased substantially in the past several years, especially after construction equipment manufacturing companies began to produce telematics-enabled models. Telematics is also one of the three major heavy equipment trends observed in the construction industry (Dacuan 2015). However, only 7% to 17% of contractors currently use telematics on a regular basis although 80% of heavy off-road equipment units manufactured since 2009 have come with a machine monitoring system (Stewart 2015). A 28% increase in telematics-enabled off-highway vehicles was predicted for 2016, and one of the attributes was an augmentation in the number of rental companies entering the telematics market. The projected increase was approximately 135,000 in 2016 compared to the 2013 number of 107,000 (Kabirdas and Chandrasekar 2013; Dacuan 2015).

**Benefits Realized from the Implementation of Telematics**

Telematics is an example of active IT participation in the construction industry with an aim of improvement in efficiency. The following benefits have been realized over the course of the two decades in which telematics has existed in construction industry:
1. Reduction in Liability Concerns
2. Worker Safety
3. Protection of Equipment Value
4. Increased Equipment Uptime (reduced time due to maintenance and repair issues)
5. Augmentation in the Equipment Resale Values (Simons 2016)

Various manufacturers have developed a program that can discharge the equipment fuel expense if certain per-hour fuel consumption thresholds are exceeded. Setting up thresholds for fuel consumption in a piece of equipment can also help identify other machine issues (Moore 2015).

It is customary to routinely take oil samples for a piece of equipment, in which no issues are detected 60% of the time. Therefore, these samples result in cost and time expenditures for a contractor. This process is not productive, because maintenance action is not necessary 60% of the time (Monnot and Williams 2011). In contrast, sensors introduced by OEMs are resourceful options. These sensors send signals to the equipment owner about water or fuel contamination. This also initiates sampling for analysing the exact amount of contamination.

**Review of the Necessities of the Use of Telematics in the Construction Industry**

If a piece of construction equipment remains idle for an hour, it costs the project $10, of which $4 is the fuel charge and $6 is for repair and maintenance (Morgan et al. 2014; Skipper 2014). For a small fleet with 200 working units, a 20% reduction in idle time can save $20k annually. Similarly, for a medium fleet (approximately 1000 working units), the cost savings of a 20% reduction in idle time is a staggering $1.2 million (Morgan et al. 2014). Therefore, monitoring an equipment fleet for fuel usage and idle time and tracking the other operational statistics are of paramount importance.
The following are the five reasons listed in the white paper issued by Obercomm regarding why construction professionals should adopt telematics for fleet management.

1. Equipment Security
2. Engine Alerts
3. Preventative Maintenance
4. Lower Capital Costs
5. Lower Fuel and Other Operation Costs

Beyond these five reasons, telematics has the potential to provide more benefits to the fleet manager. However, in this study, these five factors were analyzed, and the following points were observed.

**Equipment Security**

Thievery of construction equipment is a huge issue faced by many contractors that causes monetary damages as well as loss of important productive time. Per the joint report by the National Insurance Crime Bureau (NICB) and National Equipment Register (NER), 36% of the total equipment stolen in 2013 was heavy construction equipment, and several types of equipment in the largest category, Mover, Ridging and Garden Tractor (45%), also falls under heavy equipment. Figure 2-2 shows the categories of stolen equipment and their numbers and percentages for 2014.¹

Both satellite-based and cellular-network-driven telematics can provide off-hour tracking and tracking of equipment in unauthorized areas. Such tracking can be used as a preventative measure against thievery of onsite equipment.

¹ Link to the full report of NICB and NER: [https://www.nicb.org/newsroom/news-releases/2014-heavy-equipment-theft-report>
Figure 2-2. Types of equipment stolen by percentage in 2014 (adopted from National Insurance Crime Bureau (NISB) and National Equipment Register (NER), 2014 Equipment Theft Report)

**Engine Alerts**

Figure 2-3 is a graphical representation of the usage of telematics data by fleet managers by specific purpose as reported by OBERCOMM. The highest (43.8%) percentage of fleet managers use the data for fuel usage and work hours, while use data for emission monitoring and compliance is option utilized by lowest percentage (3.8%) of the contractors. This figure shows trends in utilization of telematics data by contractors.
Preventive Maintenance

Based on the hours of operation reported by operators, the maintenance and schedule for each piece of equipment are established. A discrepancy in the reported machine hours from the actual machine hours causes a significant shift in the maintenance cycle. Telematics avoids the possibility of under-maintenance or over-maintenance of equipment.

Low Capital Cost

Appropriate maintenance cycle and diagnostics reduce the wear and tear of equipment, which, in turn, results in savings in repurchase or other investment costs in particular types of equipment. Because equipment ownership cost is considerable (especially in heavy civil construction projects), savings on capital investment can be a huge advantage.
Table 2-1 shows the average construction equipment cost on a project, and Table 2-2 shows the percentage of growth in construction equipment rental cost from 2012 to 2018 (OBERCOMM 2014).

Table 2-1. Average price of equipment from 2011 to 2017 (adopted from OBERCOMM 2014)

<table>
<thead>
<tr>
<th>Type of Equipment</th>
<th>Price in Year 2011 (In $)</th>
<th>Price in Year 2014 (IN $)</th>
<th>Price in Year 2017 (IN $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Graders</td>
<td>316,776</td>
<td>316,776</td>
<td>350,408</td>
</tr>
<tr>
<td>Bulldozers</td>
<td>332,731</td>
<td>368,056</td>
<td>142,654</td>
</tr>
<tr>
<td>Front-End Loaders</td>
<td>117,642</td>
<td>130,132</td>
<td>142,654</td>
</tr>
</tbody>
</table>

Table 2-2. Equipment rental prices (adopted from OBERCOMM 2014)

<table>
<thead>
<tr>
<th>Type of Rental Equipment</th>
<th>Annual Growth in Price From 2012–2015</th>
<th>Annual Growth in Price From 2015–2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forklift</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Earth Moving Machine</td>
<td>0.9</td>
<td>1.4</td>
</tr>
<tr>
<td>Aerial Lift</td>
<td>3.1</td>
<td>4.6</td>
</tr>
</tbody>
</table>

**Lower Fuel and Other Operating Cost**

Construction project estimates are made based on market studies to predict project completion costs, and part of such estimates is based on fuel rates, which fluctuate on a daily basis. To provide security against these fluctuations, telematics provides saving options and fuel optimization. Moreover, satellite-based tracking provides security against equipment thievery, unnecessary idling and careless operation, which add to the fuel consumption.

**Telematics as a Safety Measure**

In addition to the top five benefits for which telematics is generating popularity amongst construction professionals, safety by mitigating accident hazards is also a huge benefit. A.J. Johns analyzed telematics as a tool for safety (Skipper 2015). The cost of repair and maintenance was cut by almost $3 to $4 per hour after the company began to use telematics in 2014. Alongside this advantage, safety issues regarding off-
road machines were mitigated, and this point was brought to the attention of the insurance companies (Skipper 2015). Monitoring of equipment work onsite includes a record of excessive breaking, sharp turns, excessive and hard acceleration or other similar signs which indicate that an operator is disturbing the smoothness of operations. Operator performance, machine overall health (because any discrepancy due to abnormal machine handling adversely affects machine health) such as excess fuel consumption, body frame damage due to minor or major accidents, and system wear and tear indicate safety issues. An increase in work environment safety has dual benefits: it prevents work productivity loss onsite due to accidents and, in turn, reduces insurance cost associated with equipment.

