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Master in Management Program

DIGITALIZATION AND WAREHOUSE MANAGEMENT IN RUSSIA: AN APPROACH FOR IMPLEMENTATION OF DIGITAL SOLUTIONS

Master's Thesis by the 2nd year student
Concentration – International Logistics and
Supply Chain Management
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ЗАЯВЛЕНИЕ О САМОСТОЯТЕЛЬНОМ ХАРАКТЕРЕ ВЫПОЛНЕНИЯ ВЫПУСКНОЙ КВАЛИФИКАЦИОННОЙ РАБОТЫ

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АННОТАЦИЯ

Автор	Наумова Карина Владимировна
Название магистерской диссертации	Цифровые технологии для складской логистики в России: алгоритм внедрения цифровых технологий
Факультет	Высшая Школа Менеджмента
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Год	2016
Научный руководитель	Шульте Аксель Тео, PhD, доцент
Описание цели, задач и основных результатов	Цифровые решения в складской логистике могут быть конкурентным преимуществом для улучшения точности компоновки заказа, снижения затрат на персонал и повышения производительности труда работников склада. Многие компании стремятся понять, как внедрить цифровые решения в складской логистике. Целью данного исследования является разработка алгоритма внедрения цифровых решений для складской логистики в российских компаниях. В рамках исследования были выявлены цифровые решения в области управления складом и изучены кейсы российских и международных компаний, которые внедряли цифровые решения в складской логистике. На основе анализа были выявлены цифровые решения, которые в дальнейшем были сопоставлены между собой с точки зрения их актуальности, затрат и простоты реализации. В результате было выявлено, что система управления складом и технология голосового управления являются наиболее распространенными и актуальными технологиями в складской логистике в России. Лучшие практики внедрения цифровых решений в складской логистике были исследованы с помощью анализа кейсов. Был разработан алгоритм с указанием стадий внедрения, их содержания и длительности для системы управления складом и технологии голосового управления для российских компаний.
Ключевые слова	Цифровые технологии, складская логистика, система управления складом, технология голосового управления

ABSTRACT

Master Student's Name	Karina V. Naumova

Master Thesis Title	Digitalization and warehouse management in Russia: an approach for implementation of digital solutions
Faculty	Graduate School of Management
Main field of study	International Logistics and Supply Chain Management
Year	2016
Academic Advisor's Name	Axel Theo Schulte, Dr./PhD, Associate Professor
Description of the goal, tasks and main results	Digital solutions for warehouses can be a great competitive advantage to improve order-picking accuracy, decrease personnel costs and increase warehouse employees' productivity. Companies are struggling to understand how to implement digital solutions in warehouse management. The research goal of the thesis was to develop an algorithm of implementing digital solutions in warehouse management for Russian companies. For achieving this goal digital solutions in warehouse management were determined and multiple case study analysis was carried out. Based on the analysis digital solutions in warehouse management were revealed and compared in terms of their relevance, costs and ease of implementation. As a result, it was found out that Warehouse Management System (WMS) and pick-by-voice are the most widely applied and relevant technologies in warehouse management in Russia. Best practices of implementing digital solutions in warehouse management in Russian and international companies were investigated using within-case and cross-case analyses. Finally, an algorithm with stages of implementation, their duration and content of implementing WMS and pick-by-voice was developed for Russian companies.
Keywords	Digitalization, warehouse management, Warehouse Management System, pick-by-voice

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List of abbreviations

The list of abbreviations used by the author in the master thesis is provided in order to avoid misinterpretations.

3PL – third-party logistics
CRP - conference room pilot
DC – distribution center
EDI - electronic data interchange
ERP - enterprise resource planning
Industry 4.0 – fourth industrial revolution
IRD - implementation requirements document
IT – information technology
KPIs – key performance indicators
MRP - material resource planning
RFID – radio frequency identification
ROI – return on investment
SRD - systems requirement document
UAV - unmanned aerial vehicles
VDT – voice direct technologies
WMS – warehouse management system

Introduction

Digitalization has already entered our lives and has made significant changes in our society (Dedrick et al., 2008; Fitzgerald et al., 2013). Digitalization has a significant impact on all economic sectors and revolutionizes industries, as it refers to the fourth industrial revolution, which is happening in 21st century. In today's age of digitalization to stay competitive and increase profit more and more companies are inclined to apply digital solutions in their operations, including warehouse management (Pfohl et al., 2015). This tendency can be explained by the fact that currently traditional warehouses, which do not use digital tools, do not always meet warehouse customers' needs. In addition, complexity of supply chains has reached a level, where conventional warehouse systems are not efficient anymore (McKinsey Digital, 2014). Thus, there appears a necessity to use innovative technologies in warehouse management. Companies face the need of integrating information technology management and warehouse management, i.e. digital solutions and warehouses.

Warehouses are considered as a vital link within company's supply chain. Warehouses are no longer perceived as only costs centers, which rarely can add value (Faber et al., 2002; Motorola Solutions report, 2013). This development can be explained by the movement from linear to complex supply chains, digitalization, major shifts in customer demographics and buying patterns, globalization, increasingly demanding customer and supplier requirements as well as evolving regulations. Therefore, warehouses can drive competitive differentiation and, by doing so, increase company profit.

Under the influence of digitalization and globalization, warehouses today are being asked to increase order-picking accuracy and productivity of warehouse employees, execute more transactions, offer more value-added services and process more returns. At the same time warehouses have less time to process orders, more demanding customers, less time to process returns, higher level of environmental and staffing pressures (Ramaa et al. 2012). Thus, under the above mentioned rising expectations and requirements for warehouses, digital solutions for warehouses can be a great competitive advantage to overcome these challenges and increase company profit and its key performance indicators. However, many companies are struggling to understand how to integrate and implement digital solutions in warehouse management (Accenture, 2014).

There are some studies in the field of automation solutions (Warehouse Management System, Enterprise Resource Planning, Client Relationship Management system etc.) in warehouse management (Autry et al. 2005; Ramaa et al. 2012; Legutko et al. 2012); however, there is a lack of research, which is focused on investigating digital solutions in warehouse management both in international and Russian companies. Moreover, there is no research on

developing a n algorithm of implementing digital solutions in warehouse management. An algorithm in this case means a set of stages to follow in order to implement digital solutions in warehouse management. Algorithm consists of specific steps with stages of implementation, their duration and content of implementing digital solutions for Russian companies. Algorithm and approach terms in the study are considered as synonyms and further algorithm term is used.

This proves that extant studies on warehouse management and its digitalization have limitations, since there are no studies dedicated to investigating digital solutions in warehouse management and there isn't any research among extant studies regarding developing an algorithm of implementing digital solutions in warehouse management. Hence, the problem of lack of an algorithm of implementing digital solutions in warehouse management is raised.

All of the above mentioned indicates that there is a research gap, which this thesis will close. Thus, the research gap consists of lack of research among extant studies regarding development of an algorithm of implementing digital solutions in warehouse management. Despite the fact that digital solutions have only recently started to appear in warehouses of Russian companies, plenty of companies understand the importance and potential of applying digital solutions in warehouses and its positive impact on warehouse efficiency (Pfohl et al., 2015).

Taking into consideration all the above mentioned, this research has relevance and managerial implications for companies. The results of this thesis will be useful for a wide audience: for supply chain managers, warehouse managers, warehouse specialists, IT managers and for all managers, who are involved in implementation of digital solutions in warehouse management. The developed algorithm for implementation of digital solutions can be useful not only for Russian, but also for foreign companies, which intend to introduce digital solutions in warehouse management.

The following research **goal** was formulated:

- To develop an algorithm of implementing digital solutions in warehouse management for Russian companies based on best practices of international and Russian companies

The following research **objectives** were formulated:

1) To review digitalization phenomenon and its implications for warehouse management
2) To identify digital solutions in warehouse management
3) To analyze best practices of implementing digital solutions in warehouse management
4) To develop an algorithm of implementing digital solutions in warehouse management for Russian companies

Research object in this thesis are digital solutions in warehouse management in Russian and international companies. **Research subject** is the algorithm of implementing digital solutions in warehouse management in Russian and international companies.

Research problem of this study consists of lack of an approach of implementing digital solutions in warehouse management in Russian companies.

Research questions are the following:

(RQ1) Which digital tools are used in warehouse management?

(RQ2) How digital solutions should be implemented in warehouse management?

The study is based on a qualitative approach, and the main research method is multiple case study. Both primary and secondary data are used. Secondary data includes journals, internal documents of the company and textbooks. Regarding primary sources, in the research qualitative semi-structured interviews and consultations with digital solutions' integrators are conducted. Thus, triangulation principle is fulfilled, since different research methods and data from different sources are used. This allows to reduce the level of subjectivism, which is typical for qualitative research.

The master thesis consists of three stages of research. The first stage is the theoretical chapter, which reviews phenomenon of digitalization, warehouse operations, digitalization implications for warehouse management. Moreover, in the first chapter it is identified which digital solutions are applied in warehouse management and what impact do they have on warehouse management. Further, Warehouse Management System (WMS) and pick-by-voice solutions are analyzed in terms of their functionality, benefits and drawbacks of these technologies and implementation recommendations. The second chapter includes research methodology. Case study is the major method, which is used in the thesis. For achieving research goal semi-structured interviews with companies' managers and consultations with digital solutions' integrators are conducted. The third chapter includes analysis of the best practices of implementation of digital solutions in warehouse management. For the research within-case and cross-case study analyses are applied. Based on the conducted analyses, an algorithm of implementing digital solutions in warehouse management for Russian companies is developed.

The research is conducted on the basis of around a hundred sources, which include scientific articles, books, industry reports and conference papers. The sources were found in such databases as EBSCO, Emerald, JSTOR, Elsevier, Taylor & Francis, Wiley Interscience.

The study has both theoretical and practical implications. From the theoretical perspective the thesis provides contribution to the sphere of digital solutions in warehouse management, which is quite uninvestigated. Based on the literature review analysis digital solutions in warehouse management were determined, reviewed and compared. Moreover, it was inferred that the most widely spread and relevant technologies in warehouse management in Russian companies are Warehouse Management System (WMS) and pick-by-voice. Regarding

practical implications, an algorithm of implementing digital solutions (WMS and pick-by-voice) in warehouse management was developed, which can be applied by Russian and international companies, which intend to introduce digital solutions in warehouse management. The algorithm with the stages of implementation, their duration and content and responsible employees will be especially useful for warehouse managers, IT managers and other employees, who are involved in implementation of digital solutions in warehouse management.

CHAPTER 1. DIGITALIZATION AND WAREHOUSE MANAGEMENT

The chapter is concentrated on investigating digitalization in warehouse management. The aim of the conducted literature review is to provide a comprehensive overview of extant studies regarding digitalization in warehouse management and to identify digital solutions applied in warehouse management. Since the topic of the master thesis includes both digitalization and warehouse management, the literature review combines both spheres. Therefore, the review is organized thematically and consists of two parts: digitalization in warehouse management and Warehouse Management System (WMS) and pick-by-voice. First of all, phenomenon of digitalization is traced over time. Afterwards warehouse operations and future trends should be established. Then, digitalization implications for warehouse management are explained and consequently digital solutions in warehouse management are revealed based on academic articles and latest industry reports. Impact of digital solutions on warehouse management is investigated and as a result it is revealed that WMS and pick-by-voice are the most widely applied and relevant digital solutions in warehouse management in Russia. Consequently, these two solutions are investigated in detail, i.e. their functionality, benefits and drawbacks and implementation recommendations. Eventually research gap is defined after the conducted literature review.

1.1. Digitalization in warehouse management

1.1.1. The phenomenon of digitalization

To begin with, digitalization concept should be introduced. The terms of digitalization and digitization are sometimes used interchangeably in the literature (Yichang, 2001; Sohn et al., 2002; Geschke, 2006; McKinsey Digital, 2014; Hirsch-Kreinsen, 2016), since they are closely interrelated.

The first use of digitalization and digitization terms is attributed to the mid 1950-s in conjunction with the computers (Haigh, 2001). Digitization means the conversion of analogue data into digital form (Houissa, 1999), while digitalization refers to increase in usage or adoption of digital or computer technology by the company, industry (Gartner, 2016). It can be inferred that digitization refers to the material process, while digitalization attributes to the phenomenon of spreading and adoption of digital technologies. Further, digitalization phenomenon is scrutinized among the extant studies.

The term ‘digitalization’ appeared in its contemporary usage in an essay of Wachal (1971). In conjunction with computerization Wachal (1971) shared his view on the social implications of the ‘society’s digitalization’ in terms of research referred to computer-assisted humanities. The scholar discussed objections and potential of such kind of research. It can be

noted that after 1971 digitalization has become a widely discussed topic among the researchers and focus of the research has been shifted more to studying ways that digitalization influences and shapes contemporary world (Williamson, 1975; Naisbitt, 1984; Wijnhove and Wassenaar, 1990; Chareonwongsak, 2002; Cetina and Bruegger, 2002; Verhulst, 2002; Van Dijk, 2005). Williamson (1975) addressed digitalization in the context of governance mechanisms. During the decade from the middle 1970s till the middle 1980s there were scholars, who have explored impact of computerization from the buyer-seller perspective. Significant contribution regarding this area was done by Mathews et al. (1974) and Mathews et al. (1977), who studied how computerization influenced selling and buying process to the computer assisted buyers.

As Naisbitt (1984, p.22) argued 'computer technology is to the information age what mechanization was to the Industrial Revolution'. Thus, the author claimed the significance of digitalization and its solutions in the information age. Wijnhove and Wassenaar (1990) studied digitalization from the perspective of organizational usage of information technology. Brynjolfsson and Hitt (1998) examined productivity and information technology uptake in terms of digitalization.

Moreover, scholars have explored that digitalization has been facilitated by and facilitated the rise of globalization (Chareonwongsak, 2002). Hence, there can be observed a mutual influence between digitalization and globalization. Further, researchers have explored the impact of the digitalization and globalization on national sovereignty, culture, people, capital and commodities. For example, Cetina and Bruegger (2002) have examined that digital media has become an essential element of global capital flows. Several researchers (Verhulst, 2002; Van Dijk, 2005) have analyzed digitalization further in terms of communications. Verhulst (2002) claimed that the new communication system is facilitated by devices, which are able to manage digital signals. Van Dijk (2005) added that there appeared a single communications infrastructure which connects all activities in society. As Castells (2011) emphasized digitalization has become one of the defining characteristics in the modern society. Digitalization allows to reveal new technologies, which can significantly impact social and economic spheres (Avent, 2014). Following Avent (2014) there has been a research by Evangelista (2014), who studied the economic impact of digital technologies in Europe. Hirsch-Kreinsen (2016) pointed out that no other issue as digitalization has been discussed so often in professional circles and underlined major role of digitalization in future economic and social development.

According to Hirsch-Kreinsen (2016) two phases of digitalization can be defined. The first phase can be attributed to the end of the 1990s, when digitalization has been already established in various industry sectors, where production and communication were based on the data and information usage and intangible transactions. Zuboff (2010) added that during the first phase of digitalization influenced not only companies and industries, but also triggered changes

in individual business models. The second phase of digitalization refers to the period since the end of the 1990s till the present day and this phase is oriented to digitalization of physical objects of all kinds (Hirsch-Kreinsen, 2016). Zuboff (2010) denoted this phase as a 'second-wave mutation', which has an impact on economic and technological spheres. It is interesting to mention that from the technological perspective second phase of digitalization can be called as 'Internet of things' (Hirsch-Kreinsen, 2016). Comparing the mentioned two phases of digitalization it can be inferred the second phase is far more complex due processes' materiality (Zuboff, 2010).

As was shown in McKinsey Digital (2014) digitalization allows companies to grow quickly and enter new markets at low cost. Moreover, digitalization facilitates companies' growth through creating network effects and decreasing to a great extent marginal costs, such as storage costs, transportation costs etc.

Along with the digitalization concept fourth industrial revolution (or Industry 4.0) term should be defined since these phenomena are closely connected. Pfohl et al. (2015) defined Industry 4.0 as the sum of all disruptive innovations, which can be obtained and implemented in a value chain. In Industry 4.0 term Pfohl et al. (2015) include the following trends: digitalization, modularization, transparency, automatization, mobility, network-collaboration and socializing of products and processes. As Pfohl et al. (2015) note digitalization is the most important element of the fourth industrial revolution and enables development of all other features.

In this paper digitalization and more specifically digital solutions in terms of warehouse management are examined, since the goal of current research is to develop an algorithm of implementing digital solutions in warehouse management. Further, the warehouse operations and warehouse trends are examined.

1.1.2. Warehouse operations and trends

Warehouses serve as an essential connection among suppliers, distributors and customers in the supply chain (Chen and Wu, 2005). According to Motorola Solutions report (2013) a warehouse is no longer perceived as a cost center, but as a growth center, which can be a powerful company's asset for driving profitable growth and improving warehouse operations. There is a classical definition of a warehouse by Bartholdi and Hackman (2006), according to whom a warehouse is a facility in the supply chain for consolidating company's products, reducing transportation costs and achieving economies of scale. Gong (2008) explored a polling-based dynamic order picking system for online retailers and added that warehouse can also provide value enhancing processes and decrease response time. As Hwang and Cho (2006) evaluated, warehousing costs account for 2-5% of total cost of sale of a company and consequently minimizing warehousing costs has become a formidable issue for companies.

There exist different classifications of warehouse operations, but basically they resemble each other and have a general pattern. Basic classifications of warehouse operations were developed by Frazelle (2002) and Tompkins et al. (2003). These classifications include division of warehouse operation into inbound and outbound processes. Based on scholars' classifications a scheme of warehouse operations was developed, which is presented below.

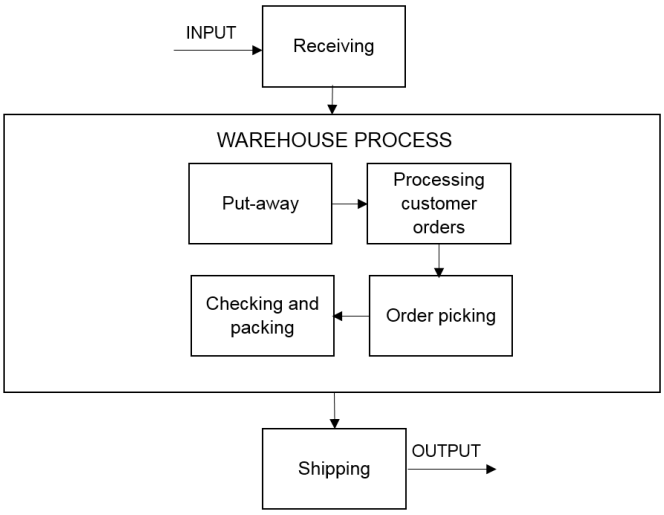

Figure 1. Warehouse operations flow
Source: Based on Frazelle (2002); Tompkins et al. (2003)

Further, to understand how digital solutions can affect warehouse management, warehouse operations should be explained. The first inbound process is receiving. It includes activities related to consistent receiving of the items which come in warehouses, checking the quantity of quality of received items and allocating items to storage (Gu et al., 2007). Receiving process accounts for about 10% of operating costs in a warehouse (Druri, 1988).

The subsequent inbound process is put away. This activity consists of material handling, location verification and product placement (Gong and De Koster, 2011). Put away process usually accounts for about 15% of operating costs in a warehouse (Druri, 1988).

The next process is processing customer orders, which is the first outbound process. During this stage warehouse personnel verifies that inventory is available to ship, produces pick lists, prepares necessary shipping documentation schedules order-picking and shipping processes (Gong and De Koster, 2011).

Order-picking is the process of removing items from storage to meet a specific demand (Gong and De Koster, 2011). This process is the most time-consuming among all the warehouse operations, since it accounts for about 55% of warehouse operating costs (Druri, 1988). Order-picking can be divided into four processes: travelling (55% of order-picking time), searching (15% of order-picking time), extracting (10% of order-picking time) and paperwork and other activities (20% of order-picking time) (Bartholdi, 2006).

Further outbound processes as checking and packing are presented together, since they frequently happen simultaneously. Packing is rather labor-intensive process, which requires handling each customer order. During that time checking process can be carried out to provide accuracy of customer order. Packed product may be scanned to register the customer order availability for shipping (Varila et al., 2007).

The last outbound process is shipping. During shipping product probably is staged and as a result staged freight must be double-handled. Before actual shipping product is likely to be scanned to register its departure from the warehouse. Corresponding shipping documents, including the packing list, address label and bill of lading should be prepared. Moreover, shipments are weighed to determine shipping charges (Van den Berg and Zijm, 1999).

Having analyzed warehouse operations, several conclusions were made. In a typical warehouse most of the expenses occur in labor, to be exact in an order-picking process. The most time-consuming and therefore the most expensive process is order-picking and in an order-picking process the most time consuming process is travelling. That is why companies should invest resources to reduce unproductive travel time in the first place and digital technologies can be a suitable solution for that.

Changing market environment has significantly affected companies' warehouses (Van Den Berg, 1999; Selen, 2002). Chen and Wu (2005) added that customers have gained more power to impact market structure and consequently warehouse employees should be able to react to regular changes. Moreover, Chen and Wu (2005) showed that there has been a market trend in supply chain management, which consisted of pursuing a demand-driven organization with certain characteristics such as short response time, high product variety and small order sizes. Apart from more demanding customers as the main challenges warehouses face, Ramaa et al. (2012) mentioned deeper and shorter integration of supply chains, globalized operations and rapid technological changes. Thus, to cope with the rising difficulties companies are inclined to adopt innovative solutions in warehouse management (Ramaa et al., 2012). Gu et al. (2007) confirmed this earlier by arguing that implementation of digital solutions allows companies to improve warehouse processes.

