Utilization and Implementation of the E-Ticketing Technology to Electronically Track the Delivery of Construction Materials

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Abstract: Traditional paper-based ticketing systems that are used to track trucks loaded with construction materials have some major issues, such as theft, extended travel time, risk of injury while collecting tickets, illegible records due to mutilated tickets, etc. The construction industry would profit from taking advantage of the rapid advancements of data technology and the internet that have occurred within recent years. Employing digital technologies to improve their productivity, i.e., implementing electronic tickets or e-tickets instead of paper-based tickets, could make a noticeable difference in construction material delivery. Therefore, the aim of this study is to investigate the concept of e-tickets from different perspectives, including the construction field, and discuss the current applications of this technology. This paper also scrutinizes the benefits of and barriers to implementing e-ticketing for an efficient inspection approach to construction material delivery. For this purpose, scholarly articles, along with articles from departments of transportation (DOTs) and tutorial websites, were studied. It was observed that several highway projects and ready-mix concrete companies from North American countries are using or are willing to use e-tickets in their projects. Major challenges in adopting this process are confusion regarding the type of software to use, reluctance to adopt new technologies over the company legacy, unwillingness of field personnel to use e-tickets due to lack of adequate technical knowledge, etc. Major benefits of e-tickets are cost reduction, greater transparency, and productivity improvement. This paper will assist service providers who intend to implement e-ticketing to successfully adopt this service to their system.

1 INTRODUCTION

The construction industry is one of the largest industries of the world. The U.S. construction industry spent more than $1200 billion in the year 2017, and employed more than 10 million people (Valentic 2018, Anonymous 2018). The industry is highly dependent on materials, as by definition, construction is the physical building or repairing of a structure or infrastructure (Kermanshachi et al, 2017). For example, a miles-long bridge can't be built out of nothing; it requires tons of concrete, reinforcement, and asphalt materials. The sources of these materials are often located far away from the job site, and the responsible party must ensure timely delivery of the materials during the project life.

With the development of globalization and technology, construction projects are becoming larger and more complex (Kermanshachi et al, 2016a and 2016b; Dao et al, 2017). High revenues are attracting more practitioners to the construction business, and national construction companies are becoming international due to the high rate of urbanization and population growth (Javernick-Will and Scott 2009). Revenues of the construction industry highly depend on the cost and schedule performance of the construction projects (Kermanshachi 2016). Late delivery of construction materials is one of the major causes of delays (Sweis

et al. 2008; Assaf and Al-Hejji 2006; Habibi et al. 2019), and with delays, the cost and schedule of the project exceed those projected, thus negatively affecting the revenues of the construction entity.

With the rapid advances of data technology and the internet in recent years, the construction sector, like other sectors, is encouraged to use e-ticketing for inspection activities. The major benefits of adopting this technique for material delivery are having a distance-tracking facility, greater transparency, and increased productivity. Through e-ticketing, it is also possible to track delivery of construction materials, such as concrete, by providing haul reports, travel time, and the tonage of the materials. It also facilitates more complete recordkeeping. The idea of using e-ticketing in the construction material delivery system is a rather new idea, and there is a lot of room for improvement. Therefore, the aim of this study is to investigate the concept of e-tickets from different perspectives, and scrutinize the benefits of and barriers to implementing it for tracking construction materials' delivery and efficient inspection. For this purpose, the advantages and challenges of implementing different e-ticketing strategies for material delivery were studied. This paper will assist service providers, who intend to implement e-ticketing, to successfully adopt this service to their system.