Hence, companies that furnish holistic inspection reports, documented proof of maintenance and emergency repairs based on data can demand better insurance status. Moreover, companies that prefer the practice of using rented heavy equipment now choose to opt for telematics-enabled equipment for the reasons mentioned above. Furthermore, it also helps rental companies if the resale value of equipment is boosted (Simons 2016). In addition, equipment featuring a construction equipment telematics system has a 90% chance of recovery from theft. Equipment with a telematics system in docile mode can still be recovered (Doyle 2012).

**Telematics in Cranes And Related Safety Aspect**

All other benefits aside, the use of telematics in cranes is attributed to one of the most important purposes, which is the safety of workers onsite. The European construction market has been using telematics to achieve higher safety for several years. However, the US market has shown significant reluctance owing to liability issues (Monnot and Williams 2011). Monnot and Williams also noted that construction industry
associates favor implementation of this technology onsite to reduce risk. Statistics indicate that cranes are prone to the risk of accidents more than any other type of equipment. From 1992–2006, 323 construction worker fatalities in 307 incidents were reported (McCann et al. 2008), 216 (71%) of which were due to mobile or truck cranes.

Trends are changing with the increased implementation of telematics in the fleet and increased manufacturing with built-in telematics from the OEM. For example, Link-Belt has started installing telematics on all cranes during manufacturing. The service was implemented with an A1A software partnership (Hampton 2014).

**Current Working System of Telematics**

Telematics is more than a mere tracking of equipment location, and as the benefits of this technology have been realized by contractors, utilization has escalated, and now its place in the industry is well established. With the help of GPS and cellular networks, data transmission has become easy. Hence, this technology has proved to be a blessing for large and intricate construction projects. Figure 2-4 shows a typical telematics device, which can be mounted on equipment.

Figure 2-4. Telematics data delivery device (source: Construction Equipment Magazine)
(Said et al. 2014) explained the working system of telematics, a summary of which is as follows.

Currently, telematics services are provided by following two methods:

1. Original Equipment Manufacturer (OEM)
2. Third-party Telematics Service Provider (TSP)

Preinstalled telematics system equipment (OEM) is becoming increasingly common in the industry with many manufacturing companies considering telematics technology. On the other hand, TSPs are also improving this technology by providing more useful and efficient data. Both systems are briefly explained below.

**Original Equipment Manufacturer (OEM)**

Equipment manufacturing firms now manufacture equipment with telematics systems preinstalled in them, and the data collection and report creation can be accomplished by one of two ways: from the telematics service provider’s website as in TSPs or from the manufacturer’s own website designed for the telematics data transmission.

**Third-party Telematics Service Provider (TSP)**

A telematics dongle costs approximately $100. This dongle can be plugged in with OBDII equipment, which has an onboard diagnostics port. An account subscription and signup activate the services, and fundamental information such as location, engine power status (on or off), engine temperature and fuel economy information then becomes available (Jackson and Samford 2016). There are variations in the installation process based on the type of equipment and its system. If the telematics service provider follows the AEM/AEMP standard, then all information from the mix fleet becomes available on a single website.
Components of Telematics

Figure 2-5 explains data transmission process of telematics.

Figure 2-6 explains three components of the telematics, which are explained in brief as follows.

1. Transponder – A device to be installed on equipment after or during manufacturing to transfer equipment data to the receiver’s website. The transponder is a hardware connection to the equipment and is placed to receive location and operation data on a real-time basis (Said et al 2014).

2. Medium to Transmit Data – The data transmission medium can be either GSM (Global System for Mobile Communication) or CDMA (Code Division Multiple Access).

3. User Interface – This allows the end user to access and interpret information gathered from the equipment.
Monnot and Williams (2011) explained these components by the following four points:

1. Data collection and buffering
2. Transmitting and receiving data
3. Processing and archiving
4. Dissemination and use

Figure 2-7. Working system of telematics (adopted from Monnot and Williams 2011)
The question Monnot and Williams attempt to address is whether the data can be effectively disseminated to improve the overall fleet management process. It is one thing to obtain information from the telematics system mounted or installed in the equipment, but extracting the most suitable information that can increase the fleet management efficiency is different thing altogether. Based on their research, there are four parameters on which users should focus, which are given in the following.

**Four Important Parameters**

**Actual Machine Hours**

This provides the end user with the actual hours of equipment use in the field in a working day. This information is integral in determining the service scheduling cycle and utilization technique, a critical part of equipment return analysis. Fleet managers who do not use telematics data usually rely on the reported machine hours, which usually differ by 10 to 15% from the actual values. This creates a cost recovery difference. In any case, the difference causes under-maintenance or over-maintenance of the machines and subsequent expenses. Regarding utilization, up to 40% improvement can be realized once the home office receives information on exact machine hours (Monnot and Williams 2011). The advantage is also realized in the preconstruction phase, and cost estimation based on historical cost data can also be made more accurate.

**Machine Location**

Machine location provides improved billing as well as geo-fences for the equipment, which helps prevent unauthorized use or theft. This information is useful for the displacement of the repair and maintenance team on equipment location which, reduces both time and cost.
Machine Health

Any equipment health issue can be programmed to send out alerts upon its occurrence. Training pertinent to issue resolution should be given to the diagnostic teams and operators to simplify mitigation.

Real-Time Fuel Consumption

Fuel consumption is important to any contactor for multiple reasons. Obtaining information on fuel consumed in a given time is more important than mere machine hours because it shows the reason behind the excess use of fuel—i.e., due to machine problems, operator fault or inappropriate application.

Issues with the Use of Telematics

Of the several issues identified in previous research regarding data collection and handing through telematics, the most pressing is the interpretation of a huge volume of data in a way that can cater to the needs of the end user.

The use of complementary software to format data into a more user-friendly manner is one approach to solve this problem (Equipment World 2013). The use of cloud computing is one of the suggested methods for automatic data collection and transfer by technology experts and service providers. One of the prominent problems in widespread acceptance of this technology is growing pains for professional to simultaneously work with telematics—especially when those professionals are already providing good equipment fleet management. A management team with a busy schedule is being asked to provide extra effort to analyze and provide pertinent information (Moore 2016).
AEM/AEMP Standard for Telematics Data Collection

The Association of Equipment Management Professionals (AEMP) is an organization dedicated to managing affairs related to heavy and off-road equipment managers. The Association of Equipment Manufacturers (AEM) is an organization dedicated to advancing equipment manufacturers in the global market. A total of 19 data points have been identified by AEMP and AEM that help make mixed-fleet equipment management less troublesome. Those parameters are mentioned below.

