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ACHIEVING MORE EFFICIENT WORK FOR CONSTRUCTION COMPANIES WITH THE APPLICATION OF INTELLIGENT INFORMATION SYSTEMS IN REAL-TIME

Summary: *In this paper, we propose the use of intelligent real-time information systems that can provide all the necessary data, information, and knowledge for more efficient work and decision-making in construction companies. An appropriate data warehouse is necessary for the functioning of such an information system. Here we will suggest some new ways to fill them. To more efficiently collect some of the necessary data for the warehouse, we will propose the use of drones, the Internet of Things, and the 5G network to access them. Based on the processed data and the obtained information and knowledge, we will propose the use of intelligent real-time information systems in a construction company. Such an intelligent system can provide a construction company not only with more efficient work and decision-making but also with a competitive advantage. We will also list a small part of the new technological solutions that a construction company needs for more efficient collection and faster transfer of necessary data to the data warehouse, and more efficient connection of machines, devices, and things.*

Key words*: data warehouses, construction companies, drones, the Internet of Things, more efficient work and decision making*

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INTRODUCTION

The construction industry works very intensively, and a large amount of data and information is generated. Data and information are created during the production of drawings, which are made in the design phase, then through various project reports that arise during the construction process and all phases from the idea to the complete completion of the project. That is why collecting and arranging construction data and information is very important for a construction company because of their need and usability. To collect such a significant amount of data, we need data warehouses and appropriate software for searching them.

It is considered that the construction industry employs about 7% of the working-age population in the world **(**Perera et al. 2014). It is one of the sectors with the largest number of employees. Despite such a large number of employees, the construction industry is characterized by very low productivity. Other industries have significantly modernized and transformed and thus increased

their productivity. Automation has completely conquered and changed the manufacturing and service sectors.

The prevailing opinion is that the construction industry is among the least digitized industries in the world. According to some research, the productivity of employees in the construction industry has recently been growing at a rate of 1% per year, and productivity in the economy grew on average by 2.8 % per year, while productivity in the field of production grew by 3.6 % per year (Perera et al. 2014).

The possibility of efficient control of the occurrence of costs is not one of the most important factors causing the situation. To cost and be able to monitor and control in real-time, construction companies must use the latest IT tools efficiently. Now data warehouses and the latest software with the right hardware can keep track of all construction company costs and revenues at any time.

Distance between the construction company and the construction site they are often big a, and that efficient and fast communication makes it difficult, which creates additional complexity in the management and cooperation of all actors. Therefore, the implementation of 5G mobile networks will be necessary not only for more efficient communication but also for the ability to connect more devices, things, and machines.

The management and use of information and communication technologies in construction companies, to help and support those who work and those who make decisions, is still a very complex issue (Travar 2021) When it comes to communication and cooperation in the construction industry, integration, and management, technical aspects are usually discussed. There is a noticeable lack of studies on the use of IT tools in construction projects from an organizational point of view. There are only a few studies that have examined the perception of users of IT tools they use, as well as their impact on project management practices in construction.

The construction industry often operates on the principle of project-based organizational forms, in which several companies work together on a specific project, for a limited period. The literature in this area cites difficulties in acquiring knowledge beyond project boundaries, as well as sharing knowledge and skills between all parties participating as project partners (Mokyr 2010). Although many claims are often right, the projects being worked on are temporary, and the companies working on the projects often change.

The construction industry has made a historic change in the process and way of designing buildings today, slowly abandoning 2D drawings, and moving towards 3D design based on digital models using BIM (Building *Information Modeling*).

In the developed countries of the world, the use of BIM has become very popular in the construction industry. A small number of companies apply and use the full potential provided by this technology, and understand its importance and implications for business processes and business culture (Badrinath 2016). Although this type of information technology is relatively new in the business world, several studies have identified changes in business practice and the development of new roles, and new forms of responsibility (due to the emergence of new forms of supporting electronic data). From research dealing with information systems management, we know that the implementation and use of new IT technologies lead to changes in business routines. These changes may relate to business relationships, work responsibilities, development and transfer of knowledge, and the development of new habits, roles, and ways of doing business (Boton 2016).