To get a deeper understanding of warehouse management, warehouse trends of the future are further presented. According to Hurdock (2000) the warehouse trends of the future will focus on the following aspects: customer-centric supply chain, operations and time compression, continuous flow, electronic transactions, customized warehouses, cross-docking, third-party warehousing, complete automation, standardization, continued upskilling of the workforce to keep in touch with technological advancements in the industry. Capgemini (2010) elaborates warehouse trends further and adds that in future there will be collaborative warehouses, where multiple manufacturers store their products. Moreover, Capgemini (2010) states that warehouse

locations on the cities' outskirts will function as hubs for cross-docking final distribution. Regarding non-urban areas, they will have regional consolidation centers for cross-docking final distribution. Regarding the specific figures of warehouse future trends according to Motorola Solutions report (2013) till 2018 35% of the surveyed companies intend to increase number of warehouses and distribution centers (DCs) and 38% plan to expand the size of warehouses and DCs. In 2018 use of multimodal voice and screen guidance will increase by more than 2,5 times and 67% of companies are going to take inventory using mobile handheld computers or tablets (Motorola Solution report, 2013). Furthermore, 66% of companies are going to equip their staff with technology and 70% of companies intend to conduct automation of warehouse processes (Motorola Solution report, 2013).

It can be inferred that some of these mentioned trends have already penetrated into today's warehouses such as cross-docking, third-party warehousing, fully automated warehouses. It is noteworthy to mention that majority of the warehouse trends are closely connected with digital technologies, which reflect the current and future significance of digitalization in warehouse management.

1.1.3. Digitalization implications for warehouse management

As mentioned earlier implementation of digital solutions provides opportunities for companies to improve their warehouse processes (Gu et al., 2007). Fitzgerald et al. (2013) in MIT Sloan report argue that using digital technologies enable companies to streamline their operations and improve customer experience. Both aspects are extremely significant for warehouse management, since streamlining operations can facilitate increasing warehousing efficiency and high customer service level can increase customer satisfaction. In customer experience category the most prominent elements, where digitalization had the greatest impact, were improving overall customer experience and enhancing existing products and services in customer-friendly ways (Fitzgeral et al., 2013). Considering the operational improvement category all elements had been influenced by digitalization more or less equally and these elements include improving internal communications, automating operational processes and enhancing workers' productivity (Fitzgeral et al., 2013). It should be noted that fourth industrial revolution and digitalization are inevitable and real for supply chain management and warehouse management for several reasons (Schulte, 2013). Firstly, fourth industrial revolution and digitalization are urgently necessary since traditional methods which were used earlier in supply chain management cannot meet increasing demands and external requirements anymore. Moreover, every day new technologies are developed all over the world and there are enough resources to further innovations development (Pfohl et al., 2015), which means that fourth

industrial revolution and digitalization are technically possible. Lastly, due to emergence of new business-models and markets most of the fields, including warehouse management are influenced by e-commerce, IT technologies and innovations, such as integrated IT solutions for a warehouse, innovative order-picking technologies etc. (Schulte, 2013).

In the report of McKinsey Global Institute (2013) it is stated that digitalization has the potential to decrease or even eliminate transportation and marginal production costs of virtual goods. As discussed in the report digitalization can decrease costs in three major ways. The first way consists of creation of purely digital goods that can be easily transported. Considering warehouse management such digital goods can be created as bills of lading, regular reports, receipts etc. It is interesting to mention that digitalization can transform even some physical flows of people into virtual flows by allowing employees to work remotely using digital technologies. The second way includes using 'digital wrappers' for increasing value of physical flows. In warehouse management digital wrappers can be computers, mobile terminals, tablets, headphones, etc. As emphasized by McKinsey Global Institute (2013) potential of digital enablers has been revealed for some time, but their use has been increased only recently. The third way consists of digitalization acting as a counter by transforming value chains and thus physical components flow can be made directly to consumers.

Pfohl et al. (2015) added that disruptive innovations are able to influence companies' supply chain processes, including warehouse operations. For instance, delivery information of transported goods can be changed in real-time and whenever needed (Whang, 2010). Consequently, digital technologies (such as RFID technologies in this case) allow to carry out problem management online and centrally (Pfohl et al., 2015).

As it was shown in McKinsey Digital (2014) companies consider the main improvement areas in warehouse management those areas, which are connected with operational effectiveness, namely with labor and quality. Thus, digitalization will facilitate changes in these areas using advanced digital technologies. Corresponding point of view is reflected in the report Deloitte Industry 4.0 (2015), where it is claimed that the manufacturing companies perceive substantial potential of digitalization in warehousing logistics (74% of respondents). In McKinsey Digital (2014) it is pointed out that digital technologies work as an enabler in warehouse management, notably they ease information exchange, can visualize and control the processes via digital tools such as tablets, mobile terminals etc. and simplify communications between warehouse employees. Moreover, digital technologies are able to facilitate stronger cross-functional integration in companies and cooperation along the product lifecycle, thus significantly increasing value for the whole company (McKinsey Digital, 2014). It is noteworthy to mention that digital technologies will be especially useful if company has remote multiple sites and digitalization in this case will play a major role.

McCrea (2015) shares her view on the increased usage of mobile solutions in warehouse management. According to David Krebs, president of enterprise mobility and connected devices at VDC Research, more and more warehouse managers intend to apply mobile solutions on a regular basis to streamline warehouse processes and increase warehouse employees' productivity (McCrea, 2015). Leading applications in warehouse management according to Krebs' view include receiving/shipping and put-away/picking applications and there is also a growing interest in additional applications around load planning, cross-docking, and parcel and item dimensioning. Krebs evaluated investment environment for mobile warehouse technology as a robust one, and according to his estimation, in 2015 mobile budgeting regarding warehouse solutions has been risen by 8,7% (McCrea, 2015).

Hirsch-Kreinsen (2016) pointed out that digitalization as an element of fourth industrial revolution will enable completely new level of automation through using highly flexible data enabled by Internet. At the same time in Hirsch-Kreinsen (2016) research it is indicated that with the digitalization proliferation foreseeable consequences might have not seen yet in terms of socioeconomic structures, namely in labor. For instance, some companies might downsize their personnel due to usage of digital technologies and subsequent increased worker productivity.

Based on the above mentioned analysis of digitalization implications on warehouse management it can be inferred that digital technologies facilitate warehouse management efficiency through interaction with data and establishing collaboration among warehouse employees and other departments' personnel. Regarding operations with data, digital solutions are able to capture data, provide access to the data (allow data visibility) and analyze or contribute to the data analysis.

1.1.4. Digital solutions in warehouse management

While searching through the academic articles it was found out that there is no defined set of digital solutions specifically for warehouse management. However, there exist determined digital technologies in logistics, supply chain management and business and separate studies of some digital technologies, which are used in warehouse management. As mentioned earlier, digital solutions represent specific technologies, which can be included in automated solutions. Thus, taking into account earlier conducted analysis of digitalization and warehouse operations and industry reports on digital technologies in logistics and supply chain management, digital solutions in warehouse management are identified.

Extant major reports on digital solutions in logistics, supply chain management and business include Disruptive technologies (McKinsey Global Institute, 2013), Logistics Trend

Radar (DHL, 2014), Industry 4.0 How to navigate digitization of the manufacturing sector (McKinsey Digital, 2014), Industry 4.0 – The Capgemini Consulting View: Sharpening the Picture beyond the Hype (Capgemini Consulting, 2015), The Impact of Industry 4.0 on the Supply Chain (Pfohl et al., 2015) and Three Paths to Advantage with Digital Supply Chain (BCG Perspectives, 2016). Despite the fact that the reports have different classifications of digital technologies, all reports emphasize significance of intersection of supply chain management and digitalization at the present. Logistics Trend Radar (DHL, 2014) proposes the following technologies, which are expected to affect logistics in the following decade.

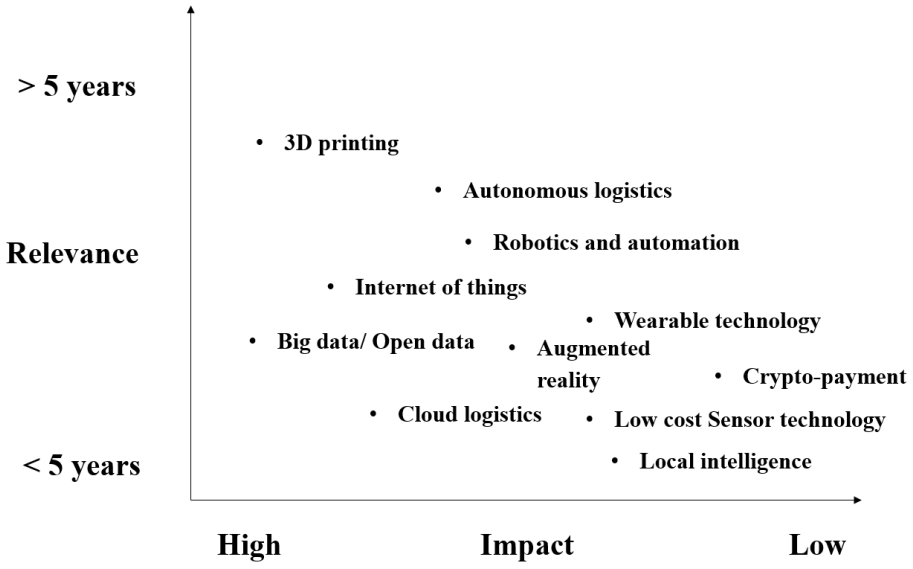

Figure 2. Technology Trends in Logistics Industry
Source: DHL Logistics Trend Radar, 2014

It is noteworthy to mention that the above presented figure has both technology trends (e.g. autonomous logistics) and digital solutions (e.g. 3D printing). Based on established earlier warehouse operations (receiving, put-away, processing customer orders, order picking, checking and packing, shipping) among the revealed by DHL technologies the following digital solutions can be attributed to warehouse management: robotics and automation, 3D printing and augmented reality.

Pfohl et al. (2015) propose another classification of digital technologies and concepts in the report 'The Impact of Industry 4.0 on the Supply Chain'. Thus, the authors identified the most discussed technologies and concepts within the relevant literature. This classification includes technologies and concepts for all elements of Industry 4.0 (digitalization, modularization, mobility etc.), that is why this classification was adopted specifically for digitalization and only elements referring to digitalization are left.

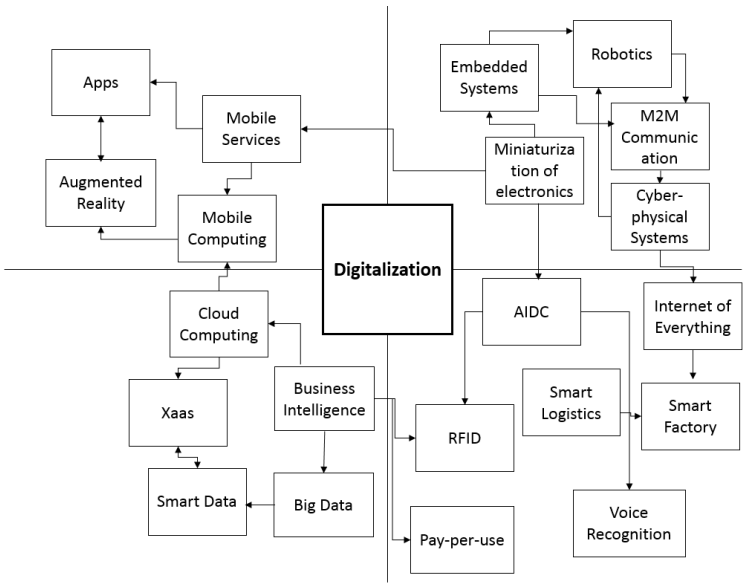

Figure 3. Technology Trends in Supply Chain Management
Source: Pfohl et al. (2015), The Impact of Industry 4.0 on the Supply Chain

It can be noted that apart from the technologies, which were revealed based on DHL report (2014), the following technologies can be also attributed to warehouse management: RFID (radio frequency identification) and voice recognition. In McKinsey reports 'Industry 4.0 How to navigate digitization of the manufacturing sector (2014) and 'Disruptive technologies: Advances that will transform life, business and the global economy' (2013), Capgemini Consulting report 'Industry 4.0 – The Capgemini Consulting View: Sharpening the Picture beyond the Hype' (2015) and BCG report 'Three Paths to Advantage with Digital Supply Chain' (2016) there were observed similar technologies and trends, therefore they are not presented further.

To get a more comprehensive understanding which digital solutions can be used in warehouse management articles in logistics journals were also analyzed. One of the leading and most widely used systems in warehouse management is Warehouse Management System (WMS) (Harrington, 2001; Patterson et al., 2004; Autry et al., 2005; Morton, 2009; McCrea, 2012; Napolitano, 2012; Hoffman, 2013; McCrea, 2014; Bond, 2015). Despite the fact that WMS is more an automated software solution than the digital one, this technology is widely spread in warehouse management and attributed to digitalization and Industry 4.0 (DHL, 2014). Therefore, WMS is included further in digital solutions in warehouse management.

Another digital solution, which was found in warehouse management, is pick-to-light technology (Qiang, 2008; Trebilcock, 2008; McCrea, 2015). This technology is intensively used in order-picking process in warehouse management (McCrea, 2015). Pick-to-light allows to increase order-picking accuracy and boost warehouse employees' productivity.

Thus, having observed industry reports and academic articles regarding digital solutions in warehouse management, the following digital solutions in warehouse management were identified. Further, each of the digital solution in warehouse management is reviewed.

Table 1. Digital solutions in Warehouse Management

Digital solution
Warehouse Management System (WMS)
Pick-by-voice
Pick-to-light
Radio Frequency Identification (RFID)
3D printing
Augmented reality
Robotics

As mentioned earlier WMS is more an automated solution then a digital one since it is a software program for managing warehouse operations. Currently, WMS is the most widely applied solution in warehouse management (McCrea, 2012; Napolitano, 2012; Hoffman, 2013). WMS is oriented to monitor materials movement and storage and carry out corresponding transactions in a warehouse. The main company goal of WMS implementation is to improve warehouse efficiency by cutting costs and managing warehouse transactions (Ramaa et al., 2012). Napolitano (2012) underlined that WMS systems have started to support much more sophisticated operations than just core warehouse functions such as receiving, picking and shipping. As John Hill, director for supply chain and logistics consulting firm, St. Onge Company noted that WMS functionality is used by no more than 60% to 65% (Napolitano, 2012), which means that large potential of WMS is not employed.

Pick-by-voice technology or how it is also called in the literature Voice Direct Technologies (VDT) (Sowinski, 2005; Phillips, 2013) provides direct voice control tool for order picking. As Sowinski (2005) showed pick-by-voice technology can boost warehouse productivity and at the same time improve company's bottom line. Based on the conducted analysis of the articles referred to pick-by-voice technology (Terreri, 2007; McCrea, 2015) it was concluded that this technology is the second most widely applied solution in a warehouse after WMS. It should be mentioned that pick-by-voice technology is one of the applications of WMS since it is directly connected to the system (Cork, 2005). As Barrows (2006) noted early adopters of pick-by-voice technology are able to improve order accuracy to more than 99,7%. As observed by McCrea (2015) pick-by-voice technology is one of the most affordable solutions in terms of costs. For instance, even in comparison of pick-by-voice with pick-by-light, the latter solution is more expensive, since every single location requires light in this case (McCrea, 2015).

Another technology, which is also used for order-picking in warehouse management is pick-to-light. As well as pick-by-voice technology pick-to-light solution is connected to WMS system. Ken Ruehrdanz, manager of the distribution systems market for Dematic characterized pick-to-light technology as a potentially transformational tool in warehouse management (Bond, 2013). Pick-to-light technology with automated data entry allows to improve order-pickers'

productivity by 10% and decrease human errors by 95% (Andriolo et al., 2016). Importance of pick-to-light is underlined also by Chris Castaldi, manager of business development at W&H Systems, who stated that pick-to-light technology 'is a game of seconds, which turn into minutes, hours and dollars' (Bond, 2013).

During the past decade radio frequency identification (RFID) is widely applied in supply chain management and particularly in warehouse management (Wang et al., 2010). However, RFID technology is not a new one, since it was used since 1940s (Attaran, 2011). RFID technology has been intensively researched by plenty of scholars (Kärkkäinen, 2003; Lee et al., 2004; Chow et al., 2006; Goodrum et al., 2006; Delen et al., 2007; Bottani and Rizzi, 2008; Ngai et al., 2008; Poon et al., 2009). Radio frequency identification (RFID) system is a system whereby a portable computer used by an order picker communicates with a host computer from anywhere in the warehouse (Chen et al., 2013). Companies use RFID technology to improve both material and information flows via automatic identification of goods using radio frequency tags (Wang et al., 2010). In Jones et al. (2004) it is indicated that RFID tags are able to store much more information about goods than traditional barcodes. RFID system allows to substantially increase productivity, since the warehouse workers are given directions of all activities by the host computer, which tells them location of products and verifies that they picked the correct order. In spite of the all benefits of RFID, this technology is rather costly in comparison with other solutions, since RFID requires tag reader, communication costs and some infrastructure costs (Gu et al., 2007).

The next digital solution is 3D printing, which is denoted as a disruptive technology and is able to change future logistics industry. 3D printing or additive manufacturing is defined as a process, during which a three-dimensional object is produced from a digital model (DHL, 2014). McKinsey Global Institute (2013) in the report 'Disruptive technologies' estimated that economic impact from 3D printing will grow in the future and will reach up to $550 billion per year by 2025. Xiao-dong and Fan (2016) underlined that 3D printing has plenty of advantages such as personalization, miniaturization and intelligence. Furthermore, currently possibilities of 3D printers have been extended in terms of used materials (from titanium up to food and stem cells) and consequently produce more functional tools such as batteries, transistors etc. (DHL, 2014). Regarding warehouse management 3D printing reveals great potential for companies, since it allows to produce goods on-site or outsource this task to small fabricators (DHL, 2014).

Augmented reality is another digital solution, which can boost productivity of warehouse operations and streamline processes in a warehouse (DHL, 2014). Augmented reality is a combination of the real scene, which the user can view, and a virtual scene, which is generated by the computer augmenting the real scene with additional information (Novak-Marcincin et al., 2013). Augmented reality is especially useful in order-picking warehouse process and this

solution allows to apply development and path finding techniques, which help workers to greatly increase their productivity while picking orders (Cirulis and Ginters, 2013). DHL Logistics Trend Radar (2014) added that usage of augmented reality would be also beneficial for companies during such warehouse operations as loading and unloading. Moreover, augmented reality enables warehouse employees to work hands-free using smart glasses (DHL, 2014), thus such picking method as pick-by-vision is applied in this case.

The last identified digital solution in warehouse management is robotics. As Galuzzo (2015) argued supply chain management area will be one of the first industries to derive benefits from robotics. Robotics can offer an attractive alternative in the future for material handling (DHL, 2014), since robots can provide zero-defect processes and enhanced sensing capabilities. Potkonjak et al. (2000) claimed that robots can decrease production costs to a great extent since dwell-time can be reduced and automated processes can be accelerated. In warehouse management drones or unmanned aerial vehicles (UAV) can provide a game-changing alternative to some traditional methods, for instance drones can be used as security tools and for inventory in warehouses (Vyas, 2016). It is estimated that by 2017 20% of logistics companies will use drones on a regular basis for monitoring their warehouse operations, searching and event management (Vyas, 2016). Apart from that robots have plenty of advantages, for instance they enable more personal flexibility, since they are able to provide 24/7 service. In addition, robotics can adapt to chaotic and changing warehouse environment due to its self-learning systems (McKinsey Global Institute, 2013). Despite all mentioned advantages, robots remain one of the most expensive solutions in warehouse management. McKinsey Global Institute (2013) determined that industrial robots cost tens or hundreds of thousands of dollars per robot. Furthermore, adoption of robots requires additional investments, which are estimated from $1.1 trillion to $1.6 trillion by 2025 (McKinsey Global Institute, 2013). Nevertheless, there can be observed a positive trend in terms of robots' costs, notably in recent decades prices for robots have decreased annually by 10% and are expected to decline at a similar or faster rate till 2025 (McKinsey Global Institute, 2013).

Having investigated digital solutions in warehouse management it can be spotted that majority of the solutions are referred to such warehouse process as order-picking, which is the most time-consuming process in warehouse management.

1.1.5. Impact of digital solutions on warehouse management

In the previous section digital solutions in warehouse management were identified. The research goal of the thesis is to develop an algorithm for implementing digital solutions in warehouse management for Russian companies and to achieve more relevant results it was decided to focus on several digital solutions for the algorithm development. For that the

following table was made, in which all earlier discussed digital solutions in warehouse management are compared using scale from 'very low' to 'very high'. The analysis is based on reviewed academic articles of digital solutions in warehouse management (Potkonjak et al., 2000; Sowinski, 2005; Gu et al., 2007; Wang et al., 2010; McCrea, 2012; Napolitano, 2012; Ramaa et al., 2012; Bond, 2013; Novak-Marcincin et al., 2013; Phillips, 2013; Xiao-dong and Fan, 2016) and industry reports (DHL, Capgemini, McKinsey, BCG).

Table 2. Comparison of digital solutions in warehouse management

Criteria Digital solution	Costs (implementation and maintaining)	Relevance in <5 years	Ease of implementation
WMS	Medium	Very high	High
Pick-by-voice	Very low	Very high	High
Pick-to-light	Low	High	High
RFID	Medium	Medium	Medium
3D printing	High	Low	Medium
Augmented reality	High	Low	Medium
Robotics	Very high	Very low	Low

Source: Author's analysis based on articles (Potkonjak et al. ,2000; Sowinski, 2005; Gu et al., 2007; Wang et al., 2010; McCrea, 2012; Napolitano, 2012; Ramaa et al., 2012; Bond, 2013; Novak-Marcincin et al., 2013; Phillips, 2013; Xiao-dong and Fan, 2016) and industry reports (DHL, Capgemini, McKinsey, BCG)

It can be observed from the table that WMS, pick-by-voice and pick-to-light have the best values in terms of costs, relevance and ease of implementation. Since the research goal is to develop an algorithm for Russian companies, it is relevant to review technologies, which are used most widely in Russian warehouse logistics. As analyzed earlier the most popular digital solutions in warehouse management at the present in Russia are WMS and pick-by-voice (Kholinov, 2007; Blinov, 2011; Evdokimov, 2012). Moreover, as indicated in McKinsey Digital (2014) the biggest areas of improvements in majority of industries are referred to labor and quality issues and WMS and pick-by-voice solutions are able to address gap in workers' performance and decrease number of errors. For these reasons WMS and pick-by-voice are further considered for developing an algorithm for their implementing in warehouse management for Russian companies.