The standard was accredited at the 2007 Asset Management Symposium in Louisville, KY, where the necessity of standardization to bring more efficiency in telematics data management was realized (Bennink 2011). That first release, followed by updated versions 1.1 and 1.2 in 2010 and now version 2.0, has considerably changed the way in which data collection and utilization occur in asset management (Jackson 2014).

AEM/AEMP 2014 Standard Data Fields

1. Serial number
2. End-user asset ID
3. Hours
4. Location
5. GPS distance traveled
6. Machine odometer
7. Fuel consumption
8. Idle time
9. Fuel level
10. Engine running status
11. Switch input
12. PTO hours
13. Avg. load factor
14. Max speed
15. Ambient air temperature
16. Load count
17. Pay totals
18. Active regeneration hours
19. Fault codes (42)
The current version 1.2 of AEM/AEMP carries these 19 points, and the following is a link to this version’s documentation.


The draft of version 2.0 has been released by AEMP and will soon replace the existing version 1.2. It received approval from the International Organization of Standardization (ISO) for global use in July 2016. This standard is a part of ISO 15143 section 3: Machine Data (Monroe 2016; Turek 2016). This new ISO mixed-fleet telematics standard has enabled equipment users to obtain more data in their preferred business or fleet management software, ease in access and improved capability to manage and analyze information across the entire fleet (ISO 2016; Monroe 2016; Turek 2016).
Figure 2-8. ISO 15143-3 Standards for Fleet Management Using Telematics (Source: AEMP, with permission)

Data Standards of AEMP 1.2 (2010) is designed to provide machine information with data points including but not limited to the following:

1. Installation Information: Telematics installation date and time (blank field by default indicates that telematics was installed when the equipment was built)

2. Equipment make, model, ID and serial number.

3. Location Information: Last known location (location name if available), date and time, latitude and longitude, altitude.

4. Operation Hours: Cumulative operation hours, date and time, reset date of data.

5. Fuel Tracking: Fuel consumption, date and time, measurement unit, latest 24 hours’ fuel consumption.

6. Distance: Distance travelled (most useful for earthmoving equipment), measurement unit (odometer rating), reset of data date and time.

Date and time reporting in AEMP Standards follows the ISO 8601 format, in which reports are YYYY-MM-DDThh:mm:ss. Fractional seconds are not counted in this reporting format.

Summary of Literature Review

It has been observed during this literature search that telematics has potential to grow and features benefits to improve fleet performance. Limited research at an academic level promotes the need to study telematics in depth. Therefore, the aim will be to understand telematics from the end user’s perspective. Literature review can be summarized in followings two paragraphs;

The concept of telematics originated in France in 1978 for the transmission of information over long distances. Telematics as a technology was first used in the logistics and automobile industries and later adopted by construction. There are three
components on which the functioning of telematics depends: transponder, transmission medium and user interface.

AEM/AEMP have jointly suggested 19 data points for reporting telematics data as “Telematics Data Standards 2.0.” These standards have also received ISO approval for global implementation. This literature search highlighted the absence of a comprehensive survey of position and acceptance of telematics from construction industry professionals. This corroborates the problem statement and research objective.
CHAPTER 3
AIM, OBJECTIVES AND METHODOLOGY

Research Objectives

Problem Statement – Previous research highlighted the components, working system and benefits of telematics to some extent. However, understanding the position of telematics from the end user’s perspective is an unexplored territory. This research aims to understand telematics from the viewpoint of professionals who are using it. To achieve this aim, the methodology adopted is a survey questionnaire. There are four principal objectives of this research.

1. First objective was to assess telematics the way survey respondents use it. E.g. equipment fleet size, type of project, working team size, and years of experience with telematics (Covered in Section 1 Questionnaire).

2. Second objective was to understand usability of telematics. Focuses on information about scope and duration of pertinent training if any, provided to the employees, data points most frequently collected for asset management, other supporting software if any, quantifying benefits of telematics under different scenarios (Covered in Section 2 Questionnaire).

3. Third objective was to understand data management and reporting system, schedule of reporting, method of reporting and system of communication amongst various individuals involved. (Covered in Section 3 Questionnaire).

4. Finally, how the collected data helps their team manage fleet? How the collected data helps solve machine problems and improve efficacy was analyzed (level of satisfaction with this technology)? (Covered in Section 4 of the Questionnaire).

The research technique adopted for this study is a comprehensive Web-based survey questionnaire distributed to professionals working with construction equipment fleets who have experienced telematics. Different methods were used for the preparation of the sample space of this study. Those methods are discussed in ‘Survey Planning and Method of Contact’. The total sample size for this survey by personal contact is 297.
Survey Planning and Method of Contact

The survey questionnaire was constructed to collect and synthesize data and represent it in an organized manner. The survey was designed and distributed using Qualtrics Survey Software. A survey design via the University of Florida’s collaboration with Qualtrics was used so that the respondents could ensure that the research was for academic purposes following university protocol. The respondents were contacted via their email addresses and requested to complete the survey questionnaire at their convenience. The AEMP management team also shared survey details and the questionnaire with professionals to encourage participation. All survey respondents were selected from professional connections on LinkedIn of the primary investigator and co-investigator. Professionals were identified with the description of the work in profile, and telematics was used as a primary keyword in the search. Upon approval of the protocol from the IRB at the University of Florida, these individuals were contacted via their email addresses and briefed with the survey objective, methodology and their role in the whole process. The following information was shared with the respondents as part of the mandatory informed consent.

The request email consisted of the following four parts:

1. Introduction of the research investigators (investigator and advisor)
2. Introductory email for technology and research
3. Suggested date by which the responses were expected and their role in the whole process
4. Informed consent document (same document submitted to IRB for review)

Appendix B

In addition to contact via email, social media platforms were used (LinkedIn, Facebook and Twitter) as secondary means to ensure the participation of more respondents. Given the implementation efficiency and potential difficulties, a primary
objective was to prepare an inclusive questionnaire that could analyze the usability of telematics with the least time-consuming survey.

The survey questionnaire was divided into four categories by purpose. These categories gathered data from general information about the respondents and their team to specifics on their experience regarding the use of telematics. The survey was so designed to minimize the time and effort required to answer questions with maximum data points. No descriptive questions were used, and multiple options were given wherever possible. Moreover, no questions were asked regarding sensitive personal information such as age, gender or race. The following are the four subcategories of this survey.

1. Primary Questionnaire: This first category consists of questions regarding general telematics information—e.g., number of years professional/team has/have used telematics, typical fleet size of a project, number of projects on which they have used this technology. The purpose of this category was to collect primary information on the respondents’ background with telematics and the type of technology (OEM or TSP or both) their firm/project team uses.

2. Usability Review: In this category, questions were asked regarding reasons why professionals use this technology. Some of the questions consisted of the task of rating specific usability points in terms of usefulness. These questions were designed to understand the duration of the transition since they first began to use telematics, information on the number of employees working with telematics, the training period if any and points covered in training to better use telematics. Questions were also asked regarding any other supporting software used along with telematics for simplifying tasks.