The McKinsey *Global Institute* estimates that by 2030, the world will have to invest $ 57 trillion ($57 billion) in infrastructure to keep pace with global gross domestic product growth. This data can be a significant incentive for all companies in the construction industry to find and apply new solutions to improve productivity and transform existing work practices, through the application of new technological solutions and new innovative business models.

1. INTELLIGENT INFORMATION SYSTEMS

The amount of data that construction companies collect and store is constantly increasing, as is the complexity of that data and the number of unrelated databases. Construction companies can find themselves in a situation that is flooded with data, the amount of which is constantly increasing. Twenty years ago, the information they possessed consisted mainly of data from their databases. The amount of data included was relatively small.
The problem is how a construction company can learn to manage such large amounts of data and turn it into information, knowledge, intelligence, and profit. Data, information, and knowledge enable construction companies to operate more efficiently and be more competitive and successful. Large amounts of data (data warehouse) (Gandomi 2015) collected by construction companies lie unused, so it is necessary to provide appropriate software (tools) for their processing (mining).

Now more and more companies are starting to use information systems that can provide real-time gold valuable information. Such systems have implemented a data warehouse that is filled with real-time data and processed (Asma 2017). Such technological solutions help construction companies to centralize their data warehouses, to access them faster and more efficiently, and for employees to better understand key business processes based on real-time data, as well as be able to predict future events through adequate business analysis. Employees are looking for faster answers from intelligent information systems, without the need for guesswork. They ask for a report on significant business results on demand, and to get instant insights into the behaviour of what is being controlled or measured. All this is necessary for them to more effectively identify weaknesses. This will lead to time savings, faster access to information and knowledge, and more efficient work and decision-making.
The basis of an intelligent real-time information system is a single data warehouse.
The data warehouse must contain:

- Internal data - obtained from the integrated ERP and BIM system.
- Historical data - all data and information relating to the entire period of operation of the construction company. From its founding until today.
- External data - all data collected from drones, the Internet of Things, the work of the competition, events in the digital and classic markets, data from the stock market (eg oil prices), and the like.
- Operational data - data on daily events by individual projects, debts, machines, employees, subcontractors, investors, etc.
- Other files and files are integrated into a single system.

Access to key business data and information is critical, and if this is difficult, it limits the ability of a construction company to operate more efficiently (Hao Zhong 2015). If accurate business information is not easily available in real-time, then it is difficult to work efficiently and make the best decisions. For this not to happen, it is necessary to implement a data warehouse that with appropriate software solutions can lead to an intelligent information system in real-time. Such a work strategy aims to respond to the needs of the construction company for better access to information and knowledge.
The strategy of implementing an intelligent real-time information system is much more than electronic data exchange. A strategic approach to the implementation of an intelligent system helps to prioritize business requirements, increase transparency and promote access to key information for all employees.
An intelligent information system requires that all levels of work and decision-making in a construction company have access to data, information, and knowledge, not just the level of decision-making (Chang 2017). There are many new technological tools now available that help

accelerates the flow of information across all levels of a construction company to encourage collaboration and better inform all developments (Batty 2013). The real-time intelligent information system will be available to all self-service employees. They will enable and help each employee to access data and information related to his role in the business process. Functions such as directing data, and extracting data from other sources into charts and maps, in real-time, should represent certain analytical information for employees. Centralized information obtained from such a system enables all employees in a construction company to cooperate on one version of the truth. In doing so, they can use consistent, constantly updated data and information, of high quality, through many communication channels (computers, mobile phones, platforms, etc.).

During basic work operations, employees collect a lot of data and information about everything they do: construction work, investors, employees and the property they own and use, the status of individual projects, the efficiency of using certain machines, and the like. That data and that information are usually stored properly in databases. The problem is that so far this data has remained unused and unused. Most employees know that information is potentially valuable, but it is often very difficult to find. People who need some data or information sometimes don't know how to get it or don't even know if it even exists.

Use data, information, knowledge, and information and communication technologies to gain a competitive advantage, the slogan is now the most widely used inefficient construction company in the developed countries of the world. Yes, that was achieved, Fr. it is necessary to implement data warehouses and an intelligent real-time information system. Construction companies now differ in how they make optimal use of collected data, information, knowledge, and new technologies. The way data and information are collected, processed, and used will determine whether they are winners or losers. The competition is growing today. There is now more and more information about the competition, as well as about investments and the market, which is global today. Competitive winners will be those who create advanced digital systems based on the concept of business intelligence.