2   METHODOLOGY

To fulfill the aim of this paper, a thorough search was performed, using popular search engines like google scholar. As this study presents a topic with limited existing literature, popular tutorial websites like TechRadar, initiafy, ehstoday, tutorialspoint, etc., were also considered, and the author surfed through the webpages of U.S. DOTs to collect additional necessary information. Once the information was collected, it was scrutinized thoroughly and presented in an organized way. The planning process is shown in Figure 1.
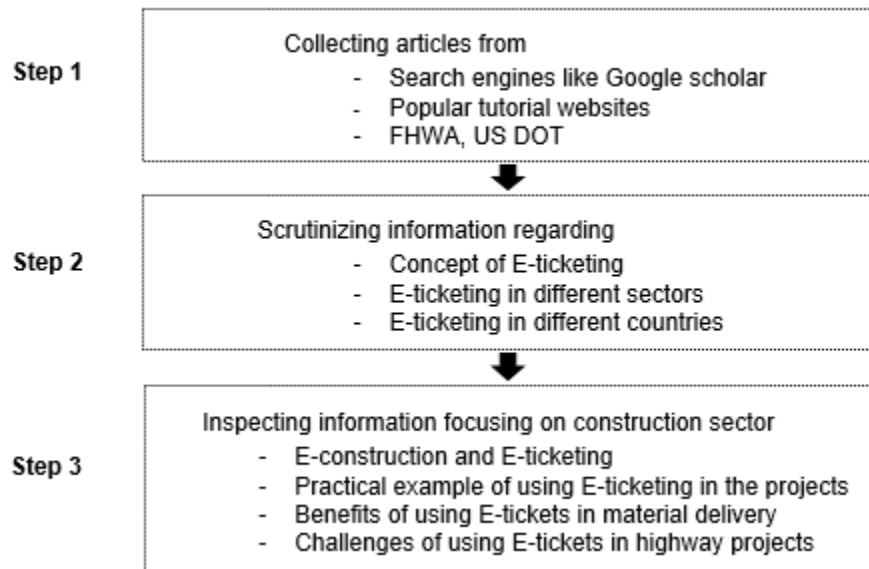

Figure 1: Research Methodology

3   OVERVIEW OF E-TICKETING

3.1   E-Ticketing

E-ticketing, or electronic ticketing, is a method of going paperless (Newcomer 2018). It is a process by which the user can store and read information through the use of electronic devices. It also provides tracking

capabilities, using GIS technology. The amount of information that can be stored varies with the adopted type of e-ticketing.

3.2   Types of E-Ticketing

E-ticketing is the concept of tracking product movement with instant updates of information with the help of GIS and the internet. The technologies that collect data using different digital mediums are collectively known as automatic identification and data capture (AIDC). Characteristics of a few of the most popular AIDCs are explained in this section.

3.2.1   Bar Codes and Optical Character Recognition (OCR)

Bar codes and optical character recognition are among the first generation of automatic tracking systems. They can store and transmit information with the help of wireless communication. The bar codes and OCR systems are quite similar, and use software that transforms bar codes into readable text, images, pdfs, etc. Bar codes have become an important element of modern human civilization, as they are being used in stores, hospitals, the airline industry, etc. (Oberfield 2012).

3.2.2   Magnetic Stripes

This is also a first-generation AIDC. Magnetic stripes use iron-based magnetic elements on a card to store data that can be read by swiping the card against a magnetic head (Wikipedia Contributor 2018). The cost of the equipment used for utilizing them varies widely.

3.2.3   Radio Frequency Identification (RFID)

For radio frequency identification (RFID), a tag is attached to the object to be tracked. Radio waves store and read the information. Railroad companies are successfully using this system to track rail cars. The main advantage of this system is that an RFID tag can be reprogrammed an unlimited number of times, which makes it cost effective; however, data flooding (producing unnecessary data) is an inherent problem (Wikipedia Contributor 2019a).

3.2.4 Smart Card

A smart card is similar to a credit card, but unlike a credit card, it contains a microprocessor that holds the information required to track products. Smart cards are being used for financial purposes, subscriber identity modules purposes, identification purposes, public transit purposes, health care purposes, etc. (Wikipedia Contributor 2019b). A smart card is very inexpensive. .

3.2.4   Voice Recognition

Voice recognition is a hands-free technology with the capability of interpreting spoken commands. The best software programs for using this facility are Dragon NaturallySpeaking, Google Docs Voice Typing, Google Now, Siri, and Cortana. Dragon NaturallySpeaking is the best software for voice dictation and recognition (Graham 2017). The main disadvantage of this system is that it costs more than other systems (Business.com Editorial Staff 2018).

