

AC 2009-271: CONSTRUCTION EQUIPMENT FLEET MANAGEMENT USING TELEMATICS TECHNOLOGY: RESEARCH AND RESULTANT EDUCATIONAL PERSPECTIVES

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Construction Equipment Fleet Management Using Telematics Technology: Research and Resultant Educational Perspectives

Abstract:

Construction industry has not kept up pace in the adoption and use of new technologies in general and for fleet-management of construction equipment in particular. As a result, the efficiency, productivity and profitability in relation to construction equipment use has suffered. Fleet management in the U.S., for the most part, still relies on traditional and labor intensive methods of data gathering and evaluation, thus depriving the management from acting on current and reliable data in a timely manner for the benefit of the company. This deficiency remains as an important issue to be addressed in construction curricula.

Use of the *telematics* technology has the capability to enhance constructions equipment fleet management to a whole new level. This paper focuses on a recent collaborative research undertaking to find more about the details of this technology and its impact so far on equipment fleet management. The purpose of the research was to evaluate the use of this technology in construction companies, determine its user acceptance, and to assess the differences it was making in fleet management. The difference made was to be assessed in terms of how this new technology had changed spatial equipment tracking, equipment utilization, equipment maintenance scheduling, operations analysis, job costing, and jobsite/project management related to construction equipment. The paper presents the results in terms of the details of the technology, the methodology of the research, the results of the evaluation, and the conclusions thereof for the purpose of disseminating such information for the benefit of the construction management educators and the construction industry, as well as, elaborating on how this work is finding its way into the classroom for the benefit of the tomorrow's construction managers.

The Technology

The term *telematics* combines “telecommunications” and “informatics.” Literally defined, telematics is the integration of GIS, wireless communications, computational systems, vehicle monitoring systems, and location devices^{1,15,24,25,26}. More specifically it is the science of sending, receiving and storing information via telecommunication devices^{1,2,3,6,20,21}. The etymology of *telematics* is from the Greek "tele" ('far away') and ~Matos (a derivative of the Greek machinari, or contrivance, usually taken in this context to mean 'of its own accord') which combine in the term "telematics" to offer a means of describing the process of long-distance transmission of computer-based information⁸.

More recently, telematics have been applied specifically to the use of Global Positioning System technology integrated with computers and mobile communications technology in equipment fleet

management systems with the goal of efficiently conveying information over vast networks. The widespread availability of broadband cellular data networks has been a major factor in the growth of the equipment fleet telematics. These networks provide reliable wireless data communications with broad coverage at a reasonable cost. GPS, AVL, MRM, WiFi, and RFID are just a few acronyms representing telematics systems and technologies. The growing list is only one indication of the expanding use and variety of applications that telematics technology offers ⁹.

Equipment telematics systems are used by equipment manufacturers and equipment users/owners for different purposes. Manufacturers use it increasingly to provide remote diagnostics in terms of identification of mechanical or electronic problems, or in general proper functioning of the equipment. A full 80 percent of OEMs (original equipment manufacturers) and dealers see telematics as a source of competitive advantage and anticipate benefits from it like enhanced customer relationships and increased parts and services revenue among others ^{5,12}.

Equipment owners/users (endusers), on the other hand, use it to obtain data about if equipment is being used efficiently, productively, and responsibly at a job site to generate revenue for the owner while carrying out the functions that they were designed and manufactured for. For end users, telematics addresses the most critical challenges facing construction and rental equipment companies: namely, increasing equipment utilization, reducing maintenance costs and increasing operational efficiency ⁴. The latter use is what this paper will be focused on. In this latter use, telematic equipment fleet management systems collect, wirelessly transmit and manage critical operational data thus enabling the construction equipment owners and managers keep on top of things, evaluate the details of the use, as well as, track the equipment.