In this paper, we proposed the use of intelligent information systems in real-time to make the right data, first information, and the right knowledge available to all employees for better performance and better decision-making in a construction company. Real-time exchange of data, information, and knowledge with the use of new technological solutions provides the construction company with easier monitoring of project progress and assessment of possible risk, quality control, and better monitoring of each project phase (Kwon 2014). The knowledge that is efficiently exchanged and used can provide a construction company with a competitive advantage (Gonzales 2019). Those companies that have more knowledge are more competitive than those that do not (Bilal 2016).

In this paper, we propose the implementation of the concept and the Internet of Things because it will lead to improved efficiency and work, visibility of construction sites, machines, and processes, better communication with investors and subcontractors, efficient cooperation between people, machines and devices. level of productivity and competitiveness.

2. INTERNET OF THINGS

*The Internet of Things (*IoT) is a new concept of connecting things and devices and can provide a huge amount of significant real-time data needed to store data in a new intelligent real-time information system. The collected and processed data can provide the construction company with better business analytics, better information modelling and construction, better and more efficient control of construction machinery and equipment, and more. The possibilities offered by this new concept are increasingly used in construction companies in developed countries of the world. We believe that this is a concept that is coming and that construction companies should start

using in this area, and therefore we dedicate certain importance to it in this paper, bearing in mind that the "Internet of Things" is becoming a feature of the new 4.0 industry.

The Internet of Things in the construction industry refers to the connection of a large number of different machines, devices, and objects with the use of the Internet to digitally exchange certain data and information and for machines and devices to react to all user needs. It is about connecting objects of different natures, such as electronic devices, and sensors, but also physical objects and beings, as well as virtual data and environments. Machines and devices are physical devices that can be assigned an IP address and given the ability to send certain data via the most common mobile Internet. In the construction industry, we connect trucks, loaders, excavators, graders, rollers, compactors, concrete and asphalt mixers, machine operators, and the like with data servers (data warehouse) of a construction company.

It is believed that the IoT will become a big deal for you in the future. According to Gartner's analysis from 2017. it is stated that 15 % of companies already use IoT in their business. Expectations that he will the percentage will grow significantly in the following years. The IoT is estimated to connect 200 billion devices very quickly, and the value of the Internet of Things market is estimated at $ 80 billion.

IoT enables the integration of a large number of devices in which they are installed and matching sensors that communicate independently with each other and with various applications. There can be three types of communication: communication things with people, communication between things, and communication between devices (*machine to machine,* M2M). Today's data collection and processing systems are a set of specific, interconnected, appropriately connected devices or specific components that collect, store and share data and information while providing appropriate corrective actions that allow for certain improvements or fulfilments. e some goals. Those systems are now integrating software, hardware, data warehouses, telecommunications equipment, users, and certain procedures used for data collection and storage and their translation into information and knowledge necessary for use or further processing (Atzori 2016)

IoT enables all construction machines and facilities to be fully monitored and controlled remotely (Perera 2014). This will ensure more direct integration of construction machinery and user computer systems, and this will ensure better efficiency, accuracy, and economic benefits while reducing human labour. It will be possible to uniquely identify each construction machine or object through the built-in sensor, computer system, and IP (Internet Protocol) address. IoT applications will benefit go and Internet Protocol version 6 (IPv6), and will be able to communicate with devices connected to almost all objects due to the extremely large address space of the IPv6 protocol with ^{2,128} addresses. The protocol used so far - I Pv 4 had o is only 2^{32} or 4,294,967,296 addresses. The new addressing system will enable the identification of all items with appropriate sensors.

These are smart and networked devices that are connected to the use of wireless internet, and can efficiently exchange certain data and information with each other. It's not working not only about connecting computers and smartphones, but also construction machines, rollers, graders, home heating systems, coffee makers, microwave ovens, refrigerators, table lamps, TV, and computer system with devices on the construction site, with the helmet of a construction site employee with performance monitoring software, and so on (Rathore 2016). Built-in sensors, processors, and software in construction machines and devices as well as the ability to connect them now dramatically improve their functionality and performance. It is a large number of sensors and an apparatus that will send certain data in real-time on the situation on the construction site, on the efficiency of work of each employee and each machine. All this data will need to be accepted and stored in a data warehouse, processed and translated into useful information or knowledge, and distributed in the first volume, at the right time, to a particular employee to be able to work or make decisions more efficiently. For the collection, processing, and sharing of information and knowledge, we need appropriate data centres in a construction company or the "cloud".