In order to achieve the research goal WMS and pick-by-voice technologies are investigated in more detail.

1.2. Warehouse Management System and Pick-by-voice solutions

1.2.1. Warehouse Management System

WMS functionality

At present Warehouse Management System (WMS) is the most popular solution in warehouse management both in international (McCrea, 2012; Hoffman, 2013) and Russian companies (Blinov, 2011; Evdokimov, 2012). As mentioned earlier WMS is a software system or database driven computer application for tracking and managing warehouse processes. McCrea (2012) fairly characterized WMS as 'the grandfather of the supply chain software space' and WMS continues its reign at the present time. WMS serves as a linking node for integration of digital solutions (e.g. pick-by-voice, pick-by-light, RFID etc.).

Faber et al. (2002) distinguishes three types of warehouse management systems:

- Basic WMS – this type of WMS is the most simplistic, since it is appropriate only for stock and location control and recording information. The focus of the Basic WMS is on throughput.
- Advanced WMS – apart from the functions of a basic WMS, this type has extended possibilities such as planning of resources and activities for synchronizing goods' flow. The focus of the Advanced WMS is on throughput, stock and capacity analysis.
- Complex WMS – this type of WMS is the most sophisticated one, since it allows to optimize a warehouse or even group of warehouses. In terms of functionality, complex WMS offers a wide variety of functions such as value added logistics planning, transportation functions, dock door etc. Moreover, complex WMS provides comprehensive information about all the goods, notably about their location, further destination and why these goods are stored in the warehouse.

Another classification of WMS systems is proposed by Vjestica (2012), according to whom there are three types of WMS:

- Standard WMS – this type of system requires a set-up and WMS elements cannot be changed
- Configured WMS – in this system there are opportunities to change options or parameters of the system
- Customized WMS – the most sophisticated WMS, since it has range from standard modules to project specific modules and WMS elements can be changed

Motorola Solutions (2013) predicts that in 2018 among WMS users there will be a shift towards Best-of-Breed and Full-featured WMS (or how it was revealed above, Complex WMS). Thus, there will be an increase by 76% among users to Complex WMS and 40% of users will not use Basic WMS systems anymore.

Rama et al. (2012) emphasized that WMS could be separate systems or modules of an Enterprise Resource Planning system (ERP). Moreover, WMS systems can be applied as paper based, radio frequency/wireless based or combination of these two methods.

Main components of a WMS system are the following ones (Blinov, 2011):

1) The client part (radio terminals)
2) Mobile workstations of workflow participants (mobile trucks with scales, mobile units for sorting and distribution of goods, etc.)
3) Stationary workstations of workflow participants (operators, supervisors, employees of packing area, etc.)
4) Application Server, which can sometimes be integrated at the level of the platform used with server management database
5) Management server databases

To get a deeper understanding of a WMS functionality, the following table was built with basic, high-end and advanced features, which include tools for supporting particular supply chain and mostly warehouse operations (McCrea, 2012; Napolitano, 2012; Ramaa et al., 2012; Bond, 2015).

Table 3. Menu of features of a Warehouse Management System

Basic features	**High-end features**	**Advanced features**
Appointment scheduling	Radio frequency-directed operations	Multiple-Data center view
Receiving	Cycle counting	Stock-keeping slotting
Quality assurance	Carton manifesting	Broken-case flow
Put-away	Replenishment	Electronic data interchange capability
Location tracking	Value-added services	Parcel shipping
Work-order management	Vendor/carrier compliance	Impact analysis
Picking	Trailer manifesting	Traffic management
Packing and consolidation	Configurability	Import/export management
Shipping	Returns	
	Pick/put to light	
	Yard management	
	Wave management	
	Labor management	
	Task interleaving	
	Flow-through processing	

Benefits and drawbacks of WMS

The main advantage of WMS system in comparison with Material Resource Planning (MRP) system and Enterprise Resource Planning (ERP) system is that while MRP and ERP focus on storing products in fixed storage areas, which is clearly insufficient for effective warehouse management processes, whereas WMS systems allow to adjust storage locations

depending on products conditions (temperature, material etc.) and to make stocks inventory without interfering with production processes (Legutko et al., 2012).

Apart from this benefit, WMS system also allows to ascertain the accuracy of the orders and shipments, increase throughput with integration with other solutions (Warehouse Control System, Transportation Management System etc.) and improve labor productivity by tracking warehouse employees' productivity and change of their individual key performance indicators (Napolitano, 2012; Hoffman, 2013). Another advantage of WMS is that all of the warehouse transactions are tracked and managed by the system and WMS can display all activities in real time (Vjestica, 2012; Ramaa et al., 2015). Moreover, WMS system allows to substantially reduce paperwork, as reports with the system can be managed electronically. In addition, WMS provides better space utilization due to increased speed of fulfillment processes and consequently holding costs can be drastically decreased (Hoffman, 2013).

Speaking about particular figures Jones (2006) pointed out that typical range of savings due to WMS implementation is between 20 and 40%. Thus, WMS is able to reduce operating expenses by 35%, decrease the costs of carrying inventory by 27%, provide more efficient space utilization from 10 to 20%, drop of inventory by 50% after about 3 years, increase inventory accuracy by 20% and improve shipping accuracy by around 5%. Moreover, Jones (2006) noted that overall WMS can decrease the total costs per unit shipped, customer service and phone costs, the number of inventory out-of-stocks, improve the accuracy and timeliness of deliveries, increase profitability per order and per customer and as a result increase sales.

However, apart from merits WMS systems have drawbacks as well. WMS systems focus on 'daily, sequential, waterfall style task assignments, and this drawback has proven to be a crippling shortcoming' (Bond, 2015, p.34). That is why alternative approaches can be taken into consideration such as various digital solutions (pick-by-voice, RFID etc.). It should be mentioned that digital solutions don't replace WMS systems, but complement them, since they address specific needs in warehouse management.

WMS implementation

Among extant studies there does not exist an algorithm of implementing WMS in warehouse management. Based on further conducted research such algorithm is developed.

Harrington (2001) and Finkel (1996) propose some recommendations regarding WMS implementation. As a first step the author claims creating a project management team and appointing a project leader. As Frank Camean, senior project manager of consulting and systems integration firm eSYNC International, notes a project leader should be entirely committed to the project and it is recommended for him/her to have prior WMS implementation experience (Harrington, 2001).

As a next step, author recommends creating a project road map or implementation requirements document (IRP). This document includes project's objectives, project team members and their responsibilities, requirements for implementation (functional, operational, systems integration, technical) and business mandates such as number of interfacing applications, budget constraints, project deadlines (including interim deadlines), number of facilities/DCs involved in the project etc. Usually project team members include project manager, integration test team leaders, technical functional team leaders and application specialists (Finkel, 1996).

Further, company should decide whether to implement project using an outside consultant or independently. In case if company implements as advanced or best-of-breed WMS, it is advised to involve consultants (Aytaman, 2005).

Next, company should conduct a conference room pilot (CRP), which is a process of assessment how company's operations match software package's capabilities. This stage is carried out by the company and WMS vendor (in case company decided to acquire WMS). Depending on the project complexity, CRP development can take from 2 weeks to 2 months (Harrington, 2001).

If company wants to add any modifications to the system, it can submit these requirements to WMS provider. At the same time project team has to select and acquire all the required hardware for the new system such as bar code printers, radio frequency equipment, readers etc. Then training program and manuals need to be developed and training of internal staff needs to be started (Finkel, 1996).

After finishing WMS design, the phase of testing starts. As Fricke, principal consultant of PricewaterhouseCoopers' logistics/WMS practice, claims testing phase is the most crucial and complex stage of the WMS implementation and the consultant advises to have 4 types of testing for the project: functional, integration, volume and business readiness testing (Harrington, 2001). During the testing project the measurement of the degree to which testing is successful should be identified by the project manager and agreed by all project members.

Simultaneously with the testing phase training of WMS users should be conducted as mentioned earlier. As Aichlmayr (2002) asserts training is frequently overlooked by companies during WMS implementation. PricewaterhouseCoopers' consultants recommend to create a team, which will be responsible for training of WMS during the whole project. The training can be conducted in-house or by third-party consultants/WMS vendors.

The next stage stated by Harrington (2001) is the launch of WMS. Before the actual launch PricewaterhouseCoopers' consultants advise to carry out physical inventory of the warehouse. The launch of the WMS usually takes from 1 to 2 months.

The last stage is evaluation of WMS implementation, during which success of the project is measured as well as its specific processes/elements. Harrington (2001) and Aytaman (2005) emphasize importance of this stage, especially if WMS is implemented in several sites.

Considering payback period of WMS Trebilcock (2009) argued that for a traditional WMS it is considered to have a 2-year payback period, however in time of a down economy manager expect to have a 1-year payback or even less. As Ramaa et al. (2012) noted WMS implementation requires significant money and time investment and before implementation companies should conduct cost benefit analysis.

1.2.2. Pick-by-voice

Pick-by-voice functionality

More international and Russian companies have started to apply pick-by-voice technology for their labor-intensive such order-picking, put-away, crossdocking and cycle counting processes in a warehouse (Sowinski, 2005; Phillips, 2013; Bezotosnaya, 2013). Analysis of extant studies of digital solutions in warehouse management revealed that pick-by-voice is the second most widely spread solution in warehouses after WMS and considered as a proven and reliable technology (Sowinski, 2005; Terreri, 2007; Phillips, 2013; McCrea, 2015). Pick-by-voice technology is a surprisingly old technology, as it has been introduced in the late 1990s in US warehouses (Jones, 2006; McCrea, 2015). Pick-by-voice technology is one of the modules, which is included in WMS system (Cork, 2005).

Pick-by-voice applies voice direction and speech recognition software with hardware for guiding during picking, put-away, crossdocking and other processes (McCrea, 2015). The worker wears a headset, which is connected to a terminal/wireless computer, which in turn is attached to the worker's belt. This terminal is wirelessly connected with the WMS. The worker receives directions through the headset regarding the location of the next item, which has to be picked (Jones, 2006). Then the worker confirms the location by mentioning a unique code through the microphone and after that confirms the quantity of picked items. This process is iterated until the order is completed and then the next order starts (de Vries et al., 2015). Thus, it can be inferred that pick-by-voice enables two-way real-time communications between the picker and the system. It is noteworthy to mention that pick-by-voice requires a short training for order-pickers so that the system can adapt to the voice of pickers (McCrea, 2015).

Benefits and drawbacks of pick-by-voice

As Terreri (2009) and Phillips (2013) pointed out pick-by-voice can provide a substantial benefit for warehouse workers, since order-pickers can work hands-free and don't need to change their focus. Consequently, pick-by-voice technology is suitable for picking heavy items, since operations with these items require both hands free (Cork, 2005). Thus, pick-by-voice technology provides voice verification that the task has been accomplished so that quality and

speed of order-picking increases. Phillips (2013) also mentioned pick-by-voice could be also useful for loading operations, since technology allows forklift drivers to report load information verbally and better concentrate on their operations, increasing safety of the used equipment and goods.

Another benefit is noticed by Jones (2006) and Jezierski and Preez (2009), who state that voice direct technology can be used by workers who speak different languages within the same warehouse, which can be a major advantage for companies with international personnel.

Furthermore, costs of pick-by-voice implementation are rather low and technology itself is rather simple, especially in comparison with other digital solutions for warehouse management, which require more investment and provide comparable results (McCrea, 2015).

Moreover, pick-by-voice technology allows to simplify cycle counts, since the worker can do a count and generate a replenishment request during order-picking. Voice direct technology can reduce warehouse costs between 10 and 25% and help to achieve 99,8%, which is not considered as a rare case (Barrows, 2006; Terreri, 2009). Thus, pick-by-voice is an inexpensive tool, which can influence company's bottom line.

Overall, it can be inferred that voice direct technology enables to have an increase of accuracy rates, productivity rates, safer working conditions since pick-by-voice technology serves as a step-by step 'mentor' for warehouse employees.

Apart from the benefits pick-by-voice has also some disadvantages. De Vries et al. (2015) observed that order-picker performance still greatly depends on the ability of the worker to use pick-by-voice technology efficiently. Furthermore, McCrea (2015) noted that companies that use pick-by-voice technology could face problems in case warehouse employees speak in an unusual manner. For instance, pick-by-voice technology cannot be used by workers who change their speaking manner, e.g. at first stutter, then speak very fast etc.

Pick-by-voice implementation

As in the case of WMS, among extant studies there is no algorithm of pick-by-voice technology implementation in warehouse management. However, there are some recommendations for the implementation, which are presented below.

Phillips (2013) underlined that to achieve better results companies are advised to integrate pick-by-voice technology into existing supply chain processes in the company and investigate its usage in every workflow.

According to Hounsell (2005) before the implementation of pick-by-voice warehouse processes should be reviewed in order to understand in which ways the new technology can bring better results and form the requirement for the new tool. Moreover, company needs to decide whether to modify existing process and equipment or not. As Hounsell (2005) points out this stage can be one of the most time-consuming during the whole implementation project.

In the beginning the project team should be assigned managed by the project leader. Communications during the all implementation project should be maintained in order to curtail gossips and misunderstanding of the new technology and deliver clear expectation among the employees (Luedde and Miller, 2009). Further, training with the all involved parties is conducted, which usually takes several short sessions (Hounsell, 2005). This stage is a crucial one, since it facilitates personnel engagement in the project (Luedde and Miller, 2009).

A pilot project for pick-by-voice is advised to be done since it allows to reveal software and hardware errors and inefficiency before the actual launch of technology (Hounsell, 2005).

The last stage includes measuring performance of the employees after pick-by-voice implementation (Luedde and Miller, 2009) and this evaluation enables to make more consistent forecasts regarding workload.

Speaking about financial attractiveness of voice direct technology as observed by Jezierski and Preez (2009) the average payback period of the technology is around 1 year or less, although authors also mention examples of companies where pick-by-voice technology's payback period was around 3 months.

In order to further investigate digital solutions in warehouse operations, empirical study is conducted. In the second chapter of this thesis, analysis of the best practices of companies in warehouse digitalization is carried out. During empirical study, implementation of such digital solutions as WMS and pick-by-voice is analyzed. After that, based on conducted theoretical and empirical research, an algorithm for implementing of digital solutions (WMS and pick-by-voice) is developed for Russian companies.

1.3. Research gap

Having conducted comprehensive literature review of digitalization in warehouse management it was identified that digitalization has made influential changes in supply chain management and more specifically in warehouse management. More and more companies apply digital solutions in warehouse management to stay competitive and increase profit. Moreover, it was observed that warehouses have become a significant link within the supply chain and considered as growth centers, which can add value. Thus, digital solutions can be company's competitive advantage in warehouse management and companies should understand how to implement digital solutions in warehouse management.

From the literature review it was determined that there are plenty of studies referring to automation solutions in warehouse management, such as software programs (WMS, ERP, CRM etc.). Moreover, in extant studies there are some identified technologies, but they mostly refer to supply chain management or logistics and not to warehouse management. Additionally, there is lack of research of developing an algorithm of implementing digital solutions in warehouse management.

Hence, the following research questions were stated:

- Which digital tools are used in warehouse management?
- How digital solutions can be implemented in warehouse management?

It is noteworthy to mention that the thesis is country specific since the research goal of the study is to develop an algorithm of implementing digital solutions in warehouse management for Russian companies based on best practices of international and Russian companies. Thus, cases of Russian companies and Russian branches of international companies are investigated. Hence, this thesis adds value and brings originality to the current studies, which are limited in terms of studying digital solutions in warehouse management in Russia.

Research gap exists in both theoretical and practical perspectives. From the theoretical perspective the research contributes to the sphere of digitalization in warehouse management, which is quite uninvestigated. Thus, digitalization implications for warehouse management and digital solutions in warehouse management were revealed. Additionally, impact of digital solutions on warehouse management was established. Hence, the study is valuable to the theoretical spheres.

From the practical perspective during the research an algorithm of implementing digital solutions (WMS and pick-by-voice) in warehouse management was developed, which can be used by Russian companies and serve as a base for digital solutions implementation in warehouse management for international companies. Thus, the study holds value for warehouse managers, IT managers and other employees, who participate in implementation of digital solutions in warehouse management.

1.4. Summary of Chapter 1

The literature review of digitalization in warehouse management, which is presented in the first chapter, is conducted thematically. It consists of two parts: digitalization in warehouse management and Warehouse Management System and Pick-by-voice. In the first part of the chapter digitalization in warehouse management was investigated. Thus, phenomenon of digitalization and its development over time was reviewed, warehouse operations and trends were identified. Additionally, implications of digitalization for warehouse management were established as well as specific digital solutions, which are applied in warehouse management. A table with digital solutions in warehouse management and their impact on warehouse management was built, which will serve as a basis for further research. Having determined that

the most relevant at present days and the most widely spread technologies in Russia in warehouse management are Warehouse Management System (WMS) and pick-by-voice solution, these technologies were the basis for further research. The second part of the first chapter includes review of two digital solutions: WMS and pick-by-voice. During this part functionality of both technologies was established as well as their benefits, drawbacks and recommendations for implementation.

Having analyzed articles on digitalization of warehouse management, it was found out that there are very few studies, which identify digital solutions in warehouse management. Moreover, there is no research on developing an algorithm for digital solutions implementation in warehouse management. All of the above mentioned indicates that there is a research gap in the topic of warehouse management digitalization and this topic can be investigated in this master thesis.

CHAPTER 2. METHODOLOGY OF RESEARCH

The second chapter includes description of the methodology which has been applied in the research. For the research multiple case study research strategy was chosen, since it complies with the research goal and the research questions of the thesis. To begin with, research strategy is presented, which includes using qualitative research approach and multiple case study strategy. After that data collection process is described. Further the process of data analysis is elaborated. Finally, the research quality is discussed, which consists of reliability and validity.

2.1. Research strategy

This study is based on qualitative research approach, which is chosen according to stated research goal and which allows to investigate research questions. Qualitative research study has plenty of advantages, for instance observation and measurements in natural settings, interpretation and rational approach, subjective ‘insider’ view, holistic perspective and others (Ghauri, 2005). In addition, since the topic of digitalization in warehouse management is currently under development, especially in Russia, it is early to carry out quantitative research

and measure any data. Field of digitalization in warehouse management is quite new and complex and extant theories are not fully available to explain the phenomenon, that is why a qualitative approach is the preferred one (Kotzab et al., 2005). Moreover, topic of digitalization in warehouse management is not well structured in the secondary sources, that is why qualitative research strategy is more suitable in this study.

In order to apply qualitative approach, various research methods in logistics and supply chain management can be used, which include surveys, case study, interviews, focus groups, modelling, experiments etc. (Larson and Halldorsson, 2004). All these methods can be useful tools for research in supply chain management field (Larson and Poist, 2004), but it is important to choose a research method, which corresponds with the research problem and research goal of the study.

After the analysis of the articles and textbooks on the researched topic it was inferred that case study is the most appropriate research method for achieving master thesis goal. As Stuart et al. (2002) state case study is an appropriate research method for the field of supply chain management. One of the advantages of the case method is its ability to address 'Why?' and 'How?' questions in the research process (Ellram, 1996; Meredith, 1998; Yin, 2003). Since the main research question of the study is 'How digital solutions can be implemented in warehouse management?', case study is suitable for the research.

According to Yin (2003) a case study is 'an empirical enquiry that investigates a contemporary phenomenon within its real life context especially when the boundaries between phenomenon and context are not clearly evident'. Since the topic of warehouse digitalization is uninvestigated one and digitalization is considered as a contemporary phenomenon (Pfohl et al., 2015), case study is particularly helpful in this thesis. Moreover, there exists paucity of theory in the field of digitalization in warehouse management and lack of well-supported definitions, notably digitalization and digitization terms are frequently used interchangeably, automated and digital solutions in warehouse management are not clearly defined. Thus, these factors favor the usage of case study as a research strategy.

Furthermore, data in supply chain management and warehouse management are quite unstructured (Kotzab et al., 2005) and case study as a qualitative method is suitable in this study. Stuart et al. (2002) suggest that case study is an appropriate research method, which allows 'to map the field of supply chain management, as they allow identification and description of critical variables'.

Case study are applied to achieve various goals: to provide description (Kidder, 1982), test theory (Pinfield, 1986; Anderson, 1983), or generate theory (Gersick, 1988; Harris and Sutton, 1986). In the master thesis cases study research strategy is used in order to generate theory using evidence from case studies. As Meredith (1989, 1993) showed in several papers

case study can capture conceptual developments, but at the same time not proposing immediate broad theories (Swamidass,1991; Wacker, 1998). Moreover, case study allows to carry out continuous analysis and thorough and deep analysis of the objects, but still case study results can be biased due to the fact that this method is rather subjective and has limited representativeness. It is worthwhile to mention that results from the case study cannot be statistically generalized. According to Yin (2003) the goal of case studies is to derive analytical generalizations, not statistical ones.

Yin (2003) states that there are three types of case studies: exploratory, descriptive and explanatory. In the research combination of descriptive and exploratory case studies are used, since these types of case study allow to profoundly describe a phenomenon within its context and allow to define questions (Kotzab et al., 2005).