3. Data Management and Reporting: In this category, questions were asked regarding processing and reporting methods used by construction project management/fleet management teams—e.g., do project management teams have an established schedule of data reporting? What method of data reporting do they use?

4. Indicators from Collected Data: This was the final category in the questionnaire. In this category, questions were asked regarding how the collected data help professionals deduce the productivity improvement strategy of an entire fleet—e.g., which data points do they consider for fleet management? Do professionals determine the maintenance and/or repair schedule of equipment based on the obtained data? Moreover, based on their overall experience and the questions
asked in this survey, do they recommend the use of telematics for fleet management to fellow professionals?

Appendix A is a copy of the IRB approval for survey under the “Excepted Review” category. Appendix B contains the request email and survey questionnaire as sent to the research participants.

Scope and Limitations

The target population for this study was small, and the scope was limited to USA-based contractors and construction management firms. The reasons for the small sample population were the limited time of the study period and the requirement of standardized language of communication and data analysis. The primary focus was on collecting responses from contractors who work in heavy civil construction. Heavy civil construction involves many pieces of heavy equipment onsite for a long duration. Equipment kept on the work site during the construction phase is susceptible to damage, theft, wear and tear. Therefore, this review focused on information related to heavy civil equipment.

The survey was designed in a way that can simplify the conveyance of benefits of this research. The questionnaire was divided into several categories explained in the next section for the systematic collection of information. The target population consists of professionals who have worked with this technology. The list of professionals was obtained from various sources—e.g. professional connections from LinkedIn, ENR list of heavy civil contractors and other social media sources.

Population Dynamics

The target sample for this research investigation includes, but is not limited to, Telematics Service Professionals, Project Engineers, Project Superintends, Project
Executives, Heavy Equipment Managers and other Equipment Managers. The total number of participants was (297) from across the United States. The response rate from professionals contacted via personal email was 15 (28.30%) (the total number of respondents was 55). Figure 4-1 shows the survey population and percentage of respondents. As shown in Figure 4-1, out of 297 invites, most of the population consists of equipment management-related professionals; 129 (43.43%) are designated as equipment managers followed by 47 (15.82%) designated as asset managers. The target sample size also includes professional with titles of Project Manager, Construction Manager, Project Engineer, and Superintendent.
CHAPTER 4
ANALYSIS OF COLLECTED DATA

The data analysis was also designed and conducted in accordance with the four categories in which the questionnaire was divided. There were 28 questions in the entire survey. Qualtrics automatically recorded responses upon completion of survey. A total of 55 (18.51% of response rate) completed responses were recorded by January 25, 2017, after which the survey was officially closed. Nineteen incomplete responses were removed from the original record list to make the analysis more relevant per the study objective. Those 19 responses were less than 20% of the total. The recorded responses were then analyzed and tabulated to demonstrate the result in graphical manner. Analysis was conducted in both an MS Excel spreadsheet and Qualtrics. Features of Qualtrics software were used to perform certain operations of data analysis. Two different types of analysis were performed. In gross analysis, data were analyzed without considering each response individually. Graphic representation and corresponding analysis was carried out for 10 questions given the amount of data each question demands.

Respondent Evaluation by Category

Out of 129 professionals with the profile of equipment Manager, 44 responded to the survey. This category consists of 43.43% of the total population, and 80% of contacted professionals responded to this survey. This introduces bias in the response due to professionals with one type of background forms major response sample.
There were nine questions in the first section with an objective of gathering primary information about the fleet management system used by professionals/their team or their company. In this part, the questions were asked regarding the telematics system itself—e.g., name of the telematics service provider, type of service provider (TSP or OEM), duration for which they/their company has used telematics, types of projects. A list of telematics service providers (companies) noted during the survey is briefly provided in Appendix D. The reason for asking about the telematics service provider and type was to generate a broad overview of current market developments. Finding the names of chosen service providers and subsequently other considered options was the primary motive of those questions. Twenty (38.46%) respondents mentioned more than one service provider for their fleet management task.
Other Options For Services

Thirty-two (64%) of the respondents indicated that their firm considered other options, and 13 (25%) respondents stated that they looked for more than one option in addition to the one they were using.

Type of Telematics Services Used

It has been noted that 20 (38.46%) companies use both OEM and TSPs for data management. Figure 4-2 shows the number of respondents with the specific type of telematics services providers they use. The use of both types of service providers indicates that fleet managers/companies consider each service provider based on project parameters/requirements. Larger construction companies with regional head offices across the US use different service providers in their respective offices.

![Figure 4-2. Telematics service user by service provider type](image)

The question was asked regarding the reasons for which companies opt for telematics. Improvement of maintenance and repair schedule received 34 responses. Managing larger fleets, achieving fuel economy, and protecting equipment and workers were other major reasons with 28, 27 and 26 affirmative responses, respectively.
Equipment protection includes multiple factors, and tracing the location of every piece of equipment is an important point. There were 26 responses to the point of equipment, and worker safety rates 4.41 out of 5 for ‘accurate machine location’ as a useful feature of telematics. Monitoring operator behavior received 24 affirmative responses, indicating that companies are moving toward technological reliance for work attitude assessment. Figure 4-3 shows the number of responses received for each of the five options given to the professionals as a reason for the selection of telematics.

**Figure 4-3. Reason(s) for selection of telematics as a fleet management tool**

Average years of experience was observed to be 7.23 years with an upper limit of 26 years and a lower limit of 6 months. Figure 4-4 shows the range of years of experience for professionals with telematics. Nineteen (36.53%) respondents said that they have between 6 and 10 years of experience. In addition, 15 (28.84%) respondents
have total project level experience of less 50 since adopting telematics. Seven (13.46%) responses were unquantifiable because the respondents did not provide any specific number.

![Year Range for Telematics Experience](image)

**Figure 4-4. Years of experience using telematics**

The average fleet size for which telematics can be considered as an optimal technology was difficult to assess because the size of the project, company, working team and method of services provided were different for each respondent. Therefore, four categories were created to distribute the fleet size provided by every respondent. Because the answer type for the question was data entry, some of the answers were unclear and hence were placed in the unspecified category.

Figure 4-5 shows all six categories and the number of responses in each. It was observed that 18 (34.61%) professionals gave fleet size less than 50. This creates a contradiction regarding the reason “To manage bigger fleet size,” which received the second-highest response. In addition, it has been suggested that telematics should be
used for larger fleets (mentioned in the literature search and review). However, because the question does not specifically demand the total fleet size of the company under telematics, the respondents interpreted the question differently. Moreover, one respondent mentioned fleet size in the range of 75 to 500. This response was placed in the category of 301 to 600 because there is equipment in the fleet with telematics enabled on all of them.