Employees in the construction industry will be able to use a lot more data, information, and knowledge, and thus will the process of building a post is more efficient and cheaper. To achieve this, we need to integrate and connect a large number of construction machines, devices, and things, and for that, we need large-scale infrastructure, with systems for processing large amounts of data in real-time and unequivocally recording and interpreting data received and collected from various sources.

(Ning 2011) state that thanks to the sensors and relevant data provided by managers, all employees of the construction company be able to monitor much better how machines and devices are used efficiently in real-time. Based on the obtained data, information, and knowledge, managers will be able to make more efficient decisions, and all employees will work more efficiently and better. If you want to realize a complete vision of the Internet of Things and provide technologies that allow you to interact with almost any device, appropriate software, anytime, anywhere. One of the basic conditions for data exchange is that users must know about the existence of devices, and also all devices must know about the existence of users.

To realize the requirements The Internet of Things requires significant changes in the architecture of the system, and communication that must be more flexible, more adaptable, completely secure, but not intrusive (Yucong 20 15). To implement the integration of the Internet of Things on the Internet of the Future, it is necessary to solve numerous technological challenges and obstacles. First of all, there is the need for much cheaper, more energy-efficient, and self-sustaining intelligent devices, the transition to a new version of IP protocol (Ipv6), and the availability of appropriate software that collects and analyses data, and privacy and better data security. Technological challenges also relate to the speed of data processing, achieving interoperability, standardization, and the like.

using information available through smart devices, it is possible to monitor and control smart construction machines and facilities with a certain reduction in energy and maintenance costs. Construction supervision, the usability of individual construction machines and devices, regulation of the construction process, and everything can be achieved with integrated systems of appropriate control of mobile devices. Machines and devices will be part of the concept and the Internet of Things, data will be stored in the cloud, and devices will be controlled over the web using the right application (Zhong 2014).

The implementation of the concept and the Internet of Things will lead to significant changes in construction companies, especially in more economical businesses. Significant changes can be expected in: It will improve the efficiency and work of construction companies due to the simpler state and remote control; certain profit results provided by software-based solutions, and appropriate innovations in hardware with increased visibility of construction sites, machines, processes, better communication with investors and subcontractors, and efficient cooperation between people, machines, and devices, which will provide higher-level productivity.

Those construction companies that use the Internet are significantly opening up the market and reducing labour and operating costs. In the past periods of development, logistics, transport, energy and other factors of work have been decisive for a successful business. With the use of new technological solutions, these factors are becoming less important, and competitive advantage and a more efficient business now depend on the efficiency of doing business, good ideas, and available data, information, and knowledge. New technological solutions have contributed to the establishment and development of better cooperation between employees, which in economic terms meant reducing costs and improving the exchange of information and knowledge. New information and communication technologies provide new platforms for the exchange of information and knowledge and provide cheaper information and more efficient communications between investors, contractors, and employees both on the construction site and in offices and the like.

The rapid development of information and communication technologies, primarily intelligent systems and Internet platforms, lead to a major turnaround in favour of smaller companies. By efficiently using new technological solutions, smaller companies gain powerful "weapons" in competitive competition with large companies in the market (Heiskanen 2017).
Depending on the ability to accept and effectively apply new smart information on communication technologies, the readiness of a construction company to ensure fair competition in an increasingly demanding market, regardless of its size and financial power, will also depend. Construction companies that manage to efficiently connect components, machines, and facilities according to the concept and the Internet of Things, and use the information and knowledge gained, can increase efficiency, productivity, and reduce the use of energy and other resources, succeed and reduce their marginal production costs. (Sewdass 2020). The importance of the Internet from the economic point of view for construction companies is reflected in the fact that its concept quickly leads to the use of almost free goods, and thus provides higher productivity, which changes the current economic situation towards reducing marginal costs. All this will give the construction company a more efficient business and competitive advantage.