According to Yin (2003) there are two classifications of case studies: single case study and multiple case study and holistic and embedded case study. A single case study is usually used when it represents a critical case or a unique case. Furthermore, a single case can be chosen if it is typical or provides an opportunity to observe and analyze a phenomenon which was studied only by few researchers. Multiple case strategy implies using more than one case study for the research. In multiple case strategy it is expected that findings of the first case occur in other cases as well and as a result these findings can be generalized. In this thesis multiple case study is used, which increase level of results' accuracy and help to provide a sustained and comprehensive research. There are certain criteria, which should be taken into account while selecting case studies. For multiple case study method a replication logic often can be used, but it is also can be used within a certain domain (Eisenhardt, 1989).

Regarding second classification, it is referred to the unit of analysis. When holistic case study is used, it means that the research is concerned with the organization as a whole. As for embedded case study it is applied when there is a need of examining a number of logical sub-units within the organization, perhaps departments or work groups, which means that several units of analysis will be involved for the analysis (Eisenhardt, 1989). An embedded case study is used in the research, since several units of analysis are involved in the study, such as warehouse department and IT department.

It should be noted that research process for case studies resembles that of other research (Yin, 2003; McCutcheon & Meredith, 1993). Stuart et al. (2002) proposed a five-stage research process, which is presented below.

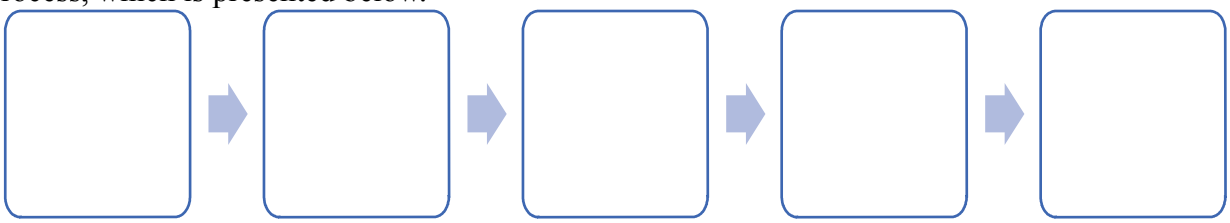

Figure 4. The five-stage research process model

This research process model is used in this thesis and for convenience research is described by three stages. The first stage is the theoretical chapter, which investigates digitalization in warehouse management and such digital solutions as Warehouse Management System and pick-by-voice. The second stage includes conducting an empirical study, during which the analysis of the best practices in warehouse digitalization is accomplished. The third stage of the research consists of developing an algorithm for implementing digital solutions in warehouse management for Russian companies.

2.2. Data collection

The case study research strategy may include such data collection methods as interviews, documentation, archival records, direct observations, participant observations and physical artifacts. Thus, case study allows to have multiple sources of evidence, which is known also as data triangulation (Yin, 2003). To carry out comprehensive research both primary and secondary data are used.

Secondary data are usually used in descriptive and explanatory research, which corresponds to chosen case study group (Saunders, 2011). Secondary data was extremely important in the beginning of the empirical study when companies were selected for the case study analysis. After selecting companies and receiving agreement from them for participation in the research, data about company's warehouse logistics and digital solutions in warehouse management were obtained through the secondary sources. In this master thesis secondary data includes internal company documents, articles and official companies' websites.

As for primary sources, in this research in-depth semi-structured interviews and consultations with digital solutions' integrators are conducted. In addition, for one of the cases direct observation is conducted. Qu and Dumay (2011) claimed that the interview is one of the most important qualitative data collection methods and this method has been widely applied in various studies. For achieving research goal semi-structured interviews were chosen. This type of interviews was selected due to its flexibility since it allows to modify questions, their order, flow of the conversation and obtain hidden insights from the respondents (Qu and Dumay, 2011). At the same time, semi-structured interviews have the basis of the questions and topics to be covered during the interviews. Regarding consultations with digital solutions' integrators several companies were chosen after conducting interviews in the companies where digital solutions were implemented. In one of the companies warehouse manager agreed to demonstrate digital solution in action (WMS) and showed company's warehouse. Thus, direct observation of company's warehouse logistics and digital solution was conducted.

The main data collection methods in the thesis are in-depth interviews, consultations with digital solutions' integrators and company documentation. Official company websites, and direct observation are also used for the analysis.

The data collection process consisted of three phases: pre-data collection, data collection and follow-up data collection. Each of the phase is discussed further in more detail.

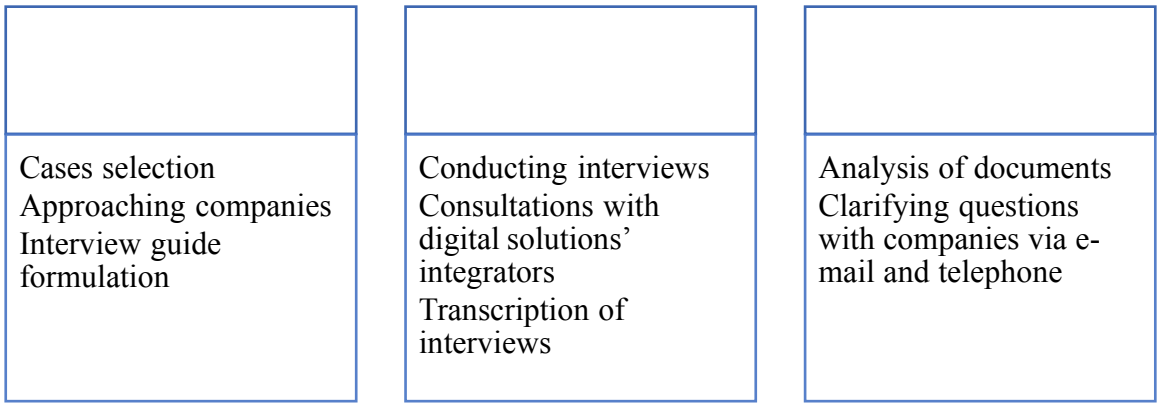

Figure 5. Data collection process

The first phase is pre-data collection. This stage consisted of cases selection, approaching companies and formulating interview guide. In order to select cases criteria for cases selection were identified. The following criteria were established chosen for cases selection:

- Companies should be logistics providers (3PL) or distribution companies
- Companies should have experience in implementing digital solutions in warehouse management
- Russian companies or Russian branches of international companies

After identifying criteria for cases six companies were found for the research. Five of the companies are 3PL providers and one company is a distribution company. Based on the data from secondary sources it was found out that all companies had vast experience in implementing digital solutions in warehouse management and were either Russian companies or Russian branches of international companies. Moreover, companies are different in terms of country of origin and company size, which enhances possibility of making analytical generalizations through the case study research strategy. After these six companies were reached and an agreement from them to take part in the research was received, it was possible to move to the next step of pre-data collection – interview guide formulation.

Interview guide was developed both in English and Russian since several interviewees from Russian branches of international companies were not native Russian speakers. Interview questions guide can be found in Appendices 1 and 2.

Phase II

The second phase is actual data collection. During this stage interviews with companies' representatives were conducted, consultations with digital solutions' integrators were carried out and further interviews were transcribed.

All interview questions are open and interviews are semi-structured, since there was a list of questions, which contributed to research investigation, but at the same time the questions were reformulated or varied during the interviews. The interviews were carried out face-to-face or via Skype, which provide high level of accuracy and preciseness. Moreover, face-to-face interviews and Skype interviews allow to provide more comprehensive research, understand processes and their sequence, which is very beneficial for the qualitative research strategy. Interviews are conducted with managers of high and medium levels, which allow to understand both strategic and operational views on asked questions. Below a table with interview respondents can be found for all six cases.

Table 4. Semi-structured interviews respondents

Case company	**Interviewees' position**
Company A	1) Head of Warehousing 2) Marketing director 3) Warehouse manager 4) IT specialist and IT manager
Company B	1) Warehouse manager 2) IT manager and IT analyst 3) Sales director 4) Financial director
Company C	1) Commercial manager 2) Warehouse Manager 3) IT manager
Company D	1) Warehouse manager 2) Director of logistics 3) IT director 4) Marketing director
Company E	1) Contract logistics manager 2) IT manager 3) Head of corporate sales 4) Warehouse manager
Company F	1) Warehouse manager 2) Business applications development manager 3) Head of competence center project department

Before the interviews each respondent received the interview questions guide as well as the brief research structure so that the interviewee has clear expectations regarding the interview and feels more comfortable during the interview. Interviews were conducted from January till mid of April 2016. This prolonged period of interviews conducting can be explained by the fact that reaching some of the companies took several months, since some of the case companies were reached via telephone or e-mail on official companies' websites and arranging interviews

required confirmation of several managers. The average length of interviews was around one hour.

The interview questions were divided into several groups depending on the data collection objectives. The first group of questions includes questions about digital solutions in warehouse management. The second group consists of questions regarding specific digital solutions in warehouse management, how these solutions were implemented, who was responsible during each stage of implementation, which problems company faced during the implementation etc. Interview questions guide can be found in Appendices 1 and 2.

In one of the researched companies direct observation was accomplished, since warehouse manager agreed to present digital solution in action (Warehouse Management System) and gave a tour of company's several warehouses.

After conducting interviews it was found out that in several cases companies cooperated with IT integrators or consulting companies to implement digital solutions in warehouse management. Thus, two companies were reached, which helped case companies to implement technologies. These companies are IT integrator Ant technologies and consulting company KORUS Consulting. Additional interviews with these companies were conducted regarding the specific digital solution implementation (WMS or pick-by-voice). Interview questions were based on earlier mentioned interview questions guide, but were focused solely on the digital solution implementation (stages of implementation, responsible employees, problems during implementation etc.). Moreover, after additional interviews consultations with representatives of Ant technologies and KORUS Consulting were carried out in order to ensure the accuracy of the developed algorithm for implementing of digital solutions in warehouse management.

When all the interviews and consultations were conducted, interviews were transcribed. Manual coding was used for all the collected primary data to provide data accuracy and transparency. Interviews were transcribed both in Russian and English since interviews were conducted in both languages.

Phase III

The third stage of data collection process is follow-up data collection. This stage included collection of company's documentation and clarifying questions and facts via e-mail with the companies' representatives.

Company documentation included internal documents such as presentations, reports, guides, excel files with tables and graphs. This documentation allowed to derive additional data regarding digital solutions implementation and ensure quality of the research since analysis is based on multiple sources.

Furthermore, official company websites were used again in order to verify obtained data from the conducted interviews regarding company's digital solutions and their implementation. Such sources within the websites were used as publications, news, press releases and articles.

Moreover, during the follow-up data collection regular e-mails were sent to the companies' representatives in order to clarify some questions and verify data. Also, several telephone calls with interviewees were conducted for data clarification.

2.3. Data analysis

Since the research strategy of the thesis is case study, data analysis procedure is divided into two categories: within-case study analysis and cross-case study analysis. Both analyses were conducted during the research.

Within-case analysis includes detailed description of cases based on obtained data from interviews, consultations, company documentation, official websites, observation. Within-case analysis was extremely helpful at the beginning of the data analysis since it allowed to structure enormous volume of received data. Thus, within-case analysis allowed to obtain unique patterns for each case before making generalizations across cases (Eisenhardt, 1989). Moreover, within-case analysis accelerated cross-case comparison.

Cross-case analysis can be typically performed using two tactics (Eisenhardt, 1989). The first tactic is to select dimensions and then search for within-group similarities and intergroup differences. Dimensions can be identified based on the existing literature or research problem or the researcher can choose them. The second tactic consists of selecting pairs of cases and then listing similarities and differences between each pair of cases. There is also an extension to this tactic, which consists of grouping cases into larger groups (more than two cases in a group) for comparison. As Eisenhardt (1989) pointed out comparison of cases can lead to novel findings such as new concepts and categories in terms of the research problem. For the research the first tactic was chosen and dimensions were chosen by the researcher and approved during the consultations with digital solutions' integrators.

During the data analysis chain of evidence was demonstrated to provide transparency and reliability of the research. Moreover, multiple quotations were used in each case and as Pratt (2009) asserts quotes can serve as a proof of further inferences.

For organizing and exploring data coding was used, which is an essential analytical procedure used during the research (Strauss and Corbin, 1990). All interviews and additional data (information obtained from consultations, company websites, observation) were coded manually. For the data analysis open, axial and selective coding were conducted to investigate digital solutions implementation in warehouse management. In order to carry out open coding interview transcripts were analyzed several times not to miss any relevant details. After that different labels were made, for instance 'project group during implementation'. Next, axial

coding was conducted, which allowed to group open codes into categories (Strauss and Corbin, 1990). Eventually, selective coding was carried out in order to identify broad categories based on developed axial codes. Thus, the applied codes were summarized in the following table.

Table 5. Coding procedure

Selective codes	Axial codes
Digital solution content	Functionality
	Solution elements, required equipment
	Responsible employees of managing the digital solution
Reasons of implementing the digital solution	Productivity
	Costs
Problems during the digital solution implementation	Software errors and bugs
	Human factor
Implementation of the digital solution	Stage duration
	Stage content
	Number of stages
	Economic effect
	Peculiarities of implementation in Russia
	Responsible employees during each stage of implementation

Four selective codes were developed based on the data analysis: digital solution content, reasons of implementing the digital solution, problems during the digital solution implementation and implementation of the digital solution. In Chapter 3 there are presented results of within-case and cross-case analyses, where axial codes were taken as a basis for the analysis.

2.4. Research quality

In order to ensure quality of case studies, it should be verified that case studies meet the requirements of validity (whether the stated evidence is valid) and reliability (whether the stated evidence is correct) (Stuart, 2002; Yin, 2003). For case study research, Yin (2003) points out how validity of the research can be ensured. He proposes three types of validity: construct validity, internal validity and external validity. These three types of validity are 'applied during different stages of the research process, as reliability and validity are ensured by a clearly structured research process' (Yin, 2003).

As for the construct validity in the chosen case studies different data sources are used: interviews, consultations, direct observation, internal company documentation, companies' websites. Moreover, a chain of evidence is carried out since during the interviews all the

respondents answers' are recorded not to miss any important details. Taking into account all of the above mentioned it can be concluded that conducted case studies have construct validity.

Since internal validity is useful in explanatory studies, not in descriptive ones, this test is not considered for case studies (Yin, 2003).

External validity is achieved in this research by using multiple case design whereby pattern-matching approach is adopted (Mentzer and Kahn, 1995). Thus, replication logic in multiple case studies is used to achieve external validity.

Reliability is established in the research design by using the protocol consistently across interviews and a common database for collecting and analyzing data. In addition, the interviews are audiotaped for subsequent transcription to minimize researcher bias and support data quality and reliability. In order to increase reliability of the study a chain of evidence was maintained. For that direct quotations of the interviews' respondents were presented and specific companies' documents were referred. Thus, an external observer of the study has the opportunity to trace the evidence derivation from stated research questions and received raw data to case study conclusions (Yin, 2003).

2.5. Summary of Chapter 2

The second chapter consisted of the research methodology, which will be the basis for the research. The thesis is based on qualitative research approach, which is chosen according to stated research goal and allows to investigate research questions. Since topic of digitalization in warehouse management is not well structured in the secondary sources, that is why qualitative research strategy is more suitable in this study.

The primary research strategy is multiple case study. This particular method was chosen for the research since it allows to address 'Why?' and 'How?' questions in the research process and the research is an uninvestigated one. In the research descriptive and exploratory case studies are applied, since this type of case study presents a complete description of a phenomenon within its context, i.e. how digital solutions are implemented in warehouse management. For the analysis of case study within-case analysis and cross-case analysis are applied in order to identify within-group similarities coupled with intergroup differences. For that, specific dimensions were chosen by the researcher and approved during the consultations with digital solutions' integrators.

Regarding data both primary and secondary sources are used. In this master thesis secondary data includes internal company documents, companies' websites. As for the primary sources, in this research qualitative semi-structured interviews with companies' managers and digital solutions' integrators are conducted. As for the criteria for cases selection, Russian companies or Russian branches of international companies were chosen, who are third-party

logistics providers (5 companies) or distribution companies (1 company). Moreover, as an obligatory criterion was experience of companies in implementing digital solutions in warehouse management. Interviews in this study are one of the main parts of case study strategy. The interviews in some cases were followed by additional consultations with the interviewees to clarify some aspects and verify data. Moreover, for one of the cases observation was used. Thus, triangulation principle is fulfilled since data from different sources and different research methods are used, which allows to decrease level of subjectivism and bias, which is typical for qualitative research. During the study it was verified that the research has both construct and external validity and reliability in the thesis is also established.

CHAPTER 3. APPLICATION AND BEST PRACTICES OF DIGITALIZATION IN WAREHOUSE MANAGEMENT

As it was mentioned in the first chapter the following digital solutions were chosen for the development of an algorithm of implementing digital solutions in warehouse management: Warehouse Management System (WMS) and Pick-by-voice.

For the research of automation and digital solutions in warehouse management 6 companies were chosen: Company A, Company B, Company C, Company D, Company E and Company F. Due to the confidentiality reasons names of the companies are not revealed in the thesis and further companies are referred as Company A, Company B etc.

The following criteria were chosen for cases selection:

- Logistics providers (3PL) and distribution companies
- Experience in implementing digital solutions in warehouse management
- Russian companies or Russian branches of international companies

Thus, the following table with the cases overview was developed.

Table 6. Cases overview

Cases	Company A	Company B	Company C	Company D	Company E	Company F
Industry	Logistics provider	Logistics provider	Logistics provider	Food distributor	Logistics provider	Logistics provider
Country	Belgium/ Russian branch	Russia	Russia	Denmark/ Russian branch	Germany/ Russian branch	Finland/ Russian branch
Digital solution	WMS	WMS	WMS	Pick-by-voice	Pick-by-voice	Pick-by-voice
Implementation of the digital solution	2005	2005	2005	2010	2014	2014
Implementation approach	Independent	Cooperation with the integrator	Independent	Cooperation with the integrator	Independent	Cooperation with the integrator
Number of implementation stages	5	6	5	5	5	6
# interviews logistics	1	1	1	2	2	1
# interviews IT	2	1	1	1	1	1
# interviews sales, marketing, finance	1	2	1	1	1	1

Next, case studies for each company are presented. According to Eisenhardt (1989) one of the tactics for cross-case patterns searching is selecting categories or dimensions. Since topic of digital solutions in warehouse management is uninvestigated one and consequently there are no dimensions considering this topic in the existing literature, the dimensions were chosen by the researcher and approved during the consultations with digital solutions' integrators (IT integrators or consulting companies). For the within-case analysis and the subsequent cross-case analysis the following dimensions were chosen:

1. Reasons of implementing the digital solution in warehouse management
2. Problems during the digital solution implementation in warehouse management
3. Stages of implementation of the digital solution, duration of each stage
4. Responsible employees during each stage of implementation of the digital solution

The within-case analysis is structured the following way. In the beginning overview of the company and its warehouse logistics are given. Then existing digital solutions in warehouse management in the company are identified. Further, each of the earlier mentioned dimensions is analyzed regarding particular company's digital solution in warehouse management.

3.1. Within-case analysis

3.1.1. Within-case- analysis of companies with Warehouse Management System

Company A

Company overview and its warehouse logistics

Company A is an international logistic provider, which has subsidiaries in 20 countries Company's headquarter is located in Antwerp, Belgium. Company A is a full-value transport company, which is oriented to creating new opportunities for its clients and offering customized solutions.

Company A has subsidiary in Saint Petersburg, which was the first company's office opened in Russia. This office has been existed since 1993 and has developed into a full-value transport company rendering services such as liner agencies and international forwarding. Total site surface of company's warehouses is 200 000 m^2 (Official website of Company A, 2015).

In order to investigate company's digital solutions both primary and secondary data sources were used. Apart from collecting data from company's website, articles in newspapers, a series of interviews with company's employees were conducted. Interview questions are presented in Appendix 1. Overall, four semi-structured interviews were conducted with the following company's representatives: marketing director, warehouse manager, IT specialist and IT manager and head of warehousing. Moreover, such method as an observation is applied, since company agreed to demonstrate all its warehouses and its WMS system.

Existing digital solutions in warehouse management

As it was found out from the interview with the marketing director that company has the following digital solutions in warehouse management: Warehouse Management System (WMS), Electronic Data Interchange (EDI), Cargo security and tracking system and 3D printing. Next, each of the digital solutions is briefly discussed. Considering WMS system Company A has implemented it without assistance and installed it in warehouses in Saint Petersburg and Chelyabinsk. WMS system is used in the company on a regular basis in the warehouses and serves as an inseparable tool of all warehouse operations. EDI system was also implemented by company's employees without any assistance and this system is used for data interchange in all company's warehouses and for WMS functioning as well. Cargo security and tracking system was also implemented by Company A by itself and this system is currently used only for maintenance of the company's customers that require transportation of valuable goods. As for 3D printing it was found out that this digital solution is at the very early stage of implementation in the company. At the present company acquired Da Vinci model of 3D printer for the general testing technology and the understanding of its features. As marketing director stated 'it's

extremely early to say that digital solution has been implemented'. Moreover, he added that 'there are many options for the implementation of the 3D printer'. Initially, company sees the development of this digital solution as offering customers some additional services that will help them increase the value of their business, for instance quick printing of spare parts for the customers. It is worth mentioning that most of digital solutions in warehouse management Company A implemented on its own except 3D printing. Due to implementation of digital solutions using its internal personnel, Company A has valuable experience of implementing such solutions.

Further, such digital solution of Company A as WMS is analyzed based on the earlier chosen dimensions taking into account interviews answers, observation of WMS (visual demonstration of WMS in the company by head of warehousing), company's documentation and website.

Reasons of implementing the digital solution in warehouse management

Regarding reasons of implementing WMS in warehouse management there were several opinions from company's managers. For instance, head of warehousing mentioned the following reason:

'WMS is an inseparable part of everyday warehouse operations and this system is a part of Big data'.