3.2.5   Near Field Communication (NFC)

Near field communication (NFC) is a method of transferring wireless data that is derived from RFID. The distinguishing characteristic of this system is that it doesn't require an internet connection. It performs data transfers from devices that are in close proximity; however, it also enables devices to transfer a limited amount of information among themselves. The most popular use of this system is the smartphone (Faulkner 2017).

4   E-TICKETING IN DIFFERENT SECTORS

In 1984, after six years of preparation, United Airlines became the first company to use e-ticketing successfully. The main factors that encouraged the airline companies, as well as travelers, to use e-ticketing were freedom from carrying paper documents and the security of the information. The airline sectors have also realized other benefits, like eliminating paper-ticket fraud, eliminating lost/stolen tickets, reducing document distribution cost, etc. However, adopting e-ticketing in more open-access sectors, like railroad services, was challenging at the beginning. After making some alterations to the airlines' systems, railroads in different countries are using e-ticketing successfully. Among these alterations, electronic or manual check-in and check-out points with prepaid e-tickets, restricting the access to the stations, and creating e-tickets applicable for short distances are mention worthy. Railroads primarily use smartcards with RFID types of e-tickets (Ng-Kruelle et al. 2006). The magnetic ticketing system is the most-used e-ticketing system in the transportation system; however, the public transportation system has been trying to adopt the contactless ticketing system since the 1990s, with the use of RFID and NFC. The health sector is successfully using e-ticketing to track their inventories, medicines, and even patients; they mainly use the bar-code type of e-ticketing. The logistics practice is another sector that widely uses e-ticketing (Kandel and Klumpp 2012). Another sector that highly depends on e-ticketing for tracking is the postal service, as they strive to provide real-time visibility of their mail and packages to their customers (Anonymous 2017a). The transportation sector is using e-tickets quite successfully. Quite a few of the state departments of transportation in the USA now use e-tickets to track material-loaded trucks, and the rest of them plan to use them in the future.

5   E-TICKETING IN DIFFERENT COUNTRIES

The world is becoming more and more dependent on the internet. Worldwide, there were 4.1 billion people using the internet in December 2018 (Stevens 2018), many of them using it for making price comparisons and verifying the quality of products before shopping for them. Hence, internet-based e-ticketing is becoming increasingly more popular, and many countries are adopting it for online shopping. E-marketing has become quite popular in countries from the Asian Pacific region, like the Philippines, Thailand, Hong Kong, and Malaysia. Because it is convenient and easy to use, Malaysian people are adopting e-ticketing quite comfortably, but a few people still have trouble depending on a human-less system and are hence uncomfortable using it (Sulaiman et al. 2006). In Germany, the railway authority is successfully using a RFID type of e-ticketing to track passengers' tickets and rail cars (Ng-Krulle et al. 2006). Several ready-mix concrete (RMC) companies in Canada are also using e-ticketing and e-invoicing for delivering concrete and tracking RMC trucks (Anonymous 2017b).

6   E-TICKETING IN CONSTRUCTION INDUSTRY

Construction projects are becoming mega-complex projects, with a lot of information that must be recorded regularly. The traditional paper-based system has become cumbersome, so the construction industry has successfully started using e-construction, with the aim of going paperless and making the information more secure and accessible to the stakeholders. Over the last few years, departments of transportation of several states (Texas, Missouri, Iowa, Rhode Island, West Virginia, Florida, etc.) held e-construction summits to discuss the advantages of and barriers to adopting e-construction, and almost all of them liked the idea of going paperless. A major addition to this idea could be adopting e-ticketing for material delivery. Figure 2 shows a very simplified material supply system of a construction project.