Overall, while the number of U.S. fleet vehicles equipped with telematics / MRM systems has grown to more than 1.7 million, the total market penetration remains at only 10 percent, leaving ample opportunities for continued market growth and expansion. Both end users and vendors are optimistic about future penetration of telematics. End users believe that 20 to 30 percent of new equipment will be fitted with the technology in the next three years. And vendors foresee a 15 to 20 percent penetration for new equipment over the same time period. According to a C.J. Driscoll & Associates study ⁵, the commercial telematics market, also known as mobile resource management (MRM), is expected to expand to 5.8 million units by 2009, with revenues growing to more than \$2 billion. For many fleet operators and telematics is a very promising technology. Currently, more than 2.5 million units are in service, managing fleet vehicles, mobile workers, trailers, heavy equipment, and other assets. However, with more than 20 million fleet vehicles, nearly 5 million trailers, and more than 1 million pieces of heavy construction equipment in service in the U.S., most of telematics' potential remains untapped. More than three out of four construction equipment manufacturers in North America now offer telematics products and services to their customers, according to an Accenture (NYSE:ACN) study of executives in the construction industry ^{1,2}.

Historically, the construction equipment industry has taken a conservative approach to using new technologies, but we're now witnessing a transformation of these companies from product manufacturers to endusers. Equipment telematics will be the key enabling technology that changes their business model and allows them to focus on service and growing revenues ¹³. Still,

the cost are still high in this maturing industry and companies will have difficulty in adopting this new technology unless the costs decrease. Due to its novelty, sellers of the technology lack the necessary skills to do promote the technology adequately and leverage the powerful management capability it offers. End users want telematics to work across equipment brands, but no standards for communication have been set in the industry. As these barriers are addressed, the adoption of telematics by the construction industry will increase even more and the benefits to be realized will promote it even further. For many fleet operators and telematics is a very promising technology^{14,16,17,18,19}.

Fleet management is the management of a company's equipment fleet. Fleet management includes a range of Fleet Management functions including equipment financing, equipment maintenance, equipment telematics (tracking and diagnostics), driver management, fuel management and health & safety management. Construction-equipment fleet management allows companies to remove or minimize the risks associated with equipment investments, improving efficiency, productivity and reducing their overall ownership costs through what it enables equipment owners to do as to be detailed below. These functions can either be dealt with by and in-house Fleet Management department or an outsourced Fleet Management provider^{22,23}.

Equipment fleet management data and reports provision, whether done by the end users or renters of equipment or outsourced to a service company typically entails provision and tracking of following type of data:

Track equipment hours (engine on vs. engine off)

Track equipment hours (working vs. idling)

Equipment Spatial tracking - GPS location (track equipment location by jobsite or as added security feature)-Virtual fences and after-hours security alerts

Curfew (Set operating start times and track if the machine is operated outside the timeframe)

Low fuel warnings

Dashboard alerts

Track work levels (low load, medium load, high load) and fuel utilization for each level

View total fuel consumed

View time spent moving machine vs. using machine

Track machine functions used

Information can be viewed on the Internet

Alerts can be sent directly to customer's cell phone or pager

Download information directly from the machine

User-defined management and maintenance reports

Multiple maintenance profiles and notification:

- Productivity Reporting
- Driver directions and instructions
- Critical machine-health monitoring
- Easy back-office software integration
- Reliable message delivery and ruggedized construction

Benefits:

- Reduce cost and increase productivity and profitability
- Optimize preventive maintenance and extend equipment life
- Maximize equipment utilization and uptime
- Improve customer service and satisfaction
- Monitor equipment health
- Integrate equipment data with your business systems
- Reduce the risk of loss due to theft or unauthorized use

Telematics-based equipment fleet management technology enable and/or help addressing the following:

- What's happening *right now* at your jobsite?
- Do your job cost estimates contain a *margin of error* that sometimes costs you the business?
- Have you received all the tax credit you're entitled to?
- How can you get accurate jobsite data without tying up people with tasks and paperwork?
- How can you insure service is done *exactly* when it's needed?
- Do you have the best-available tools for decision-making?
- Which equipment is under-utilized?
- Which repair activity takes the most time?
- Which equipment has the most "down time"?
- How many loads were moved last month?
- What's your biggest headache?
- Productivity?
- Service costs?
- Compliance management?
- Fuel Management?

The Company

Earthwave Technologies Inc.⁷ has been in business since 2000 as a user of telematics technology to provide real time data to construction equipment owners i.e. construction companies and equipment renters through its Fleetwatcher system.