Head of Warehousing

Moreover, IT and warehouse managers underlined that WMS helps to keep track of warehouses' key performance indicators and make forecasts. One of the greatest benefits of WMS according to them are savings in terms of personnel, time and expenses. For instance, WMS helps to improve customer service, increase productivity and reduce overhead costs. Moreover, the whole documents flow is included in WMS, which is very convenient for the company to accelerate warehouse operations.

As marketing director stated Company A is going to commercialize WMS and intends to sell WMS as an independent commercial product in 2016. It should be noted that WMS will be sold only to production companies and not to logistics providers. Thus, company keeps one of its competitive advantages, since company's WMS is considered as one of the best systems on the market (Marketing director, 2016).

Stages of implementation of the digital solution, duration of stages

As mentioned earlier, WMS system was implemented from within and company implemented it using only its own personnel. As Head of Warehousing stated WMS implementation started in February 2005 and was developed gradually. WMS implementation finished in January 2006, so that implementation took 1 year or 250 working days.

As a first stage of implementing a WMS company did an initial analysis, which included development of logistics warehouse model, identifying WMS requirements and making decision considering acquiring a WMS or developing a WMS on its own. According to Head of Warehousing initial analysis can also include such additional steps as WMS providers' selection and tender arrangement, but since Company A implemented WMS on its own, these steps were not included in WMS implementation. Warehouse manager stated the following reasons of development of logistics model:

'Development of logistics model is necessary to determine the warehouse processes and required documentation, allocate labor resources and loading equipment, calculate performance storage for each process area, forecast volumes in the warehouse'.

Warehouse manager

Moreover, the theoretical description of the warehouse interaction with external storage services was provided. The process of creating a logistics warehouse model is quite complex, and as warehouse manager noted 'if the company does not have experienced warehouse specialists, company should attract external consultants'. The result of this step was the development of the detailed recommendations regarding warehouse operations and the need for the implementation of WMS was determined. The development of logistics warehouse model took around 10 working days and was conducted by director of logistics and warehouse manager.

The next step of the initial analysis was identifying WMS requirements based on the established logistics warehouse model. This step included determining of how WMS would describe the goods and packaging, how it would distribute the processing warehouse zones, how it would work with documents and reports, as well as what would be the interface of the system and the ability to integrate it with other software programs. The outcome of this step was Systems Requirement Document (SRD), a document with a detailed description of the required parameters of the management system for a particular warehouse (in this case – for a warehouse in Saint Petersburg). This step required around one week or 5 working days. The step was carried out by director of logistics, warehouse manager and warehouse specialists.

The last step of the initial analysis was making decision considering acquiring a WMS or developing a WMS on its own. During this step Company A determined that it has sufficient resources for developing WMS without assistance and it doesn't have to buy any ready-made software program. It can be observed that developing a WMS on its own is not generally typical even for logistics providers, but due to the fact that Company A had experienced warehouse and IT specialists and also had subsidiaries abroad, which already implemented WMS and could share their experience, decision about developing a WMS from within was not a hard one for Company A. The make/buy decision took 2 working days and was accomplished by director of logistics and warehouse manager.

As a second stage of implementing a WMS Company A started to plan WMS implementation. To begin with, company defined WMS implementation framework – goal, objectives, potential limitations, basic requirements for the system and the expected results of the project. Definition of the project framework took 2 days. Then, company assigned responsible employees for WMS implementation. The WMS implementation team consisted of Head of Warehousing, IT director, warehouse manager, warehouse specialists, IT specialists and an HR specialist. As a project manager Head of Warehousing was assigned. Also a project coordinator was assigned who was the warehouse manager of Company A. After assigning the project team, a budget of warehousing department was adjusted taking into account WMS implementation expenses. Budget adjustment was carried out by Financial director and Head of Warehousing. After that existing hardware and software programs in all company's departments were evaluated by IT specialists so that WMS can be integrated with the existing systems. Further, communications among all project team members regarding WMS implementation were established, for instance frequency of meetings, regular consultations via e-mail and calls etc. Afterwards, an internal promotion of WMS system has started in the company so that all personnel would be aware of the new coming system and would be prepared for changes. This task was accomplished by Marketing director and HR specialist. The planning stage required around 2 months.

The third stage of WMS implementation consisted of developing of a WMS. This stage was the most time-consuming since it required determining WMS content, specific modules, which are to be included in WMS, detailed description of these modules, defining integration of WMS and existing systems. This stage required around 6 months and was carried out by director of logistics and IT specialists.

The fourth stage was practical implementation of WMS. This stage included informational and technical support throughout the whole WMS implementation project. Further, a pilot version of WMS was launched, which included main WMS functions. After that feedback about pilot version was received and as a result all shortcomings were corrected. As an example of a shortcoming Head of warehousing cited an example when a pilot version revealed that WMS was not integrated with the security system, which could complicate and slow down warehouse operation to a great extent. When all shortcomings were corrected, WMS was implemented to the full extent, i.e. all initially approved modules were launched in the system and WMS was launched. After that trainings for warehouse and IT specialists were carried out. After the WMS launching the feedback was collected one more time in order to eliminate all the potential shortcomings. Throughout the whole practical implementation stage monitoring of WMS usage was carried out. The stage required around 2 months and was accomplished by

director of logistics, warehouse manager, IT director, warehouse specialists, IT specialists and HR specialist.

The fifth stage was the last one and consisted of evaluation of WMS performance. During this stage key performance indicators (KPIs) of warehousing department were measured from the date of WMS launch. According to Head of Warehousing KPIs have been greatly improved since the WMS implementation, for instance stock accuracy, order accuracy, number of incidents and near misses have been drastically improved. Moreover, amount of control was significantly reduced, which allowed employees to invest their time in other tasks. However, direct and precise impact of WMS implementation was hard to measure. As marketing director stated:

'There were many other factors, which could potentially influence warehousing department performance (e.g. seasonality, personnel changes etc.), that is why we didn't evaluate impact of WMS implementation right away.'

Marketing director

Further, payback period of WMS was evaluated and equaled 1,5 years. The evaluation stage required around 2 months to identify impact of WMS implementation. The stage was carried out by warehouse manager, HR director and HR specialist.

Despite the fact that WMS was implemented in 2006, WMS development team in Saint Petersburg was constantly working on system improvement. Currently, Company A has assigned a WMS product manager, who is in charge of the entire system. As it was found out from the interview with IT manager and IT specialist Company A intends to launch plenty of additional modules in WMS, for instance mobile application WMS SaaS for Android, flexible licensing module, voice order picking module, module of inventory management for clients and others.

Responsible employees during implementation of the digital solution

As mentioned earlier for the WMS implementation project Company A assigned a team, which consisted of Head of Warehousing, IT director, Warehouse manager, warehouse specialists, IT specialists and an HR specialist. As a project manager Head of Warehousing was assigned and as a project coordinator Warehouse manager was assigned. During some of the stages other employees were involved, such as Marketing director, but these employees were not included in the core project team and for that reason were not mentioned earlier.

Problems during the digital solution implementation in warehouse management

During the WMS implementation there were some problems, which further were eliminated. For instance, as Head of warehousing mentioned the following problem during the WMS implementation:

'There was a lack of module-based structure during the implementation and that complicated tracking and managing warehouse operations'.

Since company developed a WMS on its own and didn't have prior experience of developing such system, the mentioned problem was a quite predictable one. Currently, Company A WMS does have module-based structure, what is especially beneficial for the company, since it is going to commercialize WMS in 2016. Another problem during the implementation was lack of documentation (e.g. how the system was built) and no database structure. Furthermore, during the implementation company sometimes applied trial and error approach, for instance when it launched some of the additional modules.

Company B

Company overview and its warehouse logistics

Company B was established in 2005. It was founded with the participation of multi-modal American transport company and Company B is pleased to offer its services in the field of warehouse and transport logistics. The basic principle of Company B is to provide a high level of services that allow customers to effectively address the challenges.

Company has warehouses of categories A and A +, corresponding to the highest international standards in the field of storage and handling. The warehouse complex is located in Moscow and has a total area of over 33,000 m^2. Apart from Moscow branch company is going to establish warehouses in the Moscow region, St. Petersburg and Yekaterinburg (Official website of Company B, 2015).

The main goal of Company B is to provide integrated logistics services (design, organization and effective management of supply chain based on customer requirements) at the level of the national logistics operator with the use of modern business and information technology in the field of logistics.

For investigating company's digital solutions both primary and secondary data sources were used. Secondary data sources included company's website, internal company documentation, articles and primary data sources consisted of interviews with company's employees. Interview questions are presented in Appendix 1. In total, four semi-structured interviews were conducted with the following company's representatives: warehouse manager, IT manager and IT analyst, sales director and financial director. Moreover, an additional interview with an expert of WMS implementation was conducted, since this expert is a consultant from Ant Technologies, who participated in WMS implementation in Company B.

Existing digital solutions in warehouse management

During the interview with the warehouse manager it was found out that Company B has only WMS among digital solutions. Company B has implemented WMS in warehouse management in cooperation with the company Ant Technologies. Further, WMS implementation is analyzed in detail.

Reasons of implementing the digital solution in warehouse management

As for the reasons of implementing WMS warehouse manager noted that 'our company needed to find and implement the most suitable WMS system, which would help to quickly reduce costs in the warehouse and get a real economic benefit'.

Warehouse manager added that WMS would allow to have effective and economical use of specialized storage equipment and storage space, reduce storage costs and handling of goods. Management of the company will be able to receive full information about the warehouse in real time, which would allow to manage the company effectively.

In addition, IT manager of Company B pointed out that:

'WMS would be integrated with existing software programs and as a result accelerate warehouse operations'.

IT manager

Furthermore, warehouse manager emphasized that in 2005 Company B required multifunctional management tool that allows to significantly increase employee productivity.

Stages of implementation of the digital solution, duration of stages

WMS implementation in Company B was carried out in cooperation with company Ant Technologies, which is the leader of the Russian market of IT solutions for logistics. According to warehouse manager WMS implementation started April 2005 and finished in March 2006. Thus, implementation took 1 year or 250 working days. As senior consultant of Ant Technologies noted and Warehouse manager confirmed that currently 3PL providers tend to cooperate with consulting companies or IT integrators for the digital solutions' implementation.

The first stage of WMS implementation in Company B was initial analysis, which consisted of identifying WMS requirements and making decision considering acquiring or developing WMS on its own. As a first step company identified WMS requirements. Thus, as warehouse manager clarified, future WMS should be able to keep records of almost all warehouse operations:

- Collecting information about the address storage of goods
- Supporting the work with radio terminals and specialized equipment
- Organizing work with bar codes
- Keeping records of the working time of employees and the number of transactions made by them
- Automatically generating and delivering reports
- Implementing handling a variety of options for different clients within one warehouse
- Supporting several geographically distributed warehouses

Apart from that, it was found out that as additional requirements company stated that WMS should have a clear and open architecture with the ability to support and develop the system by company's own resources. Moreover, WMS should have a Russian interface.

Identifying WMS requirement took around 1 week and was conducted by director of logistics, warehouse manager and warehouse specialists.

The second step of initial analysis stage was making decision regarding developing a WMS without assistance or acquiring a WMS. Since in 2005 Company B didn't have any experience in digital solutions in warehouse management, company's management decided to acquire a WMS from the provider. It is worth mentioning that in 2003-2005 in Russia there was observed a phase of development among WMS systems (Trotsky, 2009) and it was quite typical for a logistics provider to attract a third-party provider to implement WMS. Therefore, company decided to acquire a WMS to make implementation process less time-consuming and less costly. The make/buy decision took 2 working days and was accomplished by director of logistics and warehouse manager.

The second stage of WMS implementation included supplier selection of WMS. In case of Company B it was required to choose a specialized system that would be able to keep records of almost all warehouse operations at the existing terminal. It should be mentioned that suppliers of WMS systems can offer either customized WMS system for the specific clients or ready-made solutions that require insignificant adaptation. As the warehouse manager emphasized:

'When choosing a supplier, it is necessary to be guided by the following criteria: ability of the WMS to meet the requirements of the developed logistics warehouse model of the warehouse, variety of WMS functions, simplicity of the system for the staff, ROI of the system, as well as reliability of the supplier and quality of supplier's services'.

Warehouse manager

In addition, the warehouse manager mentioned flexibility of WMS, which is an important issue since in case of business environment changes, settings of WMS should be able to be quickly changed to support warehouse operations. The supplier selection stage required around 3 months and was accomplished by director of logistics, warehouse manager, IT director, senior consultant and junior consultants from Ant Technologies.

The third stage of WMS implementation consisted of tender arranging. Company B considered several proposals for warehouse automation. First of all, it takes into account factors such as the complexity, functionality of the system, the possibility of adapting it in commercial logistics, ease of management and the ability to independently maintain and refine the system. Only after considering these mentioned factors company turned to the price factor. As a result, the company chose Ant Technologies provider, which offered such system as Logistic Vision Suite, which is based on supply chain management system, developed by Mantis International. According to warehouse managers and IT manager. As senior consultant of Ant technologies noticed:

'Logistic Vision Suite is a powerful modern solution designed primarily for automation of logistics business processes of large and medium-sized enterprises and oriented to help working in the various segments of the companies in the development of their business'.

Senior consultant of Ant technologies

The tender arranging stage took 3 months and was accomplished by director of logistics, warehouse manager and senior consultant from Ant Technologies.

The fourth stage of WMS implementation was planning of WMS implementation. During this stage Company B defined project framework, such as goal, objectives, expected results of the WMS implementation. Then company's management assigned a project team for WMS implementation. The project team consisted both of Company B and Ant technologies employees. From Company B there were warehouse manager, IT director, warehouse specialists, an IT specialist and an HR specialist. From Ant Technologies there were senior and junior consultants and an IT specialist. As a project manager Ant Technologies' senior consultant was assigned. As a project coordinator the warehouse manager of Company B was assigned. Further, necessary documentation required for WMS implementation was developed and approved. As a next step communication among all project team members regarding WMS implementation were established, for instance frequency of meetings, regular consultations via e-mail and calls etc. Moreover, for smoother WMS implementation an internal promotion of WMS in Company B was required. This step was carried out by marketing director and HR specialist. Planning stage took around 2 months.

The fifth stage was practical implementation of WMS. As it was found out from the interviews, implementation of WMS implies not only the physical installation of the software on the server, but also the description of the settings of business processes in the WMS system. To ensure the efficient cooperation of Ant Technologies and Company B it was important to carry out integration between the proposed WMS system of Ant Technologies and existing software programs of Company B. It was also important that customers of Company B felt comfortable working with the new WMS system.

The practical implementation stage required around 2 months and was accomplished by director of logistics, warehouse manager, IT director, warehouse specialists, IT specialists, HR specialist and senior and junior consultants from Ant Technologies.

According to the Ant Technologies consultant the practical implementation stage consisted of the following steps:

1. Installation of the server software of WMS system and client (Company B) places, tuning radio terminals for working with the new system
2. Description and configuration of the client business processes
3. Testing of the system and loading the initial data

4. Comprehensive training of dispatchers, administrators and other technical staff of the warehouse
5. Optimization of business processes included in the system
6. Development and maintenance of WMS system

In addition, as part of the implementation optional billing module was installed, which provided full control over all payments to existing customers and created an account with the maximum level of detail for any warehouse operations and the units of goods. It also allowed to bill for the various operations of accommodation, travel, recruitment, selection, packaging and shipment. It is worth noting that in the entire warehouse Wi-Fi network was set up and radio terminals and printers for printing labels were installed.

The sixth stage was evaluation of WMS performance. As a result of WMS implementation it was observed that employee productivity has increased, storage equipment and storage space has been used more effectively and storage costs were reduced. In addition, information exchange process was accelerated by several times. Company B didn't estimate return on investment of WMS implementation, since it was hard to measure the direct impact of WMS implementation on warehouse operations efficiency. The evaluation stage required around 2 months to identify performance of warehouse operations after WMS implementation. The stage was carried out by warehouse manager, HR director and HR specialist and senior consultant from Ant Technologies.

Responsible employees during implementation of the digital solution

As mentioned earlier the project team consisted both of Company B and Ant technologies employees. Company B employees included warehouse manager, IT director, warehouse specialists, an IT specialist and an HR specialist. Ant Technologies consisted of senior and junior consultants and an IT specialist. As a project manager Ant Technologies' senior consultant was assigned. As a project coordinator the warehouse manager of Company B was assigned.

Problems during the digital solution implementation in warehouse management

During the WMS there were revealed some problems. First of all, the disparity of some aspects of Russian specifics was identified, also there were software bugs and errors in the system configuration connected with the lack of experience. However, through interaction with the consultants of Ant Technologies ways of solving arising difficulties were found. The most important and serious problem during WMS implementation was the human factor. Thus, a link between the activities of each individual employee in the warehouse and prescribed business processes of WMS should have been established, thereby building a single mechanism of information system and personnel formalized rules.

Company C

Company overview and its warehouse logistics

Company C was founded in Saint Petersburg in 1997. The company is a Russian third-party logistics provider and it provides services in warehouse logistics, transportation logistics and consulting services. Company is oriented to providing individual approach to its clients and a simple and transparent billing system for its customers. Moreover, company strives to apply cutting-edge technologies in its business processes to increase efficiency of the operations and provide higher level of customer service.

Regarding its warehouse logistics, Company C has started to provide warehouse services since 1997. Company's main specialization is custody services (responsible storage of goods). At present company has a leading position on the St Petersburg market of custody services. Since 2008, company has been operating in the warehouse of category A, which complies with the highest standards in warehouse management. The total area of the warehouse complex is 25,000 m^2.

In the next 5 years company intends to diversify geographically and develop a network of branches, operating on the principle of regional distribution centers (warehouses). As potential location company considers such cities as Rostov, Samara, Nizhny Novgorod, Novosibirsk, Yekaterinburg, Kaliningrad (Official website of Company C, 2015).

In order to conduct analysis of WMS implementation in the company both primary and secondary data sources were used. Secondary data sources included company's website, internal company documentation, articles and primary data sources consisted of interviews with company's employees. Interview questions are presented in Appendix 1. In total, three semi-structured interviews were conducted with the following company's representatives: commercial manager, warehouse manager and IT manager.

Existing digital solutions in warehouse management

During the interview with commercial manager it was found out that company has only WMS among digital solutions. Regarding other digital technologies (RFID, pick-by-voice, 3D printing) commercial director noted that they are rather expensive and company cannot allow additional expenses due to the current economic downtime. Company has implemented WMS in warehouse management on its own and didn't use any outside personnel. Next, WMS implementation is analyzed in detail.

Reasons of implementing the digital solution in warehouse management

Considering reasons for WMS implementation commercial manager pointed out the following reasons:

'WMS allowed reducing time for goods' put-away and order-picking processes, decreasing number of errors among warehouse employees and reducing overhead costs, notably decreasing warehouse personnel due to increased warehouse efficiency'.

Commercial manager

Warehouse manager added that WMS was also implemented due to relocation of company's warehouse and the old software system wasn't suitable for the new warehouse, since this system caused plenty of human errors and didn't provide required accuracy rates.

Furthermore, IT manager stressed that WMS enabled integration with existing company's software programs and consequently this integration helped to eliminate double-checking of data in different programs.

Stages of implementation of the digital solution, duration of stages

Implementation of WMS in the company was conducted independently so that company involved only its internal personnel. As warehouse manager stated implementation started in February 2005 and finished in January 2006. Hence, implementation took 1 year or 250 working days. According to the commercial manager and warehouse manager nowadays 3PL providers prefer to cooperate with consulting companies for the digital solutions' implementation.

As a first stage of WMS implementation company conducted an initial analysis, which consisted of identifying WMS requirements and making decision considering acquiring or developing WMS on its own. To begin with, company identified WMS requirements. Identifying WMS requirements required 5 working days. The step was carried out by director of logistics, warehouse manager and warehouse specialists.

From the company's internal documentation it was found out that company expected the following WMS requirements:

- The system should be focused not only on account of warehouse operations, but also on the preliminary recommendations regarding the implementation of these operations (for example, recommended cells for goods storage)
- The system should store data about all the warehouse transactions performed in the warehouse
- The system should support data exchange of files of different formats (Excel, csv, txt, html)
- The system should support the designated inventory storage location, which allows locating items in the most accurate and fastest way
- The system should support warehouse bar coding elements
- The system should support the exchange of messages between the PC client and terminal client

- The system should support different warehouse modes such as cross-docking mode and wave mode
- The system should support operations with serial and defective goods

The second step of initial analysis stage was making decision regarding developing a WMS using its internal personnel or acquiring a WMS. The make/buy decision took 2 working days and was accomplished by director of logistics and warehouse manager. Company decided to implement WMS on its own, since it had highly qualified personnel among warehouse and IT employees. As warehouse manager emphasized:

'Our company was one of the pioneers on the Russian market who implemented WMS from within'.

Warehouse manager

The second stage of WMS implementation included planning of WMS implementation. In the beginning of this stage company defined project framework, such as goal, objectives, expected results of the WMS implementation. After that company developed technical design specification or product requirements document, where the following elements were stated: purpose of the object, its technical characteristics, quality of project performance, technical and economic requirements. Next, company assigned a project team for the implementation. The project team consisted of warehouse manager, operations manager, IT manager, IT specialist and an HR specialist. As a project manager warehouse manager was assigned. As a project coordinator operations manager was assigned. Afterwards necessary documentation required for WMS implementation was developed and approved. During the planning stage regular communications among the involved project members were established. Apart from that a HR specialist did an internal promotion of WMS to prevent misunderstanding of the new project and provide clear expectation about the system. The planning stage required around 2 months.

The third stage of WMS implementation consisted of developing of a WMS. This stage was the most time-consuming since it required determining WMS content, specific modules, which are to be included in WMS, detailed description of these modules, integration of WMS and existing systems. WMS was developed by company's IT specialists and this development took 3 months.