Figure 4-5. Typical fleet size for which professionals use telematics

Figure 4-6. Number of projects for which professionals have used telematics since adoption
Usability Review

In this part of the survey, questions were asked regarding how professionals use telematics on construction projects and any pertinent training given to them or other employees who work with this technology. The total number of questions in this part was nine. It has been noted that 37 (80.43%) of the companies use one or more forms of supporting software to increase the efficiency of telematics data. Most software mentioned was customized communication or data-sharing software. Some of the software is discussed in brief in APPENDIX D. A satisfaction level of 100% was also noted for the use of this software (response of “Somewhat useful” is also considered as positively satisfactory). The number of employees working with telematics ranges from 2 to as many as 600 in the companies. Quantifying the data on the number of employees was a difficult task, considering company size, fleet size, type of work, service provider and services provided. This data varies from company to company.
Figure 4-7. Usefulness of telematics from different perspective(s)
There were 12 points identified against which usefulness of telematics was assessed by asking a “Likert type” question to the survey respondents. Each usefulness point was given a rating scale of 1 to 5 with 5 being most useful and 1 being least useful. Six points received an average rating of 4 out of 5 from 12 total categories.

Table 4-1. Average rating for usefulness from 12 perspectives for telematics

<table>
<thead>
<tr>
<th>Point of Usefulness</th>
<th>Avg. Score Received</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate Equipment Hours</td>
<td>4.47</td>
</tr>
<tr>
<td>Accurate Location of Each Item of Equipment Onsite and Control Over its Movement</td>
<td>4.44</td>
</tr>
<tr>
<td>Information on Underutilized Equipment</td>
<td>4.29</td>
</tr>
<tr>
<td>Accuracy of Data Required for Maintenance Cycle</td>
<td>4.11</td>
</tr>
<tr>
<td>Fuel Efficiency of Data Received</td>
<td>4.02</td>
</tr>
<tr>
<td>Accuracy of Fuel Consumption Data</td>
<td>4.00</td>
</tr>
<tr>
<td>Accurate and Time-Efficient Data Reporting</td>
<td>3.93</td>
</tr>
<tr>
<td>Operator Behavior/Attitude</td>
<td>3.76</td>
</tr>
<tr>
<td>Accurate Prediction of Maintenance Needs</td>
<td>3.73</td>
</tr>
<tr>
<td>Improvement in Equipment Downtime</td>
<td>3.42</td>
</tr>
<tr>
<td>Equipment Most Prone to Time-consuming Repair Activity</td>
<td>2.73</td>
</tr>
<tr>
<td>Most time-Consuming Repair Activity</td>
<td>2.69</td>
</tr>
</tbody>
</table>

The use of telematics for “accurate equipment hours” received the highest score, 4.47 out of 5, and detection of equipment with the most time-consuming repair activity received the lowest score, 2.73 out of 5. The response to “Accurate location of each
item of equipment,” “Accuracy of data required for maintenance cycle data,” “Fuel efficiency calculations based on received,” “Accuracy of fuel consumption data” and “Information on underutilized equipment” also received average ratings above 4 with 4.44, 4.11, 4.02, 4.00 and 4.29 out of 5, respectively.

The use of telematics alongside other support software yields better data management, which can be observed from the responses to the question framed as, “Is your company using any other support software alongside telematics to report and interpret data more effectively?” Forty-four (80.43%) participants responded affirmatively to this question, indicating establishment of technical collaboration for management purposes. Respondents with affirmative answers were then asked to name one or more of those supporting software programs. Forty (90.90%) of the respondents think the supporting software is useful (considering both answers “very useful” and “somewhat useful” as affirmations).

A question was asked about the most common problem that the professional has encountered during the use of this technology. (Drag and place to rank in descending order.) The options given to choose from were as follows:

1. Lack of skilled manpower to handle telematics
2. Constant alerts
3. Excess of data
Figure 4-8. Rating of difficulties in using telematics

“Inconvenience due to lack of personnel” received the fewest responses for the first rank (i.e., reason causing the most trouble in using telematics.) This response justifies the 63.09% response received for the question, “Was any pertinent training given to the employees before implementing this technology?” “Constant Alerts” was noted as the most inconvenient feature of telematics with 16 respondents assigning it as the highest-ranked problem.

The size of the team working with telematics within the company is affected by one or more of the following factors:

1. Professional background of respondents
2. Nature of work performed by the company
3. Size of the company (project portfolio, number of employees, revenue)
4. Type of services provided by telematics
5. Expertise of professionals using telematics
6. Experience level in using telematics
It has been noted that companies with larger work expansion, more resources and more employees have larger teams. The team size varied from as low as 2 to as many as 600 employees.

Most employees indicated that they have received formal training from their company regarding the use of telematics. Twenty-nine out of 46 professionals (63.04%) who responded to the training question said they received training. Figure 4-9 shows commonly identified points essential to the use of telematics and the number of respondents who agreed that those points were covered in their respective training. Data Collection and Management was noted as a pivotal point with all 29 respondents including this in their response. “Diagnostic Schedule Preparation based on Collected Data” was the least covered topic in any training and was noted in 12 responses.

**RESPONSES FOR POINTS COVERED IN TRAINING**

![Bar chart showing the number of responses for each training point.](image)

- System Introduction: 27 responses
- Working System: 24 responses
- Data Collection and Management: 29 responses
- Data Reporting: 27 responses
- Diagnostic Schedule Preparation based on Collected Data: 12 responses

Figure 4-9. Scope of training given to the professional before using telematics
Data Management and Reporting System

Telematics generates a large amount of data from each piece of equipment over time. Therefore, an established data management system is necessary to mitigate waste of time and effort and enhance data usefulness. Six questions in this section were focused on understanding the management and reporting system that the professionals and their team or company use as a standard practice. An established data reporting system can be a strategic decision to draw the most out of a system. Thirty-five out of 45 (77.78%) respondents to this question gave an affirmative answer about an established data management system. Seven respondents said they that do not have an established data reporting schedule, while 3 answered “Unsure”. Eight respondents choose not to answer this question. Three respondents mentioned a software program named iDashboards. Other methods of data reporting include custom Web-based software, email, Excel worksheets, MS Project, and NoteVault. The results of this question complement the data collected about the support software and its role in fleet management alongside telematics.

The most common data reporting schedules observed from the provided options were “Weekly” with 16 (45.71%) and “Daily” with 13 (37.14%). Forty-six (86.79%) out of 55 total respondents answered question related to the convenience of an existing data reporting schedule. The respective existing data reporting schedules have an approval rating of 91.30% (considering “convenient” and “very convenient” as satisfactory remarks). Efforts have been made by AEM/AEMP to bring in more uniformity and ease in data management and reporting. A high rate of satisfaction in data reporting and management on the whole shows the success of these efforts.
Data Indicators and Overall Effectiveness

The fourth and final category of this questionnaire was the analysis of data indicators and the role of collected data in effective fleet management. This category had four questions. Because the cost of fuel and fuel consumption are equally important issues for fleet managers alongside maintenance and repair needs and equipment, questions were asked regarding the role of telematics in fuel management. Thirty-three (71.73%) respondents indicated that the collected data were factored in during asset management decisions (counting both “Yes” and “Depending upon the situation” as affirmative answers)—e.g., changing repair and maintenance schedules, deploying the maintenance team to aid equipment. Figure 4-10 shows essential points that were factored in during data collection related to fuel. Fuel is an integral part of equipment functionality, so almost all Fleet Managers acknowledge fuel consumption data generated from telematics reports.