3. DRONES

Drones - Drones are devices that are adequately equipped and can provide a construction company with a large amount of very important data. As such, they should become a standard part of every construction company's equipment. Drones equipped with appropriate cameras, sensors, and communication equipment can be used very efficiently for:
Testing the condition of structures and buildings - Drones can be used to collect significant data on the condition of a structure or building, especially in places that are difficult to access. Using appropriate sensors and cameras, data can be collected on the condition of the material, the possible presence of moisture, heat, or some other phenomena that may be problematic for the structure or building (Valavanis 2015).
Testing and surveying the construction site - The drone can effectively replace a team of people who need to collect data on the appearance and condition of the terrain on which the construction is to be carried out (Gowda 2017). With the use of certain additional devices, a large amount of necessary data and information can be obtained very quickly and thus provide savings that can sometimes range up to 90%.
Determining the condition of the construction site and performed construction works - drones can in a very short time provide a very significant amount **of** data on the situation on the construction site and the performed works, and enable daily monitoring of the situation on the construction site, and make differences about the situation in the previous period or what is planned by the project. Each drone strike can provide significant data on the condition of the construction site at a certain time at a certain location, and the obtained collected data can be compared by the drone with the use of appropriate software with the data provided by the project or some previously recorded condition. Panoramic or HD shots can provide direct monitoring of the condition of the building.
Monitoring the safety situation on the construction site and the access to the construction site - if any timely use, the drone can significantly contribute to greater safety on construction sites. All data on possible dangers on the construction site or unauthorized access to the construction site can be obtained much faster and based on such data, the recipient can react on time (Alnoukari 2020). Pricewaterhouse *Coopers* has conducted some research that shows *that* "the use of drones on construction sites reduces the number of life-threatening accidents by as much as 91%."
Conducting certain measurements - drones equipped with a good camera and the necessary appropriate software can be efficiently used to perform certain measurements while collecting

and processing significant amounts of data on the performed measurement (Hassanalian 2017). If we connect drones to the appropriate equipment, sensors, communication equipment, and information system of the construction company, they can provide the necessary data necessary for a real-time data warehouse, which are necessary for the proper functioning of intelligent information systems in real-time.

Carrying out supervision over the performed construction works - the drone can be efficiently used to provide important data for the preparation of the necessary documentation on the performed works every day (hour). All events that take place on the job site can be monitored in real-time, and comparisons of the current with the previous situation can be made. It can be used as an effective tool in the evidentiary procedure with appropriate collected data. Research conducted by *DroneDeploy* shows that with the proper use of drones, the implementation of supervision over certain construction works is reduced by 52% (Travar and Travar and Ristić 2021).

They provide the necessary efficient communication - the use of drones with appropriate communication equipment can provide efficient communication of the intelligent information system of the construction company in real-time with the construction site. The made recordings can provide all participants in a certain construction project with all the necessary data, information, and knowledge for further more efficient work, as well as the necessary changes and potential risks. To ensure sufficiently fast communication and the transfer of large amounts of data in real-time, the use of the 5G mobile network must begin as soon as possible.

In this paper, we have given only a part of the possibilities of using and applying drones for collecting and delivering data and information, and their use in the transport of machine parts, tools, and devices and use in other areas in the construction industry will not be listed due to the extensiveness of this paper.

According to research conducted in the USA in 2018, drones were used by about 20% of surveyed companies. According to the results obtained by 2020, that percentage should be over 26%. Research in England shows that the number should be over 50%. It is estimated that the construction industry in the world should use over 400,000 drones by 2023.

Here we have mentioned the good side of the use of drones in the construction industry, but it should always be borne in mind that they also have certain limitations in their work due to legal regulations, limited power supply duration, range, payload, weather conditions and the like.

CONCLUSION

In this paper, we have proposed the implementation of an intelligent real-time information system, which would provide the construction company that uses it with more efficient operations and competitive advantage. We proposed the use of drones and the Internet of Things to more efficiently and quickly access some of the data in real-time and which would be placed in the data warehouse.

We are aware that this would be only a small part of new technological solutions, but the novelty of all of them would significantly exceed the scope of this work.

We believe that new technologies and appropriate software solutions can provide the construction company that uses them with more efficient operations and higher profits.

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