The fourth stage included practical implementation of WMS. As warehouse manager stated this stage took 3 months. At the beginning of this stage a pilot version was launched in order to identify possible shortcomings of the system and to correct them. IT manager elaborated the content of the practical implementation stage:

'Practical implementation of WMS consisted not only of the physical installation of the software on the server, but also integrating WMS with the existing programs'.

IT manager

The fifth and the last stage was evaluation of WMS performance. After practical implementation of WMS warehouse manager observed that warehouse workers' productivity has been significantly increased and order-picking accuracy has been boosted so that company had very few mistakes during its warehouse operations. The evaluation stage required around 2 months to identify impact of WMS implementation. The stage was carried out by Warehouse manager, HR director and HR specialist.

As commercial manager stated company reduced its warehouse personnel by 25% after WMS implementation. Commercial manager added:

'We didn't estimate return on investment of WMS since it would be very imprecise and it was obvious for us in the beginning that WMS implementation would have much more benefits than incurred costs'.

Commercial manager

Responsible employees during implementation of the digital solution

The project team included employees from various departments such as warehouse manager, operations manager, an IT specialist and an HR specialist. Additionally, a project manager was assigned who was company's warehouse manager as well as project coordinator, who was company's operations manager.

Problems during the digital solution implementation in warehouse management

Regarding problems, which occurred during WMS implementation, there were some problems connected with technical issues such errors in software and bugs. Apart from that, commercial director noted that there was resistance from warehouse employees who did not see benefits of the WMS at first. In addition, a predictable problem occurred during integration of WMS with existing company's software since they had different data formats, layout etc.

3.1.2. Within-case analysis of companies with Pick-by-voice solution

Company D

Company overview

Company D is one of the largest distributors of food products in the Russian market. The company is part of an international holding founded in 1978 in Denmark and operating on the markets of over 20 countries of the world. Company D in Russia was founded in 2009. The partners of the company are almost all the major players in the HoReCa segment and retail industry. Company's approach of organizing warehouse processes is determined by the high requirement on the quality of goods and services. Company's mission is defined as linking

suppliers of high quality products, business solutions and brands to customers in the market, ensuring the growth of the value of their business.

In order to analyze company's digital solutions both primary and secondary data sources were used. Secondary data sources included company's website, internal company documentation, articles and primary data sources consisted of interviews with company's employees. Interview questions are presented in Appendix 2. In total, four semi-structured interviews were conducted with the following company's representatives: warehouse manager, director of logistics, IT director and marketing director. Moreover, an additional interview with an expert of voice order picking implementation was conducted, since this expert is a consultant from KORUS consulting, who participated in pick-by-voice implementation in Company D.

Existing digital solutions in warehouse management

Among digital solutions in warehouse management Company D has WMS (Manhattan SCALE) and pick-by-voice/voice order picking technology. It is worth mentioning that pick-by-voice technology is connected with WMS system. Since 2010 company has installed WMS system, implementation of pick-by-voice technology was much less complicated. Further, pick-by-voice technology implementation is investigated in detail. This technology was implemented in Company D in cooperation with KORUS consulting, a Russian system integrator, which deals with the optimization of business processes, implementation of information systems and IT-outsourcing.

Reasons of implementing the digital solution in warehouse management

Company D decided to implement pick-by-voice technology for several reasons. Firstly, the use of voice order picking in the warehouse can significantly increase the productivity of warehouse operations, improve screening accuracy and the ergonomics of the warehouse. Secondly, such system makes it possible to reduce training personnel costs. Moreover, due to the fact that voice order picking is conducted via voice portable terminals and these terminals send employees step by step voice instructions directing an employee to a particular passage or cell for the selection of the necessary goods, the employee does not have to learn the picking lists, he focuses on the task. As a result, an employee achieves a significant reduction in the number of picking errors and accelerates the processing of each order line. As it was found out from the interview with the warehouse manager, voice technology is particularly effective in warehouses with a wide range of goods, special temperature conditions, where a large amount of manual selection is expected (picking). As the warehouse manager stated his opinion considering training warehouse personnel:

'A new employee needs just one working day in order to learn how to work with a voice terminal and fully perform the duties of a warehouse worker'.

Warehouse manager

Stages of implementation of the digital solution, duration of stages

Pick-by-voice implementation in Company D was carried out in cooperation with company KORUS consulting, which is one of the leading Russian system integrators. According to the warehouse manager implementation of pick-by-voice technology started August 2010 and finished in January 2011. Thus, implementation took 6 months. As director of logistics and warehouse manager pointed out logistic providers currently in majority of cases tend to cooperate with consulting companies for the digital solutions' implementation.

In 2010, Company D has built a new distribution center with total area of 11000 m^2 in the Moscow region and started to use it. Later company decided to automate operations of the new warehouse and integrate WMS with voice order picking technology.

The first stage of pick-by-voice implementation in Company D was initial analysis. Since company already had installed WMS, logistics warehouse model was already developed before pick-by-voice implementation. Thus, the initial analysis stage consisted of making decision considering acquiring or developing pick-by-voice technology on its own. Due to the fact that Company D in Russia was founded in 2009 and didn't have vast experience in Russia, company decided to acquire voice order picking technology. The make/buy decision stage required 2 days and was done by director of logistics and warehouse manager.

The second stage of pick-by-voice implementation was supplier selection. After monitoring the Russian market of warehouse pick-by-voice solutions and taking into account experience of European subsidiaries of the Company D international holding, company's management decided to implement a voice order picking technology 'Vocollect Voice'. Partner of this technology implementation was a Russian IT-integrator KORUS Consulting, which is an exclusive partner of Manhattan Associates in Russia and CIS countries. As director of logistics underlined:

'We decided to work with KORUS Consulting, because this company has a great experience in implementing large and complex projects in the field of warehouse management'.

Director of logistics

Supplier selection stage required around 1 month and was carried out by director of logistics, warehouse manager, IT director, senior and junior consultants from KORUS consulting.

Furthermore, director of logistics added that Company D monitors actions of their competitors in terms of warehouses automation on a regular basis and according to the

company's observation Manhattan solutions, provided by KORUS Consulting at distribution centers of other companies fully met the imposed expectations. Since company already selected a supplier for pick-by-voice, tender arranging was no longer needed.

The third stage consisted of planning pick-by-voice implementation. During this stage company defined project framework, such as goal, objectives, expected results of the technology implementation. Afterwards, a project team was assigned for pick-by-voice implementation. The project team consisted both of Company D and KORUS consulting employees. Company D employees consisted of director of logistics, warehouse manager, IT director, warehouse specialists, an IT specialist and an HR specialist. KORUS employees consisted of senior and junior consultants and an IT specialist. As a project manager KORUS senior consultant was assigned. As a project coordinator director of logistics of Company D was assigned. As a next step of planning stage all the required documents for the project were developed and approved. Further, communication process between all project members was established, for example there was made a schedule of meetings, regular reports and calls. In order to accelerate the pick-by-voice implementation HR department of Company D made the internal promotion of the new technology launch among all company's employees. The planning stage took 2 months and was conducted by director of logistics, warehouse manager, IT director, senior and junior consultants from KORUS consulting.

The fourth stage was practical implementation of pick-by-voice. During this stage not only physical installation of the new technology was carried out, but also all warehouse operations were revised according to the new technology. Moreover, an integration of WMS and voice order picking technology was accomplished. The practical implementation stage required 2 months and was accomplished by director of logistics, warehouse manager, IT director, warehouse specialists, IT specialists, HR specialist and senior and junior consultants from KORUS consulting.

The fifth stage was evaluation of pick-by-voice performance. After the new technology implementation it was observed that employee order picking productivity has significantly improved and as a result employee motivation has also increased. Evaluation stage took around 1 month and was done by warehouse manager, HR director and HR specialist and senior consultant from KORUS consulting.

After 2 years company estimated the interim results of the implementation. According to the company's daily statistics staff productivity has dramatically increased, i.e. number of processed goods per each employee in the warehouse. In the beginning of 2012 employee productivity was approximately 300 kg per hour and at the end of 2012 productivity reached a value of 800 kg per hour. As director of logistics noted by the example of Company D an additional conclusion can be made.

'Improving technology helps employees to increase their productivity, consequently productivity growth leads to an increase in salary, since this criterion is taken into account in calculating the remuneration'.

Director of logistics

Hence, it can be inferred the staff has an additional incentive to increase its productivity and the efficiency of all company increases correspondingly.

Responsible employees during implementation of the digital solution

Project team consisted both of Company D and KORUS consulting employees. Company D team included of director of logistics, warehouse manager, IT director, warehouse specialists, an IT specialist and an HR specialist. KORUS team included senior and junior consultants and an IT specialist. As a project manager KORUS senior consultant was assigned. As a project coordinator director of logistics of Company D was assigned.

Problems during the digital solution implementation in warehouse management

During the pick-by-voice implementation company faced several problems. First of all, there were software bugs and errors in the system configuration connected to the lack of experience. However, through interaction with the consultants of KORUS consulting, Company D solved all system errors. One of the major problems during the implementation was connected with the personnel, since all warehouse employees should have been trained how to work with the new technology. Moreover, initial resistance of the new technology of some of the employees also took place. As a potential problem HR director mentioned staff reduction due to the future increased employee productivity. However, company's management company chose a different scenario. By increasing employee productivity with the help of pick-by-voice technology, the company did not reduce staff and instead increased volumes of trade flows, shipping and developed new areas of business. For instance, company began to develop the new area of safe custody services. As a result, since the implementation of voice order picking the number of clients has been significantly increased. The system allows to create multi-dimensional regular reports to provide customers with accurate timely information on commodity stocks.

Company E

Company overview and its warehouse logistics

Company E was founded in Germany in 1980 and currently has grown into one of the world's leading logistics providers. At present company is presented in over 100 countries. Company has plenty of capabilities in different areas such as seafreight, airfreight, contract & integrated logistics and overland. Company E provides logistics services in all key industry

sectors: aerospace, automotive, FMCG, high tech, industrials, oil & gas logistics, pharma & healthcare and retail (Official website of Company E, 2016). Company has cutting-edge IT systems, global logistics network and provides excellent customer service. Warehouse logistics is included in contract & integrated logistics area.

In Russia in contract & integrated logistics company provides comprehensive services to meet the specific needs of customers in terms of 139 000 m^2 of warehouse space in the 5 logistics centers (both specialized and multi-client), which are located in Moscow and Leningrad regions (Official website of Company E, 2016).

For the analysis of company's digital solutions both primary and secondary data sources were used. Secondary data sources included company's website, internal company documentation, articles and primary data sources consisted of interviews with company's employees. Interview questions are presented in Appendix 2. In total, four semi-structured interviews were conducted with the following company's representatives: contract logistics manager, IT manager, head of corporate sales and warehouse manager.

Existing digital solutions in warehouse management

Company E has vast in-house experience in terms of digital solutions in warehouse management. Company implemented on its own all digital solutions, such as WMS, Radio frequency identification (RFID), pick-to-light and pick-by-voice technologies. Further, pick-by-voice technology is investigated in detail.

Reasons of implementing the digital solution in warehouse management

Company implemented pick-by-voice technology for several reasons. First of all, company had problems with levels of order picking performance. Due to pick-by-voice technology implementation, company was able to improve its key performance indicators in terms of warehouse operations. As contract logistics manager stated:

'Company's management wanted to improve productivity of warehouse employees, achieve greater order picking accuracy and improve entire warehouse management efficiency'.

Contract logistics manager

Stages of implementation of the digital solution, duration of stages

Company E carried out voice order picking implementation on its own in Russia, since it had vast in-house experience of implementing digital solutions and company already implemented such technology in other subsidiaries. According to the contract logistics manager implementation of pick-by-voice technology started in the beginning of October 2014 and finished in the end of May 2015. Thus, implementation took 8 months.

The first stage of pick-by-voice implementation in Company E was initial analysis. Since company already had installed WMS, company didn't need to develop a logistics warehouse

model. Thus, the initial analysis stage included making decision considering acquiring or developing pick-by-voice technology on its own. Since Company E had rich experience in cutting-edge solutions in warehouse management and other company's subsidiaries could share their knowledge with the Russian subsidiary's employees, company decided to implement pick-by-voice technology without assistance. The make/buy decision stage took 2 days and was done by director of logistics and warehouse manager.

The second stage was planning of pick-by-voice technology implementation. This stage included identifying goal and objectives of implementation, expected results and project limitations. Then, for the implementation a project team was assigned. The team consisted of contract logistics manager, warehouse manager, IT director, warehouse specialists, an IT specialist and an HR specialist. As a project manager contract logistics manager was assigned. As a project coordinator warehouse manager was assigned. Further, all the necessary documentation was developed and communication process between all project member was established. For making the process of pick-by-voice implementation smoother an HR specialist promoted a new technology inside the company on a regular basis. The planning stage required 2 months and was conducted by director of logistics, warehouse manager and IT director.

The third stage was developing of a pick-by-voice technology. This stage wasn't a time-consuming one, since employees from another company's subsidiary shared their knowledge with their colleagues in the Russian subsidiary. During this stage specific functions of the technology, which should be included, were identified. The developing of pick-by-voice required 1 month and was conducted by warehouse manager, IT director and IT specialists.

The fourth stage was practical implementation of pick-by-voice. This stage consisted of not only physical installation of the new technology, but also all warehouse operations were revised according to the new technology. In addition, an integration of all software programs and digital warehouse solutions with voice order picking technology was accomplished. The practical implementation stage took 2 months and was accomplished by director of logistics, warehouse manager, IT director, warehouse specialists, IT specialists, HR specialist.

The fifth stage was evaluation of pick-by-voice performance. Due to pick-by-voice implementation company has spotted increased warehouse key performance indicators. As warehouse manager pointed out:

'Order picking productivity of warehouse workers has been improved by several times and order picking accuracy has also increased'.

Warehouse manager

Evaluation stage took around 1 month and was done by warehouse manager, HR director and HR specialist. During the evaluation company found out that payback period of the voice order picking technology was 6 months.

Responsible employees during implementation of the digital solution

As mentioned earlier a project team for voice order picking implementation was assigned. The team consisted of contract logistics manager, warehouse manager, IT director, warehouse specialists, an IT specialist and an HR specialist. As a project manager contract logistics manager was assigned. As a project coordinator warehouse manager was assigned.

Problems during the digital solution implementation in warehouse management

Among problems during pick-by-voice implementation company's management faced several ones. First of all, during the implementation it was found out that voice order picking is suitable only for simple order picking processes, which don't have plenty of features. Moreover, at first pick-by-voice technology wasn't able to recognize some accents of warehouse workers, since they were not Russian native speakers. Contract logistics manager described this problem in the following way:

'Some of our warehouse employees had difficulties at first with voice direction since they are not native Russian speakers and consequently system was not able to recognize their speech'.

Contract logistics manager

Further, this problem was eliminated when company updated the technology and downloaded accents recognition tool.

<u>Company F</u>

Company overview and its warehouse logistics

Company F is a Finnish public company, which penetrated Russian market in 1997 and started its operations originally in Saint Petersburg. The company is a third-party logistics provider, which provides services in warehouse logistics, transportation logistics and marketing communications. At present Company F is one of the leading companies in the logistics market in Russia. Company offers customized solutions designed specifically for each client from various business industries and is considered as a reliable partner among its customers, since company complies with the legal, ethical and professional standards of doing business.

As for the warehouse logistics, company provides such warehouse services as custody services for goods and additional services, including the handling of goods in the warehouse, crossdocking, inventory management. Total area of all company's warehouses in Russia is over 500 000 m² and all warehouses belong to category A, which complies with the highest standards in warehouse management. Total area of the warehouse in Saint Petersburg is 22 000 m². Apart from Saint Petersburg company has warehouses and offices in all major regions of the country: Moscow, Samara, Rostov-on-Don, Yekaterinburg, Novosibirsk, Vladivostok and Novorossiysk (Official website of Company F, 2016).

For investigating pick-by-voice implementation in the company both primary and secondary data sources were used. Secondary data sources included company's website, internal company documentation, articles and primary data sources consisted of interviews with company's employees. Interview questions are presented in Appendix 2. In total, three semi-structured interviews were conducted with the following company's representatives: warehouse manager, Business Applications Development Manager and Head of Competence Center Project Department.

Existing digital solutions in warehouse management

Among digital solutions in warehouse management Company F has WMS, pick-by-voice and pick-to-light technologies. It is noteworthy to mention that pick-by-voice and pick-to-light technologies are connected with WMS system. Company implemented pick-by-voice technology in 2014. Due to the fact that in 2014 company had already installed WMS system, implementation of pick-by-voice technology went much smoother. Further, pick-by-voice technology implementation is investigated in detail. Company cooperated with one of the consulting companies in Saint Petersburg for pick-by-voice implementation.

Reasons of implementing the digital solution in warehouse management

Company had several reasons for implementing pick-by-voice technology. First of all, as Business Applications Development Manager pointed out the following reason:

'Pick-by-voice technology was an inexpensive way for increasing order-picking accuracy in our warehouse'.

Business Applications Development Manager

Head of Competence Center Project Department added that company was able to accelerate warehouse operations since employee productivity was boosted. Thus, pick-by-voice technology enabled working hands and eyes-free. In addition, from the interview with the warehouse manager it was found out that pick-by-voice technology allowed decreasing personnel costs, since fewer workers were needed to provide the same level of productivity.

Stages of implementation of the digital solution, duration of stages

Pick-by-voice implementation in Company F was carried out in cooperation with one of the consulting companies in Saint Petersburg. According to the Business Applications Development Manager implementation of pick-by-voice technology started in February 2014 and finished in July 2014. Thus, implementation took 6 months.

The first stage of pick-by-voice implementation in Company F was initial analysis. Because company already had WMS, all warehouse processes were revised and documented

before pick-by-voice implementation. Hence, the initial analysis stage included making decision considering acquiring or developing pick-by-voice technology on its own. As warehouse manager underlined in 2014 company experienced some reorganizational issues, that is why company's management decided to acquire voice order picking technology. The make/buy decision stage took 2 days and was done by director of logistics and warehouse manager.

The second stage of pick-by-voice implementation was supplier selection. During this stage company thoroughly analyzed existing pick-by-voice providers and their solutions. For the analysis company involved the consulting with which Company F cooperation for this project. As a result, Company F developed a list of requirements for the pick-by-voice solution with specific evaluation criteria such as solution flexibility, price, level of customization etc. Supplier selection stage required around 1 month and was carried out by director of logistics, warehouse manager, IT director and consultants.

The third stage of pick-by-voice implementation consisted of tender arranging. For the tender company used developed list of requirements and the winner of tender was the company who received the biggest number of points among all criteria. Tender arranging stage took 1 month.

The fourth stage consisted of planning pick-by-voice implementation. This stage consisted of defining project framework. Next, company's management assigned a project team, which consisted both of Company F employees and several consultants from the consulting company. Company F's project members included warehouse manager, IT manager, Head of Competence Center Project Department, warehouse specialists and an IT specialist. Consulting company project members consisted of two senior consultants. Project manager of pick-by-voice implementation was one of the senior consultants of the consulting company and a project coordinator was Company F's warehouse manager. Afterwards, all the required documentation for the project was developed and approved and system of communications among project members was established. Communication included regular meetings from both sides, reports, calls and e-mails. The planning stage required 2 months and was conducted by director of logistics, warehouse manager, IT director and consultants.

The fifth stage was practical implementation of pick-by-voice. This stage included installation of pick-by-voice technology and its integration with WMS system. In the beginning of this stage a trial version was conducted in order to identify errors, bugs and other potential problems. The practical implementation stage required 1 month and was accomplished by director of logistics, warehouse manager, IT director, warehouse specialists, IT specialists, HR specialist and consultants.

The last stage was evaluation of pick-by-voice technology. As Head of Competence Center Project Department pointed out:

'We didn't evaluate return on investment for pick-by-voice, however there were spotted some significant positive changes in terms of warehouse key performance indicators. For instance, order-pickers' productivity has been increased by 26%'.

Head of Competence Center Project Department

Evaluation stage took around 1 month and was done by warehouse manager, HR director and HR specialist and one of the consultants.

Based on interviewees' answers it is interesting to notice that order-picking accuracy almost has not been changed, since company already had very high order-picking accuracy rate (around 99,7%).

Responsible employees during implementation of the digital solution

As mentioned earlier project team for the implementation of pick-by-voice consisted both of Company F employees and several consultants from the consulting company. Company F's project members were warehouse manager, IT manager, Head of Competence Center Project Department, warehouse specialists and an IT specialist. Consulting company project members consisted of two senior consultants. Project manager of pick-by-voice implementation was one of the senior consultants of the consulting company and a project coordinator was Company F's warehouse manager

Problems during the digital solution implementation in warehouse management

During the implementation there were several problems, which company faced. Firstly, one of the major problems was connected to personnel, since some of the warehouse employees were reluctant to use the new technology since they already got used to manual picking. Another problem mentioned by warehouse manager is interaction problem between the company and technology provider. Warehouse manager clarified:

'Since sometimes our company and provider of pick-by-voice had different understanding of the requirements and technology functions, there was an interaction problem and we had to spend additional time to clarify all the issues with the provider before the launch of the technology'.

Warehouse manager

Finally, one more problem was revealed during the interviews, which is connected not specifically to the implementation, but to the technology itself. As Head of Competence Center Project Department noted pick-by-voice technology is not suitable for all warehouse workers, for instance he cited an example of a warehouse employee who changed her speaking manner, i.e. stuttered and then spoke slower or faster. Hence, pick-by-voice technology cannot be a universal solution for all employees, but for the majority of workers it was a reasonable solution for productivity increase.

3.2. Cross-case analysis

According to the conducted within-case study analysis and the chosen dimensions, cross-case analysis is further elaborated. For each digital solution 3 case studies were conducted. Thus, for investigating WMS implementation such companies as Company A, Company B and Company C were observed. For investigating pick-by-voice technology implementation such companies as Company D, Company E and Company F were analyzed. Firstly, cross-case analysis for WMS is conducted and then cross-case analysis for pick-by-voice is carried out.