As shown in Figure 4-10, “Weekly, monthly and total fuel consumption profile (both real-time and cumulative)” is the most important dataset obtained from telematics reports. It indicates that construction professionals or construction companies use telematics to record complete profile of fuel consumption in their system for each equipment. The data field helps track changing pattern of fuel consumption of each equipment over the time. It also helps identify equipment which require maintenance needs. The focus on indicators from the collected data was limited and did not include cost factor.
Summary

The survey focused on various aspects of telematics. It has been noted that OEM, TSP and both types of service providers within one company claim equal market share in the construction industry. It has also been noted that 20 (37.73%) of the companies use more than one service provider. Forty-seven respondents (90.56%) answered the overall effectiveness question. Forty-six (97.87%) of the respondents indicated that the overall effectiveness of telematics is greater than 5 on the scale of 1 to 10 with 10 being most useful and 1 being least useful. In addition, 40 (85.11%) respondents answered, “Definite YES” to the question, “Would you recommend telematics as a fleet management system?” Thirty-seven (78.72%) of the respondents think that telematics is a highly useful tool for fleet management with a rating of 8 or
above on the scale of 10. The average score received for telematics as a useful and recommended tool was 8.14.

Figure 4-11 shows the ratings received by telematics from the participants.

Figure 4-11. Rating of telematics based on 55-response sample
CHAPTER 5
CONCLUSION AND RECOMMENDATIONS

Key Findings

Acceptance rate of telematics and means in which professionals utilize this technology was one the important reason behind this research exercise. There were five key findings as an outcome of this research;

Approval rating for telematics amongst its user is high (8.14 out of 10), and technology was recommended for use by 46 out of 47 (97.87%) of the users who responded to the overall effectiveness question.

It has also been noted that both OEM and TSP use simultaneous with fleet management is a more common practice than using only one type of service provider (20 out of 55). The conclusion can be drawn that companies customize services based on project-specific requirements.

Technology has provided holistic usefulness based on the analysis of usability under 12 different scenarios. Accurate Equipment Hours received the highest score of 4.47 out of 5 amongst all 12 scenarios, followed by Accurate Equipment Location with 4.44.

Among the problems encountered by professionals while using telematics, “Constant Alerts” was noted as the most vexing aspect to deal with. Sixteen respondents placed this problem as number one out of three ranking spots.

Fuel consumption is at the base of every efficient fleet management strategy, so “Daily, weekly and total fuel consumption data (both real-time and cumulative)” was noted as the most frequently used dataset with 22 responding favorably.
Figure 5-1. SWOT analysis of telematics

The advancement in construction equipment telematics is evidence of the growth of IT in the construction field over the years. This technology is largely used for heavy civil and mining projects (19, 36.53%). With AEMP and AEM’s constant efforts to make technology more accessible and less troublesome to use, telematics is likely to penetrate the construction market on a larger scale.

**Contributions to the Literature of Telematics**

Telematics has great potential to improve fleet management of heavy equipment, but it is used by only 7 to 17% of contractors in the United States construction industry (Stewart 2015), which is a small share. This research aims to increase telematics understanding amongst contractors to promote effective means of fleet management. This research provides a comprehensive review from the end user’s standpoint and makes the following contributions:
1. This research is the first attempt to analyze the current state of telematics from the end user’s perspective via a review of the construction industry usage of telematics with a broad focus on the entire US construction market.

2. This research integrates most previous studies on telematics in construction equipment in the form of a comprehensive “Literature Review” to provide future researchers with a strong working tool. The references and bibliography include most previous research citations and relevant articles. In addition, recommendations to future researchers about possible ways to work with other aspects of telematics (e.g., Cost Analysis of Telematics) are included.

**Recommendations for Future Research**

The scope of this research was limited to the construction industry of the United States, and responses recorded in this research were not a substantial representation of the actual state of construction equipment telematics when the research was carried out (however, the sample space for this project is large with 55 completed responses). Cost of investment, training and usability, level of experience, and type and scale of projects make it difficult to quantify the usability of telematics with a sample size of 297 and response rate of 18.51%. However, the survey questionnaire was designed with an objective of covering all parts pertinent to construction equipment telematics. This research is one the first attempts at an academic level to review the usefulness of telematics. More academic research will yield fruitful results.

To review telematics more inclusively and sketch a real picture of the technology’s utilization, the following recommendations are made. These recommendations are expected to improve the research results.

**Larger Sample Population**

The sample space can be more realistic with all participants having some experience with telematics. The target population for this survey was limited to 297 (invited over email, all of which were known professionals with experience in telematics)
with connections to the investigator and co-investigator and social media relation. The design of a larger sample size in collaboration with one or more telematics service providers can yield better results.

**Survey Questionnaire with Focus on Cost Analysis**

The survey questionnaire designed for this research consists of four sections and a total of 28 questions. On average, professionals with experience in telematics can take up to 15 minutes to answer all the questions. The average response time taken to complete the survey was 14 minutes and 55 seconds. The longest time taken to complete the survey was 82 minutes. Suggested additions to the survey include the following:

1. This survey questionnaire does not contain any questions on cost factors of telematics such as initial cost of investment, monthly cost of operation and maintenance (O & M), cost of other supporting software if any, and professional fees for training.

2. More questions focusing on the analysis of problems experienced by users is needed. The survey has only one question about rating the three most commonly observed problems by telematics service providers.

**Semi-Structured Interviews as a Methodology**

Conducting an in-person semi-structured interview with a similar or larger number of survey questions could yield a better result. There would be minimal confusion and thus fewer unexpected or mismatched responses to the questions. In addition, elaboration of the questions and more detailed data collection is possible—e.g., for questions such as, "On how many projects has your company has used telematics?" Such questions are open to interpretation in more than one way. Such detailed questions in an online survey are both time and space consuming. In person, the surveyor will have the opportunity to elaborate the question properly.
APPENDIX A
IRB APPROVAL

You have received IRB approval to conduct the above-listed research project. Approval of this project was granted on 12/21/2016 by IRB-02. This study is approved as exempt because it poses minimal risk and is approved under the following exempt category/categories:

2. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures, or the observation of public behavior, so long as confidentiality is maintained. If both of the following are true, exempt status can not be granted: (a) Information obtained is recorded in such a manner that the subject can be identified, directly or through identifiers linked to the subject, and (b) Subject’s responses, if known outside the research, could reasonably place the subject at risk of criminal or civil liability or be damaging to the subject’s financial standing or employability or reputation.

Should the nature of the study change or you need to revise the protocol in any manner please contact this office prior to implementation.

Study Team:

Bryan Franz Co-Investigator
APPENDIX B
SURVEY QUESTIONNAIRE

REQUEST FOR PARTICIPATION MESSAGE

Title of Research Study: Construction Equipment Fleet Management Using Telematics.