Equipment, fuel, service/repairs and labor account for the majority of the costs in construction work involving heavy equipment. The fact that in this kind of construction work these costly

assets (equipment) and expenses (labor) are remote and mobile, make them much more difficult, if not impossible to accurately monitor, measure and manage.

The proprietary system, Fleetwatcher, which was built specifically for the heavy equipment industry, gathers equipment information and delivers it in a way that is easy to understand and ready to act upon. Fleetwatcher is a unique wireless Construction Management System. It consists of a "black box" that is installed on equipment, a wireless network and an extensive but easy to use set of management reports. By eliminating the manual systems that track equipment use and activity with "technology", Fleetwatcher provides the people dealing with equipment use in the organization with the accurate, timely facts about equipment use, activity and in some cases productivity, that empowers them to manage these high priced assets and related expenses to enhance profitability^{10,11}.

Fleetwatcher uses a device contractors attach to their vehicles that collects and transmits usage data through a GSM wireless data network to Earthwave's internet-based application. The Fleetwatcher application provides the contractor with an easy-to-use, online software reporting interface that allows them to view and manage all the data collected from their equipment. Earthwave Technologies' proprietary hardware and software collects data on location/tracking, frequency of equipment use, amount of time spent working, amount of time spent idling and engine starts. Contractors use the information to determine job progress, labor hours accounting, equipment productivity, preventative maintenance needs and misappropriation of machinery.

Each Fleetwatcher unit tracks and transmits how much that equipment "runs" every day, how much it "works" every day, equipment location and load counts on certain equipment. The Fleetwatcher unit wirelessly transmits this information to a website for ease of access and ease of use. This information, which is housed on Earthwave's website, is then processed and delivered in the specific data and format requested by users. The Fleetwatcher software modules (Project Management, Equipment Utilization, Maintenance and GPS Location Modules) turns that data into timely, useful management information that can help your people in the field, in the shop and in the office do their job more effectively, efficiently and ultimately more profitably.

These reports (available online or in MS Excel format) can be shared with the whole management or operational team of the equipment owners. With over 20 reports and hundreds of filtering options available, the users have all the information they need to manage everything from a quality preventative maintenance program to equipment costs and operator performance. If desired Fleetwatcher can be automatically integrated with the equipment users' companies accounting and job cost systems thus bringing everything needed for operation and management together for a more comprehensive view. Customized GPS technology inherent in Fleetwatcher provides real time information as to where equipment is located. There is no need for guess work or endless phone calls to track down a piece of equipment. All location reports are available online or downloadable to most common mapping programs.

Fleetwatcher tracks multiple data points, including:

- cycle times
- productivity and down times

- equipment utilization and underutilization
- exact location of each piece of equipment
- project status
- budgets
- shop costs
- rental expenses
- trends and behaviors

Realizing that data is useless if it doesn't help provide real solutions to end users, Fleetwatcher provides data in reports and formats that allow end users manage their business from a number of different perspectives as detailed below:

1. Productivity:

- Identify and eliminate workflow inefficiencies
- Improve job forecasting and budgeting as a result of knowing how equipment is used
- Eliminate the manual process of collecting hourly readings without losing the data
- Determine project status on multiple projects
- Identify and evaluate trends and behaviors

2. Utilization:

- Maximize assets by making informed decisions regarding those assets
- Identify underutilized equipment to liquidate
- Reduce rental expenses
- Improve employee and equipment uptime by monitoring status

3. Idle Reduction:

- Improve profitability
- Save on equipment depreciation and maintenance costs
- Save money on fuel
- Save the environment

4. Preventative Maintenance:

- Get timely and accurate information with automated reports of engine hours and mileage
- Extend equipment life
- Avoid unplanned downtimes that can be costly
- Reduce the need to rent gear as backup
- Improve life expectancy of equipment

Real Financial Returns: Fleetwatcher provides many benefits all of which lead to the bottom line related to equipment use by informing equipment owners of exactly what equipment and people are truly doing at all times. The purpose is to provide the right data so that right decisions can be made. The benefits can be summarized as follows:

Better Asset Management:

- Improve transportation logistics
- Gain real-time insight into current fleet utilization
- Find exact equipment locations at any time
- Streamline preventative maintenance
- Stop unauthorized usage

Greater Productivity and Efficiency:

- Increase operator and driver productivity
- Decrease reliance on manual processes
- Gain real-time access to production information like start times, cycle counts, and real idle time
- Reduce fuel cost by actively managing engine idle time

Better Control over Costs:

- Reduce rental costs
- Greatly reduce fuel costs
- Improve equipment costing process by comparison of operator timesheets vs. actual equipment usage
- Increase value of equipment

Real-time engine idle tracking impacts more than the bottom line:

- Greatly reduces unnecessary idle time
- Stops accelerated depreciation of your equipment
- Reduces preventative maintenance cycles
- Provides insight into the true costs of unproductive engine idling
- Reduces greenhouse gases and pollution

The new version of Fleetwatcher, version 3.4, has some of the added features include a new manual entry of hour- meter data, a low battery alert, an ignition on alert and an enhanced idle alert. Customers will also be able to access new and enhanced reports, including a new alert report and idle summary report. More information is available at the company's website at www.earthwavetech.com.

Research Methodology

Scope of Research

The research was of a collaborative nature between the private company Earthwave Technologies Inc., and the Construction Engineering Management Technology (CEMT)

Program of IUPUI (Indiana University-Purdue University Indianapolis). This research work was motivated by the desire to find out:

- What was motivating the companies who bought the technology to do so.
- What were the main ways the companies were using the technology among the following functions:
 - Equipment tracking
 - Equipment utilization
 - Equipment maintenance tracking
 - Job costing
 - Operations analysis
 - Jobsite and Project Management
- What kinds of changes the technology was conducive to in fleet management practices.
- Were the companies using the technology able to take advantage of all of its capabilities and if not why not.
- As one of the principal intended outcomes of using the Fleetwatcher technology, were the companies able to reduce useless idling and see any monetary returns as a result.
- How effective the technology was in helping the companies carry out preventative maintenance on time without unduly hindering equipment operations.
- How effective the technology was in tracking equipment and whether the outcomes were notable.
- Overall, was the investment in the Fleetwatcher technology worthwhile in terms of the quantitative (monetary) and qualitative returns realized.
- How the technology could be improved to make it address fleet management needs of companies more effectively, efficiently, and profitably.

The companies were so chosen that they had used the Fleetwatcher Technology for a length of time adequate for them to be able to make meaningful assessment of the advantages and disadvantages associated with such use. The companies were chosen so that they owned or rented equipment, had managed both over-the-road and off-road equipment, and exhibited union or non-union characteristics.

Despite the limited size of five companies not necessarily constituting a statistically representative sample, statistical inferences were made in percentage terms to exhibit the nature of the responses.

The research was conducted by means of a survey instrument developed with additions and modifications to existing company literature and documents, as well as, some new material, all reshaped to extract responses without undue demands on the part of people responding to the survey. The survey instrument consisted of several parts as follows:

1. General Questions
2. Specific Questions
 - A. Equipment tracking
 - B. Equipment utilization
 - C. Equipment maintenance tracking
 - D. Job costing
 - E. Operations analysis
 - F. Jobsite and Project Management

A student intern was placed with Earthwave Technologies Inc. to administer the surveys and compile the results and data from the surveys. The surveys were administered through either meetings with company people face-to-face in a meeting, posing the questions, and noting and taping the answers or by sending of the survey and compiling the responses through electronic means. The Survey Instrument was sent to the companies beforehand every time.

Research Results Presentation

The survey results were presented both in Excel spread sheet form, as well as, in narrative form. The raw data from the surveys were stored on an online electronic platform for easy access to evaluate the results by company. The research results presentation manual entailed the following parts.

- Executive Summary
- Summary responses as an aggregate from all companies to each survey question.
- Individual responses from each company to each survey question presented in Excel spreadsheet form.
- Individual response from each company to each survey question as raw data printed from an online storage platform.
- Survey Instrument.