Considering WMS implementation it was observed that in general companies implemented this system for the same reasons, such as increasing productivity and reducing costs. Thus, companies strived for increasing employees' productivity during all warehouse operations: receiving, put-away, processing customers' orders, order-picking, checking and packing and shipping. As for the costs, companies expected to decrease overhead and personnel costs, since fewer warehouse personnel would be needed to provide the same level of productivity. Moreover, two of three companies decided to implement WMS to keep track of warehouse key performance indicators and have an ability to make forecasts based on historical data provided by WMS. Only one of the three analyzed companies (Company A) implemented WMS for the future commercialization. It is interesting to mention that company intends to sell WMS only to production companies and not to logistics providers in order to keep its competitive advantage in-house. For the Company C WMS implementation was especially important, because it enabled to decrease number of mistakes made by warehouse employees and with the implementation of the new system customer service level was substantially increased.

Depending on the company duration of the solution took 9 months or 1 year. Difference in the implementation duration can be easily explained by the fact that Company A and Company C implemented WMS on their own, while Company B cooperated with Ant Technologies to implement the system. Hence, it can be inferred that cooperation with the integrator/consulting company makes implementation of WMS faster, but at the same time companies who implement WMS on their own get valuable experience of digital solutions' implementation.

Regarding the stages of WMS implementation it can be noticed that companies who implemented WMS on their own have fewer stages of implementation (one stage less), since they don't have to select supplier and arrange tender, but at the same time they have to develop WMS content on their own. Thus, Company A and Company C had five stages of WMS implementation and Company B had six stages of WMS implementation. Comparing stages of Company A and Company C, who had the same number of stages, it is interesting to mention

that during the first stage of the initial analysis Company A had 3 steps (development of logistics warehouse model, identifying WMS requirements and making decision considering developing WMS using internal personnel or acquiring WMS from the third party), while Company C had just 2 steps (identifying WMS requirements and make/buy decision). This difference can be explained by the fact that Company A had to develop a logistics model to determine the warehouse processes and required documentation, allocate labor resources and loading equipment, calculate performance storage for each process area, while Company C already carried out this step, since company had reorganized its warehouse structure in 2004 and prepared a logistics warehouse model right after the reorganization.

As for the responsible employees it can be concluded that in case of developing WMS on its own (cases of Company A and Company C) project teams were quite the same in terms of structure and project team members had similar responsibilities during the WMS implementation. However, there were spotted some differences in terms of assigning major roles of the project, notably in case of Company A as a project manager head of warehousing was assigned and a project coordinator was warehouse manager, while in case of Company C project manager was a warehouse manager and project coordinator was operations manager. Thus, it can be inferred that in the first case responsibility was held by warehouse employees and in the second case it was distributed among the warehouse and operations departments. In case of acquiring WMS (Company B) project team was obviously much bigger and apart from company's employees who were involved in the project (warehouse manager, IT director, warehouse specialists, IT specialists, HR specialist) there were also representatives from company Ant technologies who included senior consultant, junior consultant and IT specialist. In this case more responsibility was held by Ant technologies since project manager was their senior consultant and project manager was warehouse manager, who represented interests of Company B and coordinated interaction between all the involved parties.

Regarding problems during the WMS implementation it can be noted that there were various difficulties, which companies faced during the implementation. However, in all cases there was spotted such problem as human factor, for instance initial resistance of employees (especially warehouse workers) towards the new digital solution since employees were used to working with other software systems or even using paper-based approach. Also in two cases (Company B and Company C) there were occasional technical problems with WMS implementation, which consisted of different errors and bugs of the new system, but during and after the implementation all these shortcomings were eliminated. Regarding individual problems there were some problems with lack of documentation and no database structure, which Company A had. Thus, during the planning stage of WMS implementation company didn't

prepare all the necessary official documents (orders, regulations etc.) required for WMS implementation and that complicated to some extent WMS implementation. Company C had also such individual problem among the observed cases as integration of WMS with existing software programs. Since Company C was less tech-savvy at that time (2005) in comparison with the other two companies, Company C experienced some difficulties from the technical perspective of WMS integration with other software programs.

Having conducted cross-case analysis for WMS it can be concluded that in general implementation of the system was quite similar among three observed cases. Thus, companies pursued similar reasons of implementing the solution, however in each case there were some individual reasons of implementing. Duration of the implementation was the same in two cases, since these companies developed the system from within and the other company cooperated with the system integrator, which accelerated the process of WMS implementation. Regarding implementation stages it was identified that companies in general followed the same path, especially those who implemented WMS using its internal personnel (Company A and Company C). In the case of cooperating with the system integrator (Company Bs) there was one more stage in comparison with the cases of independent implementing (Company A and Company C). As for responsible employees during WMS implementation is was spotted that in cases of Company A and Company C project teams were similar in structure. However, in terms of responsibilities in case of Company A project manager and project coordinator were warehouse employees and in case of Company C responsibilities were distributed between warehouse and operations departments since project manager was warehouse manager and project coordinator was operations manager. Finally, in all cases companies faced technical problems and problem connected with the human factor, as companies' employees initially were reluctant to apply the new technology on a regular basis. Additionally, companies faced some individual problems such as lack of documentation during the implementation and integration problems of WMS and current companies' software programs.

Further, cross-case analysis for companies with pick-by-voice implementation is elaborated. As for the pick-by-voice implementation it was observed that in general companies implemented this system for the same reasons, such as increasing productivity and order-picking accuracy. Furthermore, in all cases companies expected costs to be decreased, but in a different way. Thus, Company E and Company F were oriented to decreasing personnel costs after the pick-by-voice implementation so that warehouse personnel would be downsized due to increased productivity. However, Company D company was oriented to reducing training personnel costs and didn't conduct any lay-offs and found a different way. With the implementation of pick-by-voice technology warehouse workers' productivity has been increased and instead of reducing

personnel, company increased volumes of trade flows, shipping and developed new areas of business. Thus, there were not additional costs for firing employees and what is more important warehouse employees' morale has not been worsened, but only improved since they felt support from the company's management. It is noteworthy to mention that in comparison with the WMS implementation more homogeneity can be observed in pick-by-voice implementation in terms of reasons of the technology implementation.

In two of observed cases duration of the pick-by-voice implementation took 6 months and in case of the other company (Company E) pick-by-voice was implemented during 8 months. Difference in the implementation duration can be explained by the fact that for Company E implemented pick-by-voice on its own and company had vast in-house experience in warehouse management, while Company D and Company F cooperated with consulting companies to implement the new technology. Thus, it can be concluded that involving a third party can accelerate the process of implementing the new solution in warehouse management, but at the same time, companies who conduct implementation independently receive experience, which can be transferred while implementing new technologies.

Consequently, it can be noted that stages of implementation also differ to some extent, since Company E implemented pick-by-voice without assistance and Company D and Company F cooperated with other companies to implement the solution. Hence, Company E had five stages of pick-by-voice implementation: initial analysis, planning, developing, practical implementation and evaluation and didn't have such stages as supplier selection and tender arranging. Among companies who involved consulting companies for pick-by-voice implementation (Company D and Company F) there were five and six stages of implementation respectively. This can be explained by the fact that in case of company D there wasn't such stage as tender arranging since company already chose the supplier during this stage and didn't provide a tender for making a choice. Company used experience of European subsidiaries of the Company D international holding and decided to implement a voice order picking technology 'Vocollect Voice'. As for Company F company, it had six stages of pick-by-voice implementation, which were the same as in the case of Company D plus one additional stage of tender arranging, which followed supplier selection stage.

As for responsible employees it can be inferred that in cases of cooperating with consulting companies (Company D and Company F) project teams were quite the same in terms of structure and project team members had similar responsibilities during the pick-by-voice implementation. Thus, in case of Company D project team was a bit bigger in terms of both sides: company and consulting company. From the company's side employees from various departments were involved in pick-by-voice implementation: director of logistics, warehouse manager (project coordinator), IT director, warehouse specialists, IT specialists and HR

specialist. Comparing with Company F's project team from the company's side it can be spotted that in Company F's case there wasn't an HR specialist in the implementation. As for the project team from the third party, in case of Company D there were three employees involved: senior consultant, junior consultant and IT specialist, while in case of Company F there were two senior consultants. Regarding project responsibilities it was identified that in both cases of Company D and Company F responsibilities were divided equally since in the observed cases as a project manager senior consultant was assigned and as a project coordinator company's warehouse manager was assigned.

Regarding problems during the implementation it can be noted that there were different problems, which companies faced during the implementation, but in all cases there was such problem as human factor, for instance initial resistance of employees (especially warehouse workers) towards the new digital solution. Moreover, companies also faced individual problems during the implementation such as software bugs and errors in the system configuration (case of Company D), interaction problem between the company and the technology provider (case of Company F) and accents recognition (case of Company E). During the interviews with Company F's managers it was identified that interaction problem between the company and the technology provider was especially critical for the company since sometimes company and the technology provider had misunderstandings in the terms of technology functions and pick-by-voice implementations. In case of Company E accents problem was one of the biggest issues, since majority of warehouse order-pickers in the company were not native Russian speakers and because of the accents pick-by-voice technology was not able to recognize worker's speech. Company solved this problem by installing additional module in pick-by-voice, which was able to recognize different accents.

Having conducted cross-case analysis for pick-by-voice it can be inferred that implementation process of the technology was heterogeneous among the observed cases and more similarities than differences were spotted during the analysis. Considering reasons for implementing pick-by-voice companies were oriented to increasing productivity and improving order-picking accuracy. In two cases companies implemented pick-by-voice to reduce personnel costs, i.e. lay-off some of the warehouse workers. As for the duration of pick-by-voice implementation it was found out that in two cases (Company D and Company F) implementation took 6 months and in the other case – 8 months. This difference can be explained by the fact that in cases of Company D and Company F there were consulting companies, who were involved in pick-by-voice implementation and that accelerated the process. While in case of Company E implementation was conducted independently and that is why implementation was longer by two additional months. As for the implementation stages in cases of Company D and Company F,

stages very similar in terms of content except that in case of Company F there was an additional stage of supplier selection, which followed the supplier selection stage. In case of Company E there were not such stages as supplier selection and tender arranging, but instead there was a stage of developing pick-by-voice technology. Regarding project teams it was identified that in cases of cooperating with consulting companies structure of the teams were very similar as well as the distributed responsibilities. In case of independent implementing of pick-by-voice (Company E) the project team also resembled teams of the two mentioned cases (Company D and Company F) from company's side. Finally, speaking about the revealed problems during pick-by-voice implementation all companies faced problem with personnel, since warehouse employees were not eager to apply the new technology on a daily basis. Apart from that companies also faced individual problems such as technical issues (bugs and errors), accents recognition and interaction problem between the company and the technology provider.

One of the last questions during the interviews was the question regarding the peculiarities of the digital solution implementation in Russia. As interviewees underlined there were no specifically Russian peculiarities during the implementation, therefore this aspect was not considered during the analysis. Further results of cross-case study analysis for WMS and pick-by-voice are presented in the tables.

Table 7. Results of cross-case study analysis for Warehouse Management System

	Reasons of implementing the digital solution in warehouse management	Duration of the digital solution implementation	Stages of implementation of the digital solution	Responsible employees of implementation of the digital solution	Problems during the digital solution implementation in warehouse management
Company A	• Inseparable part of warehouse operations • Keeping track of warehouse KPIs, make forecasts • Increasing productivity, reducing costs • WMS commercializing	1 year	1) Initial analysis • Development of logistics warehouse model • Identifying WMS requirements • Make/buy decision 2) Planning of WMS implementation 3) Developing of WMS 4) Practical implementation of WMS 5) Evaluation of WMS performance	• Head of Warehousing (project manager) • Warehouse manager (project coordinator) • IT director • Warehouse specialists • IT specialists • HR specialist	• Lack of module-based structure in WMS • Lack of documentation and no database structure • Human factor
Company B	• Increasing productivity, reducing costs • Effective and economical use of specialized storage equipment and storage space • Managing warehouse KPIs, making forecasts	1 year	1) Initial analysis • Identifying WMS requirements • Make/buy decision 2) Supplier selection 3) Tender arranging 4) Planning of WMS implementation 5) Practical implementation of WMS 6) Evaluation of WMS performance	Company B: • Warehouse manager (project coordinator) • IT director • Warehouse specialists • IT specialists • HR specialist Ant technologies: • Senior consultant (project manager)	• Software bugs and errors in the system configuration • Human factor

				• Junior consultant • IT specialist	
Company C	• Reducing time for goods' put-away and order-picking processes • Decreasing number of errors • Reducing overhead costs • Eliminating double-checking of data in different programs	1 year	1) Initial analysis • Identifying WMS requirements • Make/buy decision 2) Planning of WMS implementation 3) Developing of WMS 4) Practical implementation of WMS 5) Evaluation of WMS performance	• Warehouse manager (project manager) • Operations manager (project coordinator) • IT manager • IT specialists • HR specialist	• Technical problems (errors, bugs) • Human factor – initial personnel resistance • Integration of WMS with existing software programs

Table 8. Results of cross-case study analysis for pick-by-voice technology

	Reasons of implementing the digital solution in warehouse management	Duration of the digital solution implementation	Stages of implementation of the digital solution	Responsible employees of implementation of the digital solution	Problems during the digital solution implementation in warehouse management

Company D	• Increasing productivity • Reducing training personnel costs • Improving order picking accuracy	6 months	1) Initial analysis • Make/buy decision 2) Supplier selection 3) Planning of pick-by-voice implementation 4) Practical implementation of pick-by-voice 5) Evaluation of pick-by-voice performance	Company D: • Director of logistics • Warehouse manager (project coordinator) • IT director • Warehouse specialists • IT specialists • HR specialist KORUS consulting: • Senior consultant (project manager) • Junior consultant • IT specialist	• Software bugs and errors in the system configuration • Human factor – initial personnel resistance
Company E	• Increasing productivity • Decreasing personnel costs • Improving order picking accuracy	8 months	1) Initial analysis • Make/buy decision 2) Planning of pick-by-voice implementation 3) Developing of pick-by-voice technology 4) Practical implementation of pick-by-voice technology 5) Evaluation of pick-by-voice performance	• Contract logistics manager (project manager) • Warehouse manager (project coordinator) • IT director • Warehouse specialists • IT specialist • HR specialist	• Accents recognition • Human factor

Company F	• Increasing order-picking accuracy • Increasing warehouse workers' productivity • Decreasing personnel costs	6 months	1) Initial analysis • Make/buy decision 2) Supplier selection 3) Tender arranging 4) Planning of pick-by-voice implementation 5) Practical implementation of pick-by-voice 6) Evaluation of pick-by-voice performance	Company F: • Warehouse manager (project coordinator) • IT manager • Head of Competence Center Project Department • Warehouse specialists • IT specialists Consulting company: • Senior consultant (project manager) • Senior consultant	• Human factor – reluctance to use the new technology among warehouse employees • Interaction problem between the company and the technology provider

3.3. Algorithm of implementing digital solutions in warehouse management for Russian companies

Based on conducted within-case, cross-case study analyses and consultations with digital solutions' integrators (Ant technologies and KORUS Consulting) an algorithm of implementing digital solutions in warehouse management for Russian companies is developed. Since WMS and pick-by-voice have their own peculiarities, separate programs for them were developed. For WMS an algorithm consists of 1 year or 264 working days (provided that on average there are 22 working days in a month) and an algorithm for pick-by-voice technology consists of 6 months or 132 working days. For both algorithms the following elements were defined: stages of implementation, duration of each stage, responsible employees and stage content. Both algorithms are developed based on the assumption that companies would implement digital solutions using both internal and external personnel, i.e. cooperate with technology provider and consulting company.

Considering an algorithm for WMS implementation the following stages were determined: initial analysis, supplier selection, tender arranging, planning of WMS implementation, practical implementation of WMS and evaluation of WMS performance. In the table provided below each of the stages is elaborated in detail in the last column Stage content.

For the successful implementation of WMS coordinated actions of various departments are required. Thus, it was defined that the project team for the implementation should include the following employees:

- Director of logistics
- Warehouse manager
- IT director
- Warehouse specialists
- IT specialists
- HR specialist
- Senior consultant (consulting company)
- Junior consultant (consulting company)

It should be noted that for WMS implementation project manager and project should be assigned to provide monitoring and resolve arising issues during the project. It is recommended to assign a senior consultant from the consulting company as a project manager and company's director of logistics as a project coordinator. Project manager will be responsible for the overall project execution efficiency, balancing interests of company, consulting company and technology provider and managing changes. Project coordinator will have a subset of project manager's responsibilities, thus he will be responsible for smooth running of the project and all related activities.

As for the algorithm for pick-by-voice technology the following stages were identified: initial analysis, supplier selection, tender arranging, planning of pick-by-voice implementation, practical implementation of pick-by-voice and evaluation of pick-by-voice performance. In the table provided below each of the stages is elaborated in detail in the last column Stage content.

As in the case of WMS for successful pick-by-voice implementation coordinated actions of various departments are required. Hence, it was defined that the project team for the implementation should include the following employees:

- Director of logistics
- Warehouse manager
- IT director
- Warehouse specialists
- IT specialists
- HR specialist
- Senior consultant (consulting company)
- Junior consultant (consulting company)

For pick-by-voice implementation project manager and project should be assigned to provide project execution. It is recommended to assign a senior consultant from the consulting company as a project manager and company's director of logistics as a project coordinator. Similarly with the WMS implementation, project manager will be responsible for project efficiency, managing interests of company, consulting company and technology provider. Project coordinator will have some of the project manager's responsibilities, thus he will be responsible for monitoring of the project and establishing communications among all the project members.

As for the compensation and benefits policy regarding implementation of both WMS and pick-by-voice solutions, it can be noted that non-financial compensation, which doesn't require investment is recommended. Examples of non-financial compensation might include gratitude, honor boards, providing workplace flexibility etc.

Further the tables with algorithms for WMS and pick-by-voice implementation are presented, where stages, their duration, responsible employees and stages content are elaborated. To identify duration of each stage additional consultations with two digital solutions' integrators were carried out to ensure the accuracy of the stage duration.

Table 9. Algorithm of implementing WMS in warehouse management for Russian companies

Stages	Duration	Responsible employees	Stage content
Initial analysis 1. Development of logistics warehouse model	8 days	• Director of logistics • Warehouse manager	• Determining the warehouse processes and required documentation • Allocating labor resources and loading equipment • Calculating performance storage for each process area • Forecasting volumes in the warehouse • Theoretical description of the warehouse interaction with external storage services
2. Identifying WMS requirements	5 days	• Director of logistics • Warehouse manager • Warehouse specialists	• Determining how WMS would describe the goods and packaging • How WMS would distribute the processing warehouse zones, how it would work with documents and reports, as well as what would be the interface of the system and the ability to integrate it with other software programs • The outcome of this step is Systems Requirement Document (SRD), a document with a detailed description of the required parameters of the management

			system for a particular warehouse
3. Make/buy decision	2 days	• Director of logistics • Warehouse manager	• Determining of resources: experienced warehouse and IT specialists, software programs
4. Supplier selection	68 days	• Director of logistics • Warehouse manager • IT director • Senior consultant (consulting company) • Junior consultant (consulting company)	• Identifying criteria of choosing WMS suppliers • Selecting supplier
5. Tender arranging	68 days	• Director of logistics • Warehouse manager • Senior consultant (consulting company)	• Arranging tender
Planning of WMS implementation 6. Planning of WMS implementation	44 days	• Director of logistics • Warehouse manager • IT director • IT specialists • HR specialist • Senior consultant (consulting company) • Junior consultant (consulting company)	• Defining WMS implementation framework – goal, objectives, potential limitations, basic requirements for the system and the expected results of the project • Assigning project team: project manager, project coordinator, other members • Adjusting budget taking into account WMS implementation expenses • Developing and approving all necessary documentation

7. Interaction with WMS provider	59 days	• Director of logistics • IT director • Senior consultant (consulting company)	• Providing regular communications with WMS provider
8. Evaluation of existing hardware and software programs in all company's departments	2 days	• Warehouse manager • IT director • IT specialists	• Evaluating existing software and hardware in order to understand which programs and hardware are needed to be aligned with the new system
9. Establishing communications among project team members	2 days	• Director of logistics • HR specialist	• Establishing communications system in order to provide precise division of responsibilities
10. Internal promotion of WMS system in the company	59 days	• Director of logistics • HR specialist	• Promoting WMS in the company to make implementation process smoother and provide clear expectations among the employees about the new system
Practical implementation of WMS 11. Informational and technical support	113 days	• Director of logistics • Warehouse manager • IT director • Warehouse specialists • IT specialists • HR specialist • Senior consultant (consulting company) • Junior consultant (consulting company)	• Providing informational and technical support through the whole stage of WMS practical implementation
12. Launching a pilot version	5 days	• Warehouse manager • IT director • IT specialists	• Launching a pilot version of WMS

		• Senior consultant (consulting company)	
13. Receiving feedback of pilot version functioning	5 days	• Director of logistics • Warehouse manager • IT director • IT specialists	• Receiving feedback from the pilot version of WMS
14. Correcting mistakes based on the feedback	5 days	• Warehouse manager • IT director • IT specialists • Senior consultant (consulting company)	• Correcting mistakes which were identified from the received feedback from the pilot version
15. Launching WMS	5 days	• Warehouse manager • IT director • IT specialists • Senior consultant (consulting company) • Junior consultant (consulting company)	• Launch of WMS
16. Conducting trainings for warehouse and IT specialists	10 days	• Warehouse manager • IT director • HR specialist • Senior consultant (consulting company)	• Conducting trainings for warehouse and IT specialists which will be involved in working with WMS
Evaluation of WMS performance 17. Evaluation of KPIs of warehousing department	44 days	• Warehouse manager • HR director • HR specialist • Senior consultant (consulting company)	• Evaluation of KPIs of warehousing department

Table 10. Algorithm of implementing pick-by-voice technology in warehouse management for Russian companies

Stages	Duration	Responsible employees	Stage content
Initial analysis 1. Make/buy decision	2 days	• Director of logistics • Warehouse manager	• Determining of resources: experienced warehouse and IT specialists, software programs
2. Supplier selection	22 days	• Director of logistics • Warehouse manager • IT director • Senior consultant (consulting company) • Junior consultant (consulting company)	• Identifying criteria of choosing pick-by-voice suppliers • Selecting supplier
3. Tender arranging	22 days	• Director of logistics • Warehouse manager • Senior consultant (consulting company)	• Arranging tender
Planning of pick-by-voice implementation 4. Planning of pick-by-voice implementation	44 days	• Director of logistics • Warehouse manager • IT director • IT specialists • HR specialist • Senior consultant (consulting company) • Junior consultant (consulting company)	• Defining pick-by-voice implementation framework – goal, objectives, potential limitations, basic requirements for the system and the expected results of the project • Assigning project team: project manager, project coordinator, other members • Adjusting budget taking into account pick-by-voice implementation expenses

			• Developing and approving all necessary documentation
5. Interaction with pick-by-voice provider	59 days	• Director of logistics • IT director • Senior consultant (consulting company)	• Providing regular communications with WMS provider
6. Evaluation of existing hardware and software programs	2 days	• Warehouse manager • IT director • IT specialists	• Evaluating existing software and hardware in order to understand which programs and hardware are needed to be aligned with the new system
7. Establishing communications among project team members	2 days	• Director of logistics • HR specialist	• Establishing communications system in order to provide precise division of responsibilities
8. Internal promotion of pick-by-voice in the company	59 days	• Director of logistics • HR specialist	• Promoting WMS in the company to make implementation process smoother and provide clear expectations among the employees about the new system
Practical implementation of pick-by-voice 9. Informational and technical support	92 days	• Director of logistics • Warehouse manager • IT director • Warehouse specialists • IT specialists • HR specialist • Senior consultant (consulting company) • Junior consultant (consulting company)	• Providing informational and technical support through the whole stage of WMS practical implementation
		• Warehouse manager	• Launching a pilot version of WMS

10. Launching a pilot version	3 days	• IT director • IT specialists • Senior consultant (consulting company)	
11. Receiving feedback of pilot version functioning	3 days	• Director of logistics • Warehouse manager • IT director • IT specialists	• Receiving feedback from the pilot version of WMS
12. Correcting mistakes based on the feedback	3 days	• Warehouse manager • IT director • IT specialists • Senior consultant (consulting company)	• Correcting mistakes which were identified from the received feedback from the pilot version
13. Launching pick-by-voice	3 days	• Warehouse manager • IT director • IT specialists • Senior consultant (consulting company) • Junior consultant (consulting company)	• Launch of WMS
14. Conducting trainings for warehouse and IT specialists	5 days	• Warehouse manager • IT director • HR specialist • Senior consultant (consulting company)	• Conducting trainings for warehouse and IT specialists which will be involved in working with WMS
Evaluation of pick-by-voice performance 15. Evaluation of KPIs of warehousing department	22 days	• Warehouse manager • HR director • HR specialist • Senior consultant (consulting company)	• Evaluation of KPIs of warehousing department

In order to visualize algorithms for WMS and pick-by-voice, Gantt charts were developed.