Mr. Rushikesh Jagushte (Graduate Student/Researcher) and Dr. Ian Flood (Academic Adviser)
University of Florida, Gainesville
M.E. Rinker, Sr. School of Construction Management
573 Newell Dr, Gainesville, FL 32603
Phone: 352-745-996
E-mail: rvjagushte@ufl.edu or flood@ufl.edu

Dear Sir/Madam

You are being requested to participate in a research investigation on ‘construction equipment telematics’ in University of Florida, Gainesville. Current master’s student from M.E. Rinker, Sr. School of Construction Management of University of Florida, Gainesville is conducting this research as a part his master’s thesis.

‘Construction Equipment Telematics’ is new concept in construction industry and it is related to method of improvement of productivity and safety of and related to the equipment. **Telematics is an integration of telecommunication and information technology** and in recent years this concept is gaining popularity due to advertised benefits.

The primary objective of this study is to analyse the implementation methods, usability, working system and problems in implementation and use of telematics. Your contribution to this study would be sincerely appreciated. All the responses given will be kept confidential and the data will solely be used for research purpose.
A link found below will lead you to the survey questionnaire design in Qualtrics Survey Software. The response will be automatically recorded upon submission. You are requested to submit your response by January 25, 2016. If you have any questions regarding this survey, we request you contact the researchers via their contact details. If you wish to unsubscribe from the questionnaire, the option is available in this email.

Sincerely,

RUSHIKESH JAGUSHTE,
GRADUATE STUDENT,
M.E. RINKER, SR. SCHOOL OF CONSTRUCTION MANAGEMENT
UNIVERSITY OF FLORIDA, GAINESVILLE
EMAIL - rvjagushte@ufl.edu      PHONE - (352) 745 9969
CONSTRUCTION EQUIPMENT TELEMATICS QUESTIONNAIRE

Informed Consent

CONSTRUCTION EQUIPMENT FLEET MANAGEMENT USING TELEMATICS: USABILITY REVIEW

Please read this INFORMED CONSENT carefully before participating in the study

Purpose of the research study

The purpose of this study is to assess telematics technology for construction equipment fleet management. Construction Equipment Telematics’ is new concept in construction industry and it is related to method of improvement of productivity and safety of and related to the equipment. Telematics is an integration of telecommunication and information technology and in recent years this concept is gaining popularity due to the advertised benefits. The primary objective of this study is to analyze the implementation methods, usability, working system and problems in implementation and use of telematics.

What you will be asked to do in the study

You are asked to complete an on-line survey through Qualtrics survey software. The questionnaire consists of 28 questions, and your participation is voluntary.

Time required

15 minutes or less.

Risks and benefits

There are no anticipated risks or benefits involved with participating in this survey.

Compensation

There is no compensation for participating in this research.

Confidentiality

Your identity will be kept confidential to the extent provided by law. Your information will be assigned a code number. The list connecting your name to this number will be kept in a locked file in survey software associated with student’s university account. When the
study is completed and the data have been analyzed, the list will be destroyed. Your name will not be used in any report.

**Right to withdraw from the study**

You have the right to withdraw from the study at any time without consequences.

**Whom to contact if you have questions about the study**

Rushikesh Jagushte, Graduate Student, Rinker School of Construction Management, Rinker Hall, University of Florida, phone (352) 745 9969.

Ian Flood, Thesis Committee Chair, Rinker School of Construction Management, Rinker Hall, University of Florida, phone (352) 273 1159.

**Who to contact about your rights as a research participant in the study**

IRB02 Office Box 112250
University of Florida Gainesville,
FL 32611-2250
Phone (352) 392 0433.

**Agreement**

By clicking "YES" you have read the procedure described above. You voluntarily agree to participate in the procedure and have received a copy of this description.

☐ YES
☐ NO

If NO Is Selected, Then Skip to End of Survey

Q. 1 Which equipment telematics service provider does your company/division use for equipment fleet management? (Telematics service provider means a firm which provides telematics services to your company. If an equipment manufacturer like Volvo, CAT, CASE etc. is providing this service then write the manufacturer's name.)

Q. 2 Did your firm considered any other service provider beside the one which in use right now?

☐ Yes
☐ No
☐ Not sure
Q. 3 Name of the other service providers which were considered for fleet management?


Q. 4 What type of data reporting and management system of telematics that your company uses?

- Original Equipment Provider
- Third Party Data Provider
- Both

Q. 5 Provide the amount of experience you have with telematics (In years and months)

Year(s)  
Month(s)  

Q. 6 What is the typical equipment fleet size on your construction project?


Q. 7 For how many projects your company has used telematics as a fleet management tool since its adoption?


Q. 8 Which of the following are reasons for which your company choose to use telematics?

- To manage of bigger fleet size
- To achieve fuel economy
- To protect equipment and workers
- To improve maintenance and repair
- To monitor operator behavior
- Other

Q. 9 For what type of construction project(s) does your company/division uses telematics?
Q. 1 Is your company using any other supporting software alongside telematics to report and interpret data more effectively? (MS Excel qualify)

- Yes
- No
- Not sure

Display This Question:
If Is your company using any other supporting software alongside telematics to report and interpret... Yes Is Selected

Q. 2 Which supporting software does your company use?

Q. 3 Rate the benefit of this supporting software for better data management and action plan?

- Very useful
- Somewhat useful
- Neither useful or non-useful
- Somewhat non-useful
- Non-useful
Q.4 Based on your experience with this technology rate the extent to which you think the following points for which telematics is useful (1 is least useful and 5 is most useful)?
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<td>Accurate location of each item of equipment on-site and control over its movement</td>
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<td>Accurate equipment operation hours</td>
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<td>Accurate and time efficient data reporting of activities on jobsite</td>
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<td>Information on underutilized equipment</td>
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<td>Equipment which is prone to time-consuming repair requirements</td>
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<td>Accurate prediction of maintenance needs</td>
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<td><strong>Accuracy of data required for maintenance cycle</strong></td>
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<td><strong>Improvement in Equipment downtime</strong></td>
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<tr>
<td><strong>Accuracy of the Fuel consumption data</strong></td>
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<td><strong>Fuel efficiency based on data received</strong></td>
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</tbody>
</table>

Q.5 What is amount of time spent by your company/division on adopting this technology? (Includes trial period if any before decision of full-time utilization)

- Less than four months
- Between four months and a year
- More than year

Q.6 Number of employees who work with this technology on project(s)


Q.7 Was any pertinent training given to the employees before implementing this technology?

- Yes
- No
- Not sure

Display This Question:

If Was any pertinent training given to the employees before implementing this technology? No Is Not Selected

Q.8 What was the duration for which this training was provided?
Q.9 What points were covered during this training?

- System information
- Working system
- Data collection and management
- Data reporting
- Diagnostic schedule preparation from the collected data

Q.1 Does your team have a data reporting schedule established?

- Yes
- No
- Not sure

Q.2 Which method of data reporting does your team mostly prefer?

- Daily
- 3-5 times a week
- 2-3 times a week
- Weekly
- Once every two weeks
- Other

Q.3 Describe frequency of your data reporting schedule?

- Daily
- 3-5 times a week
- 2-3 times a week
- Weekly
- Once every two weeks
- Other

Q.4 Frequency of data reporting schedule
Q.5 Based on your experience with this technology, how convenient do you think is data reporting?