Executive Summary

A. Preliminary Information:

- The people who responded to the Surveys carried the following titles: General Manager, Vice-President, Office Manager, Controller, Cost Accountant.
- Companies chosen are from or worked in the following states: IN, MI, OH, IL, SC, PA, NC.
- Type of projects involved:
 - Department of Transportation work
 - Site development
 - Land fill work
 - Subdivision work
 - Industrial construction
- Types of equipment involved: dozers (bulldozers), scrapers, excavators, haul trucks, articulated trucks, loaders.
- Number of equipment with Fleetwatcher technology:
 - Total for all companies= 681
 - Minimum at one company= 71
 - Maximum at one company= 277
 - Average= 136
- Length of time (months) companies have been using Fleetwatcher technology:
 - Total for all companies= 173 months
 - Minimum for one company= 4 months
 - Maximum for one company= 60 months
 - Average for all companies= 35 months
- Other total equipment for all companies at site but not having Fleetwatcher technology:
 - 101

- Equipment type for all equipment using Fleetwatcher technology:
 - Off-road
- Type of company – 3 responses :
 - 1 Union
 - 2 Non-Union

B. General Conclusions & Recommendations from Research:

Despite the fact that the sample size involved in this research undertaking was small, the results, in our opinion, were of significance to reach some conclusions that may be of value as will be elaborated on below.

The introduction of new technology by Earthwave to a new company inherently and unfortunately suffers from the reality that if the technology is accepted and bought, and, if it is used properly and it succeeds, it may very clearly indicate to the fact that the equipment fleet was probably being managed quite inefficiently and unprofitably before using the Earthwave technology. Realizing this, there is probably little incentive, if any, on the part of a lot of people involved in the decision-making process/stage to be enthused about this adoption at the beginning or ensuring its success after the purchase. It is thus recommended that Earthwave approach family-owned companies more aggressively than other types of companies and always approach from the top rather than at the fleet management level.

In line with above, the fact that some sections of the survey were responded to by people who may have had some sort of a stake in the outcomes may possibly mean that they may not have been totally unbiased in their responses and the results may need to be looked at with that premise in mind.

Earthwave markets its Fleetwatcher Software product first and foremost in terms of its capability to track useless idling. The responses from the user companies confirm the user companies' awareness and appreciation for this. Overall, however, this point did not come out as one that carried a huge importance or impact during purchasing decision-making and/or after the purchase. Part of this may be due to the fact that admitting to significant losses due to useless idling before acquiring the technology would not have looked good at this point. Another reason may be that the companies are really not able to monetarily quantify the savings from this capability of Fleetwatcher despite Earthwave's efforts in this respect and more enlightenment of the companies may be needed.

A striking observation was that despite the capability of Fleetwatcher, in our opinion, to move the companies to a totally new and enhanced platform in terms of fleet management, some companies were still somehow clinging to their previous ways of doing things like manual hour-meter readings, equipment related site visits, and the like. One explanation for this may be the inherent resistance of human beings to change. The other explanation may be that Fleetwatcher is being looked at, probably by some people involved with fleet management, as something that

they have to put up with,. A third possibility, and one about which Earthwave probably has the most control over, is lack of appreciation on the part of people who are supposed to be using Fleetwatcher as to what the capabilities of this technology they are equipped with are.

Along the same line, it is to be noted that, even the companies that understood and were using Fleetwatcher in a serious way, were not sure they had recouped the investment they had made, even though they were hopeful that they would. What this is telling us is that, for example, being able to do maintenance on time and thus preventing a costly overhaul as a result, is probably not something that they look at as something affecting the bottom line since they are not able to quantify it or it is not being recognized at all. For example, people typically do not look at the insurance premiums they are paying for their different belongings as something that is saving them money. Obviously Fleetwatcher is affecting the bottom line in every capability it brings into the picture

This again brings forth the need for education of the companies for being able to monetarily quantify outcomes, and, more importantly, train them in uses of Fleetwatcher in ways that directly affect the bottom line. Training companies to calculate savings from preventing useless idling is only one of these. Encouraging of using of Fleetwatcher to track productivity and tie it to the construction schedule, or, helping them in seeing some savings qualitatively if they are not necessarily able to see them in monetary terms may be others There are probably several other savings which are going unnoticed since they are difficult to quantify in dollar terms. An example is useless site visits. Even though use of Fleetwatcher has most probably reduced the number of visits to the project site (one company that responded to this question says that they still have visits to the site related to equipment use), this is not seen as a monetary saving of cost of management time and direct cost of trips themselves.