In a traditional material delivery system, the material-supplying process has three flows, namely information flow, material flow, and money flow (Anonymous, retrieved 2019). The process starts with the contractor placing an order with the supplier, in exchange for payment. The supplier initiates transporting the order with delivery personnel or delivery trucking, who deliver it to the contractor. Throughout the process, records pertaining to the materials are generated and kept for proving that the supplies ordered were received and paid for. This whole record-generating-and-keeping procedure is currently done by human beings on paper, and is a big disadvantage because it consumes too much time and human resources. Moreover, the manual

process almost always includes a risk of human error (Lee and McCullouch 2008). E-ticketing can be used as an efficient solution to this problem.
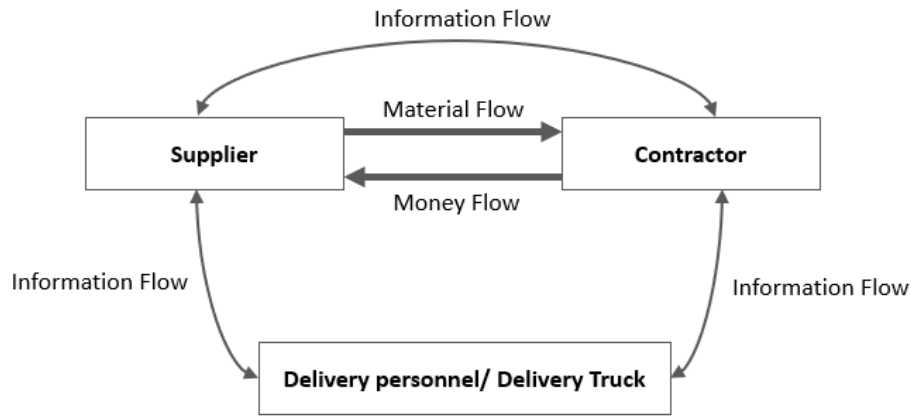

Figure 2: Simplified material delivery procedure.

6.1   E-Construction and E-Ticketing

The benefits of and barriers to adopting e-construction for highway projects are being examined, as a significant amount of time and labor is involved in completing the massive amount of documentation required by the traditional paper-based system. E-construction is the paperless administrative system that delivers projects without using any paper. In this process, every stakeholder uses an electronic medium to submit, approve, and route the required documents. This process not only saves money and time, but also improves communication among stakeholders. The Michigan DOT investigation into using e-construction in a $1 billion project revealed that it would save six million pieces of paper and reduce the contact time from 30 days to 3 (FHWA 2018). More than 45 DOTs in the USA, including Michigan, Minnesota, Florida, Utah, and Texas, are already enjoying the advantages of e-construction to the fullest. Combining e-ticketing with e-construction will make the recordkeeping even more organized and efficient.

6.2   Practical Example of Using E-Ticketing in the Projects

The Indiana Department of Transportation (INDOT) uses e-tickets in its material delivery system. The majority of the stakeholders use bar codes, and material suppliers of INDOT projects are required to develop a ticket with a bar code and other necessary data. This is called a delivery ticket, and it is carried by the trucking company. Once the trucking company reaches the job site, the INDOT inspector collects the ticket and scans it. SiteManager software is used to retrieve data from the ticket and transmit it to the trucking company, material supplier, and contractor. Major advantages, according to INDOT project personnel, are cost and time effectiveness during delivery, real-time delivery management, and instant reports for billing (Lee and McCullouch 2008).

In 2015, the Iowa DOT (IADOT) proposed using e-ticketing to track material trucks from the source to the job site by employing GIS and propriety software (IADOT and NDDOT 2015). By 2017, the IADOT had successfully used e-ticketing for tracking and synchronizing asphalt-bearing trucks for various projects (Schulz 2017).

The Delaware Department of Transportation (DelDOT) started using e-ticketing in combination with FleetWatcher software (FHWA, USDOT, UVA TTA, and VDOT 2016). Many other state DOTs are now showing a willingness to adopt e-ticketing in their projects.

6.3   Benefits of Using E-Tickets in Material Delivery

Highway projects need a lot of heat and time-sensitive material like asphalt to complete projects that cover a lot of area. The success of these projects highly depends on time-efficient material delivery; hence several U.S. DOTs are willing to use e-tickets for this purpose. Several peer-exchange meetings were held to discuss this issue. Author studied the summary reports of peer-exchange meeting among two or more of the state DOTs like Iowa, North Dakota, Florida, Massachusetts, West Virginia, Arkansas, Michigan, Washington, Texas, Montana, Maryland, North Carolina, Utah etc. Based on these reports along with other materials like Newcomer 2018, Schulz 2017, Lee and McCullouch 2008, a list of benefits of using e-tickets in material deliver are made in Table 1.