- Very convenient
- Convenient
- Neither convenient nor inconvenient
- Inconvenient
- Highly inconvenient

Q.6 Based on your experience with this technology, rank the following problems which are most likely to occur while managing fleet data. (This is a rank in order question, you can click and hold on the option to move it in upward or downward direction)

- Inconvenience due to lack of skilled personnel
- Constant alerts
- Excess of non-useful data

Q.1 Do you decide/change or alter the maintenance schedule of your equipment based on the data points from telematics?

- Yes
- No
- Depend on situation

Q.2 What data point do you/your team consider for fuel consumption analysis?

OR

Describe the data points related to fuel consumption which you/your team uses?

- Daily real-time fuel consumption rate
- Total distance travelled
- Distance per gallon of fuel consumed
- Weekly, monthly and total fuel consumption profile (both real time and cumulative)
Q.3 How effective do you think is telematics at fleet management overall based on the scale of 1 to 10 (10 being the highest and one being the lowest) based on your experience?

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10

Q.4 Would you recommend use the of telematics as a fleet management service to the future construction professionals?

- Definite "Yes"
- Maybe "Yes"
- May be "No"
- Definite "No"
APPENDIX C
DEFINITION OF RELATED TERMS

OEM – Telematics services provided by company which manufactures equipment through their market product. (E.g. John Deere provide telematics through JDLink)

End-user asset ID – Equipment tracking ID provided to the customer by service provider

Hours – Work hours of a piece of equipment

Machine odometer – Instrument to track travelled distance

Idle time – Amount of time for which equipment is inactive on field

PTO hours – Personal Time Off or Paid Time Off. It is a policy in some hand books which track employee time of off due any given reasons. Telematics data report keep track of PTO.

Avg. load factor - The ratio of load which an equipment can actually draw during an operation to the load that it could draw. (Actual load capacity to theoretical load capacity).

Ambient air temperature – Air temperature of vicinity of equipment

Active regeneration hours – Active regeneration is required when there is no sufficient heat available in an exhaust to convert the PM being collected in the DPF. Exhaust temperatures is increased by injecting a small amount of fuel upstream of the particulate filter. The chemical reaction which results over the DOC increases the exhaust gas temperatures high enough to oxidize the PM from the filter. (Source: Cummins Engine)
Fault codes (42) – 42 fault codes are listed by AEM/AEMP standards which can occur from equipment on site.
APPENDIX D
LIST OF COMPANIES MENTIONED

CAT – Caterpillar Inc., Peoria, IL – Manufacturer of equipment for construction and mining industry. Founded in 1925 in California. CAT provides telematics services via product named “Visionlink”.

CASE – CASE CE or CASE Construction Equipment is brand of CNH Global, fifth largest construction equipment manufacturing brand in the world.

Volvo – Swedish group of companies known as a ‘The Volvo Group.’ Volvo Construction Equipment was founded in 1832 and a major international brand. Volvo provides telematics services with product named ‘CARETRACK’.


Verizon – Verizon Wireless is an American wireless company. Fleetmatics and Telegois are two brand names under which Verizon worked in telematics.

Fleetwatcher – An Earthware Technology’s product for fleet management headquartered in Indianapolis, IN.

LPH Telematics – An Industrial Equipment Supply company based in Westfield, IN

Fleetmatics – Fleetmatics Group PLC is a fleet management company headquartered in Waltam, MA. A subsidiary of Verizon.

TrackIT – Advance fleet and asset management service provider. Provide scalable GPS and RFID technology.

Trimble – ‘Trimble Company Inc.’ is fleet management service provider headquartered in Sunnyvale, CA.

Divelbiss Engineering – Divelbiss Crop. is an electronic/electrical manufacturing firm headquartered in Fredericktown, OH.

John Deere – An American equipment manufacturing and financing company headquartered in Moline, IL specialized in agricultural, construction and forestry machinery. John Deere’s construction equipment now comes with a built-in telematics system and software services by the name ‘JDLink’.

Omnilink – A service provider which work in collaboration with Sprint to provide fleet management.

OEMDD – OEM Data Delivery is an off-highway equipment management service provider headquartered in Shelton, CT.

Ford Crew Chief – Ford Telematics is a trademark Ford fleet management services powered by Telegois.
HCSS – A software design specifically or construction industry applications which include services such as estimation and bidding, time cards and reporting, dispatching and scheduling, repair and maintenance, safety management etc.

Guardian Global Technologies – A Huston, TX based equipment provider with telematics services.

Qualcomm – US based multinational semiconductor and telecommunication company which provide third-party telematics services. Company has headquartered in San Diego, CA.

GeoTAB – A Canadian telematics service provider company headquartered in Oakville, Canada. Company provide telematics fleet management services for construction projects.

DPL – Third party service provider with an experience of 16, headquartered in Los Altos, CA. Company provide variety of solutions in fleet management of heavy equipment.

WebTech – GPS fleet tracking and asset management services.

BSM – US based fleet management service provider. Company provide telematics services for both heavy construction equipment and rail networks.

Komatsu – Komatsu Ltd. is Japanese equipment manufacturing firm headquartered in Tokyo. Komatsu provides telematics services by the product name ‘KOMTRAX’.

LiDAT – A telematics service providing product of German company Liebherr Group. Liebherr is an equipment manufacturing company founded in 1949.

BSM – BSM Wireless is a third-party telematics service provider. Company provide asset management solutions in rail and construction industry.

AT&T – AT&T is American multinational telecom service provider headquartered in Dallas, TX. One the largest wireless network and fleet management service provider in United States.

Lojack – United States based third-party GPS and fleet management service provider.

Zonar Systems – Seattle, WA based fleet management service provider.

Carlson – Carlson is a Software and Hardware Solution Provider specialized in land development market services.

Manitowoc – A global partner of Telegois for preparation OEM telematics service providing product named “CraneSTAR”.

NAVMAN – New Zealand based fleet management and telematics service providing company.

Bid2Win – B2W is a Portsmouth, NH based software solutions company designed specifically for the heavy civil construction works.
LIST OF REFERENCES


Jackson, T. (2014b). “Two experienced fleet managers tell how telematics data helps make their companies more competitive, explain how to adopt the technology.” *Equipment World.*  


Jackson, T. and Samford, D. (2016). “Telematics 101: Cutting through the jargon to what you need to know to get started with this fleet tracking tech.” *Equipment World.*  


BIOGRAPHICAL SKETCH

Rushikesh Jagushte was born in small town by the name Devrukh in Ratnagiri district, Maharashtra, India. He was always interested in construction and opt for undergraduate degree in civil engineering from reputed Mumbai University in India. He moved from India upon completion of his undergraduate degree in August 2015 with an intention of earning a master's degree in construction management from M.E. Rinker, Sr School of Construction Management of University of Florida, Gainesville.

Upon completion of his degree in May 2017, he will be exploring entry-level work opportunities in the field of construction. His preferences are in project management, heavy equipment management and preconstruction services.