The conclusion from above is that a concerted effort on the part of Earthwave to provide extensive training may need to be planned and implemented. It is to be noted that despite what training Earthwave is providing at the beginning, training needs to be a more ongoing undertaking with a certain frequency for a duration to be agreed upon with the user company. The reasons are turnover in the company and that as companies get more experienced with and more appreciative of Fleetwatcher, they would want it to penetrate more extensively into the fleet management culture over time.

A response that supports the above conclusion is that companies were buying Fleetwatcher as a leap of faith initially rather than as a result of very informed and definitive understanding of its capabilities.

Another observation was that if a company had a software-based way of doing things before Fleetwatcher purchase (such as maintenance-tracking using software) they did not necessarily get rid of this and put Fleetwatcher in place of it. Even though they started using Fleetwatcher in some other functions, the functions that were already being undertaken by some computer software were seemingly immune, that is, familiarity ruled the day. This prevented Fleetwatcher from taking over the fleet management culture more exhaustively. It is not clear how this can be overcome. Further education will definitely help or time may possibly take care of this in the long run by itself unless a more active approach is considered.

Our feeling overall was that companies were trying to figure out how Fleetwatcher can be used in different functions on their own, rather than, being aware of these from the beginning and trying to focus on the implementations. It is of course also possible that they are aware but are having difficulty in or resistance to implementation.

People did not usually respond to questions that needed further elaboration on or explanations but were accommodating in replying to “yes” or “no” or “multiple choice” etc., type of questions. In this respect, for future surveys one may consider : shortening the survey instrument; making online response an option; more yes, no, or multiple choice type of questions; sending the instrument to the top person and communicating about the survey with just the top person; and finding a way for the people who are supposed to be responding to the survey feel motivated to do so.

Note that despite Fleetwatcher use, even for a company using it for over 5 years, there were visits to the project site “to see things first hand”. This tendency for not being able to let go of traditional ways needs to be researched further as to why and how it can be overcome. There was nothing much to go on to research this any further from the survey responses.

None of the companies surveyed are aware of the fact that they may be entitled to the reductions in insurance premiums due to Fleetwatcher use or unaware of any reductions that may have been realized in terms of the person responding to the survey.

Similarly, none of the companies seem to be aware of the fact that they may be able to take advantage of some state/federal grants due to reduction of pollution from their equipment fleets due to minimization of useless idling. We are aware of Earthwave aggressively trying to get the point across for savings due to prevention of useless idling but not necessarily of other possible indirect savings.

Even though it reasonably should have been the case, it is not possible to trustfully conclude from the survey responses that all companies were able to make use of Fleetwatcher as much as they would have been normally expected to do so.

Our overarching conclusion, looking at all the responses holistically, is that, companies which were properly organized and had somewhat streamlined their fleet management practices before Fleetwatcher, through a computerized means or otherwise, are/were happy with and running with Fleetwatcher. Others, possibly thinking that Fleetwatcher would bring the discipline and culture for proper fleet management that did not exist to begin with and hoping that Fleetwatcher would be a panacea for their long-term and ongoing problems may need to work at it.

Paper Conclusion and Implications for Construction Education

The topic of “Fleet Management Through Use of Telematics Technology” was assigned as a research paper topic in the Fall 2008 semester in the CEMT 330 - Construction Operations and Equipment course in the curriculum. It was readily observable from the outcome of this assignment that most, if not all, of the students were not aware of this important use of

technology in fleet management that makes the task of fleet management more easy, efficient, productive, and profitable. They were happy to have been given a chance to develop some insight for this very current topic in equipment fleet management. Considering that today's students in construction management and similarly named programs are going to be the ones who will spearhead adoption and implementation of the new and contemporary technologies of their times in the construction industry, this outcome of appreciative acceptance of the assignment by the students was encouraging.

The research conducted by the authors has indicated that there may be inherent difficulties in getting the new technologies integrated into the traditional culture of construction companies or their way of working. Further research is being planned by the authors to survey students through another assignment for them to think about and present the ways they will go about in making sure worthwhile new technologies and methodologies are accepted by their prospective companies in their future careers. The authors think an effort by all construction educators in the same direction could prove to be very effective in ensuring enhancements in the nature of the construction industry into the future.

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