Table 1: Benefits of using e-tickets in material delivery

Name	Description
Increased productivity	A loaded truck doesn't need to wait while the other trucks are dumping, thus increasing productivity.
Improved safety	Personnel responsible for collecting tickets do not need to stand near idling trucks.
Time efficiency	Tickets do not need to be added manually, thus saving time.
Time management	Several trucks can be synchronized for continuous operation.
Reduced manpower	Reduces the number of men needed for manual documenting.
Accountability	Real-time tracking ensures direct travel to the job site.
Cost-effective tracking	An efficient tracking system can be implemented at a very reasonable cost.
Fastest billing	The delivery report can be sent to the accounting system instantly for billing.
Reduced paper cost	E-tickets result in minimal paper consumption.
Reduced contact time	Face-to-face contact time is reduced.
Reduced risk of losing tickets	Unlike paper tickets, e-tickets can't be lost.
Better control	E-tickets can record stopping time, calculate travel time, and record engine-running time, thus providing better control.
Improved relationships	Automated systems improve relationships among stakeholders.
Simplified data collection	Once the batch ticket is developed at the manufacturing site, data is collected and upgraded only by scanning, making the process simple.
Weight control	Weight limits of the truck and materials can be strictly maintained by the use of e-tickets. For example, state of North Dakota uses RFID tags to manage and collect data regarding weights of the trucks with material.
Clean and readable information	Eliminates personnel's stress induced by keeping the tickets clean and the information readable.
Improved tools	Provides an easy document access system, and provides searchable text.
Improved transparency	The project partners' real-time access to the documentation and material tracking makes the system transparent.
Improved access	Documents and records are available to any remote location.

6.4 Challenges of Using E-Tickets in Material Delivery

The advancement of technology significantly varies from place to place, and the availability of software that can be used for e-ticketing also varies. Moreover, making a new technology acceptable to people is always a challenge. People have be convinced of the good qualities of the new system before they ill willingly adopt it. Table 2 explains several challenges to successfully implementing e-tickets for material deliveries based on the studied materials mentioned in section 6.3.

Table 2: Challenges of using e-tickets in material delivery

Name	Description
Commercial vs in-house software	Some states, recommend that contractors use commercial or in-house software, as long as the specifications are met. Confusion might result if the contractor keeps changing the adopted software from project-to-project.
Compatible partner	One of the major issues with implementing e-ticketing is finding the right software and/or software providers.
Developing a custom system	Developing a custom system involves a lot of meticulous decisions, which might create a problem for the company.
Mismatched business processes	The newly developed custom system might not match with the business processes of involved stakeholders.
Legacy system	Companies often prioritize their legacy system over the new technologies, which might create problems.
Inconsistent data	Based on the technology and connection type, data recording or transferring might contain inconsistencies.
Inadequate technical knowledge	Personnel with inadequate technical knowledge might create problems.

7 CONCLUSION

With the advancement of technology, the construction sector, like all other sectors, is becoming digitalized. Implementing an automated delivery system with the help of e-ticketing is a highly beneficial addition to this digitalization process. Even though e-ticketing is quite popular in different sectors, including airlines, postal services, etc., construction industries are rather new at implementing this technology. Many countries are using e-tickets in various sectors, but very few are using them for construction material delivery. North American countries are pioneering the use of e-tickets in implementing e-ticketing for efficient inspection approaches to construction material delivery. After a thorough study of these project summary reports, along with other scholarly articles, numerous benefits, such as cost reductions, greater transparency, improved productivity, reduced manpower, etc. were listed in this study. Major challenges facing companies during this process are confusion regarding the type of software to use, reluctance to adopt new technologies over the company legacy, the unwillingness of field personnel to use e-tickets due to lack of adequate technical knowledge, etc. This paper contributes to assisting service providers who intend to implement e-ticketing to successfully adopt this service to their system. In addition, this study will enrich the limited number of literature entries that exist regarding implementing e-ticketing in a construction material delivery system.

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