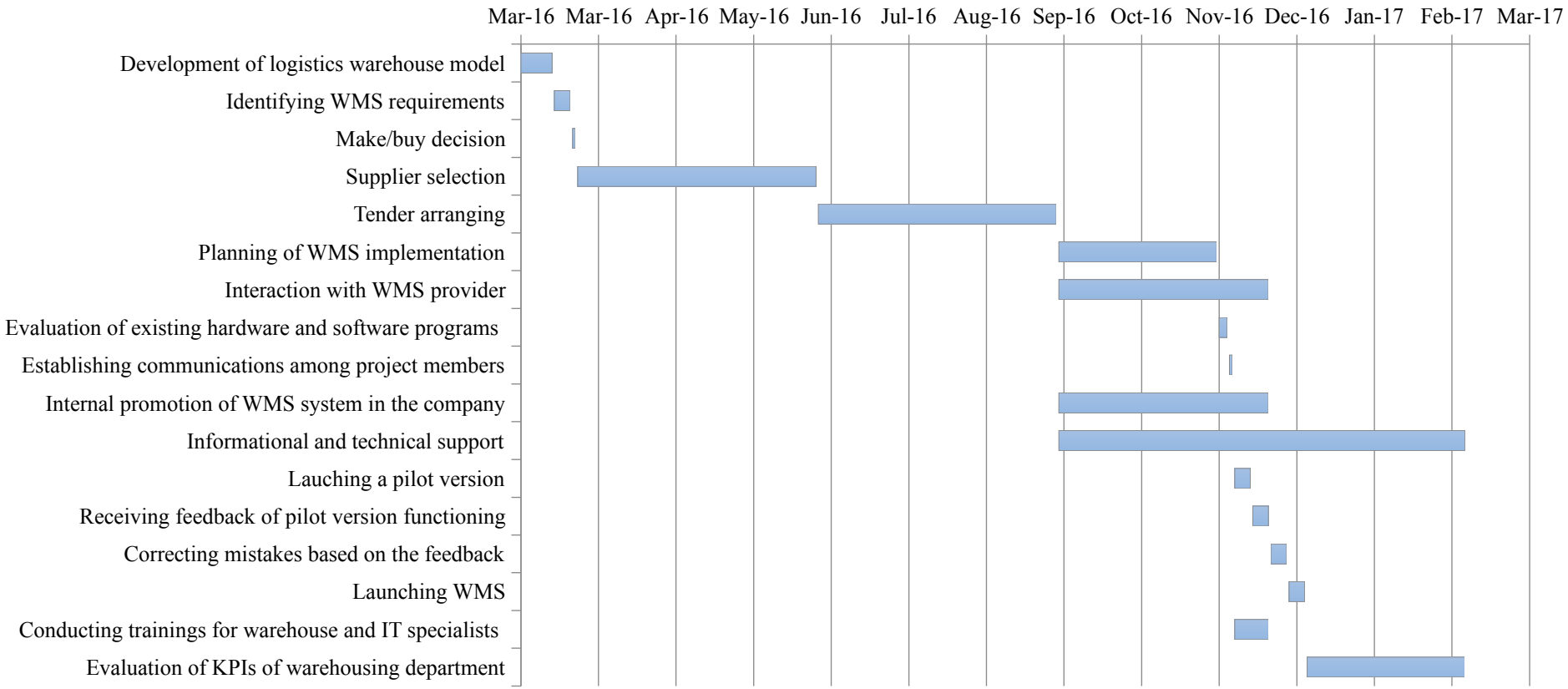

Figure 6. Gantt chart ‘WMS implementation in warehouse management for Russian companies’

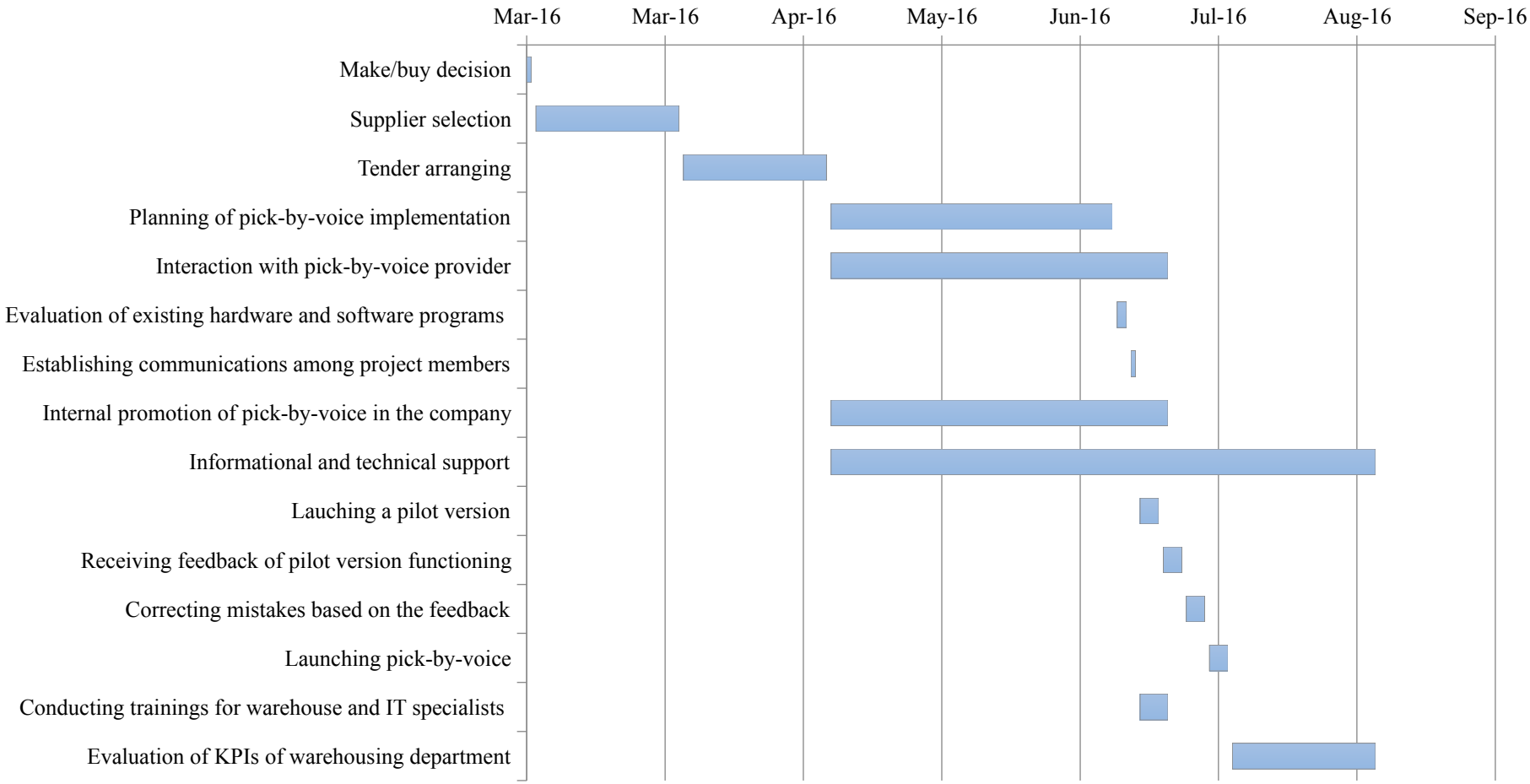

Figure 7. Gantt chart ‘Pick-by-voice implementation in warehouse management for Russian companies’

3.4. Summary of Chapter 3

The third chapter of the thesis consists of the analysis of best practices of implementing digital solutions in warehouse management. It was revealed in the first chapter currently the most relevant digital solutions in warehouse management are WMS and pick-by-voice. Hence, for these two solutions case study analysis was conducted. For the research of digital solutions in warehouse management six Russian and international companies were chosen. These companies were chosen based on specific criteria, i.e. companies should be logistics providers or distribution companies, they should be Russian companies or Russian branches of international companies and they should have experience in implementing digital solutions in warehouse management. In the beginning for each case study within-case analysis was accomplished, which was structured as follows. Firstly, overview of the company and its warehouse logistics are given. Then existing digital solutions in warehouse management in the company are identified. Further, each of defined by researcher dimensions is analyzed regarding particular company's digital solution in warehouse management. Within-case analysis was followed by cross-case analysis, during which similarities and differences among the cases were revealed. It was established that in both cases of WMS and pick-by-voice among cases more similarities than differences were spotted. As a final step an algorithm of implementing WMS and pick-by-voice in warehouse management for Russian companies was developed.

3.5. Discussion and conclusions

3.5.1. Discussion of the findings

The master thesis was devoted to digital solutions in warehouse management and their implementation in Russian and international companies. The goal of the research was to develop an algorithm of implementing digital solutions in warehouse management for Russian companies based on best practices of international and Russian companies. For achieving this goal the research has been divided into three stages: conducting literature review of digitalization and warehouse management, defining research methodology and analysis of the best practices of implementation of digital solutions in warehouse management.

Comprehensive research of digitalization in warehouse management has shown that this topic is one of the most crucial trends which influences supply chain management and warehouse management in particular. Regarding digitalization implications for warehouse management it was found out that main areas for the improvement are referred to the operational effectiveness of the warehouse, specifically to labor and quality. As an element of fourth industrial revolution digitalization contributes to increasing efficiency of warehouse operations through the digital solutions.

During the analysis digital solutions in warehouse management were revealed and further reviewed. It was established that among extant studies there is no algorithm of implementing digital solutions in warehouse management. For developing such algorithm particular digital solutions should have been chosen since it was not possible to develop algorithm for all the solutions due to time and volume of research constraints. Thus, identified digital solutions were compared in terms of their relevance, costs and ease of implementation (DHL Logistics Trend Radar, 2014; Pfohl et al., 2015; Capgemini Consulting View, 2015; BCG report 'Three Paths to Advantage with Digital Supply Chain', 2016) and it was found out that Warehouse Management System (WMS) and pick-by-voice technology are the most widely spread and relevant solutions in warehouse management in Russian companies. Consequently, algorithms for WMS and pick-by-voice were developed for Russian companies.

Empirical research of the thesis which consisted of a series of semi-structured interviews and consultations with digital solutions' integrators (Ant technologies and KORUS Consulting) allowed to achieve the research goal, i.e. to develop an algorithm of implementing digital solutions in warehouse management for Russian companies based on best practices of international and Russian companies.

Having conducted within-case and cross-case analyses of six Russian and international (their Russian branches) companies it was revealed that considering implementation of WMS and pick-by-voice in warehouse management companies in general follow the same approach of implementation and differences in cases can be attributed to specific factors such as independent implementation or cooperation with the IT integrator/consulting company, project team structure. As for reasons of digital solutions' implementation companies pursue similar goals such as increasing order-picking accuracy and decreasing personnel costs. Considering problems of implementation in all case there were spotted such difficulties as technical issue and personnel problems (initial resistance of the technology), however there were also individual problems such as lack of documentation during the implementation and integration problems with the existing company's software programs.

It is noteworthy to mention that implementation of WMS and pick-by-voice had its own peculiarities, but overall there can be observed similar approach of these solutions' implementation. Due to the fact that pick-by-voice technology is connected to WMS and pick-by-voice cannot be set up without having WMS in the company, consequently implementation process of pick-by-voice is less time-consuming.

Based on the conducted empirical research and analyzed cases the research goal could be reached. Thus, an algorithm of implementing WMS and pick-by-voice in warehouse management for Russian companies was developed. For WMS an algorithm consists of 1 year or 264 working days and an algorithm for pick-by-voice technology consists of 6 months or 132

working days. The following elements were determined for both algorithms: stages of implementation, duration of each stage, responsible employees and stage content. Both algorithms were developed assuming that companies would attract external provider of the technology and consulting company, since as it was found out from the interviews, currently logistics providers prefer to cooperate with consulting companies to make the implementation process faster and smoother. Thus, the developed algorithms for WMS and pick-by-voice were developed, which were presented earlier in Tables 9 and 10. For visualizing these algorithms Gantt charts were built. It should be noted that for both solutions estimation of stages duration was made based on working days as it was found out during the interviews, but for the convenience for managers, who might use these algorithms, stages duration was converted into calendar days. Observing Gantt charts for both digital solutions it can be inferred that some of the stages are carried out concurrently, such as planning of digital solution implementation, interaction with the provider, internal promotion of the technology in the company and informational and technical support. This overlap can be explained by the fact that these processes are needed to be accomplished sometimes simultaneously due to benefits of saving time and costs and increasing performance of the whole implementation project.

Thus, it can be concluded that both research questions of the thesis were answered, i.e. digital solutions in warehouse management were identified and reviewed and implementation algorithm for digital solutions for Russian companies was developed. As a result, the research goal was achieved.

3.5.2. Theoretical contribution and practical implications

This master thesis can contribute to theoretical perspective in several ways. From the theoretical perspective this thesis contributes to the sphere of digital solutions in warehouse management, which is quite uninvestigated. Thus, based on the analyzed articles digitalization concept was introduced and difference between digitalization and digitization terms was determined. Although, it was spotted that frequently scholars used these terms interchangeably. From the analysis of articles digitalization implications for warehouse management were defined, notably that that main improvement areas in warehouse management are attributed to the operational effectiveness of the warehouse, specifically to labor and quality (McKinsey Digital, 2014) and digitalization as an element of fourth industrial revolution facilitates increasing efficiency of warehouse operations through the digital solutions.

During the analysis of articles referred to both international and Russian companies, digital solutions in warehouse management were revealed and further reviewed. Thus, such digital solutions were identified: Warehouse Management System, pick-by-voice, pick-to-light,

radio frequency identification, 3D printing, augmented reality and robotics. The solutions were identified based on papers of the researchers (Sowinski, 2005; Gu et al., 2007; Wang et al., 2010; Napolitano, 2012; Bond, 2013; Xiao-dong and Fan, 2016) and industry reports (McKinsey, 2013; DHL, 2014; Capgemini, 2015; BCG, 2016). As it was analyzed in first part of Chapter 1, most of these digital solutions refer to order-picking process. Moreover, the study offers insights regarding impact of digital solutions in warehouse management, notably it was identified that currently the most widely spread and relevant technologies in warehouse management for Russian companies are Warehouse Management System and pick-by-voice. Thus, the study is valuable to the theoretical development.

As for practical implications it can be inferred that the master thesis is rather impactful. An algorithm of implementing digital solutions (WMS and pick-by-voice) in warehouse management was developed, which can be used by Russian and international companies, which intend to introduce digital solutions in warehouse management. This algorithm includes stages of implementation, their duration and content and responsible employees. Additionally, during the cases analysis certain problems which might occur during the implementation process were identified. Thus, companies who might use the proposed algorithm will be prepared for the potential difficulties. For users of this algorithm the implementation process of WMS and pick-by-voice appears precise and transparent, as they will have a strong basis for the digital solutions' implementation. The study holds value for warehouse managers, IT managers and other employees, who are involved in implementation of digital solutions in warehouse management.

Another practical implication of the research is that developed algorithm might be useful also for other digital solutions, for instance pick-to-light, radio frequency identification. Despite the fact that each of digital solution has its own peculiarities in terms of implementation process, as it was shown during the algorithms development for WMS and pick-by-voice, in general the implementation processes follow the same path. Thus, the developed algorithm may be taken as a basis and adjusted for other digital solutions.

Since multiple case study analysis was conducted based on Russian branches of international companies and Russian companies, the developed algorithm is valid for Russian companies. However, international companies might take the implementation stages as the basis for the developing their own algorithm.

3.5.3. Limitations and prospects for future research

The research has several limitations that should be taken into consideration. One of the limitations is referred to the chosen research strategy. Since in the thesis case study strategy is

applied, there are limitations connected to generalizations of the findings (Yin, 2003) as the was limited number of analyzed case studies per each digital solution (three case studies for each solution). This can raise some biases in terms of development of algorithms of implementing digital solutions in warehouse management. Therefore, further research can expand number of case studies in order to obtain more relevant and objective results.

Moreover, limitations are connected to the research sample. The data was collected in Russia, in Saint Petersburg and Moscow and this limits the opportunity to generalize the findings to other Russian cities. It can be recommended to conduct further research based on data from other Russian cities, thus expanding the research sample and getting more comprehensive view on digital solutions' implementation in warehouse management. Additionally, there was a limitation referred to confidentiality issues. Since the implementation process of digital solutions is considered as a confidential one, some of the details cannot be revealed during the interviews.

Finally, there were certain limitations with regard to the analyzed companies, since there were four international companies and two Russian companies. However, it should be noted that analyzed international companies were Russian branches, so that to some extent they can be regarded as Russian ones. Nevertheless, it can be recommended to analyze more Russian companies, in addition to Russian branches of international companies.

Despite all the mentioned limitations the master thesis holds both theoretical and practical value and it was possible to reveal similar patterns of implementing digital solutions in warehouse management for Russian companies.

Conclusion

The goal of the master thesis was to develop an algorithm of implementing digital solutions in warehouse management for Russian companies based on best practices of international and Russian companies. An algorithm of implementing digital solutions in warehouse management was developed and therefore a research gap was closed, since among the extant studies there wasn't such algorithm of implementing digital solutions in warehouse management. In order to achieve the research goal multiple case study analysis was carried out. During the research both within-case study and cross-case study analyses were conducted. As for the data collection semi-structured interviews and analysis of secondary data were carried out. Six international and Russian companies were investigated.

To achieve the research goal the following research objectives were stated:

1) To review digitalization phenomenon and its implications for warehouse management
2) To identify digital solutions in warehouse management
3) To analyze best practices of implementing digital solutions in warehouse management
4) To develop an algorithm of implementing digital solutions in warehouse management for Russian companies.

For the first objective the analysis of digitalization in warehouse management was conducted. It was found out that digital solutions have a significant impact on warehouse performance. Furthermore, it was revealed that there are some studies on such software tools as Warehouse Management System (WMS), Enterprise Resource Planning System (ERP), Warehouse Control System (WCS) etc., but there are few studies on digital solutions in warehouse management. In addition, it was identified that in the extant literature software tools can be sometimes attributed to digital solutions. Moreover, there are no studies on developing an algorithm of implementing digital solutions in warehouse management.

The second objective, identifying digital solutions in warehouse management, was achieved based on analyzed articles. Thus, it was found out that currently in warehouse the following digital solutions are applied: Warehouse Management System (WMS), pick-by-voice, pick-to-light, radio frequency identification (RFID), 3D printing, augmented reality and robotics. Additionally, each of the digital solution was reviewed and it was established that WMS and pick-by-voice are the most relevant and most widely used technologies in Russian companies, therefore they were further used for developing an algorithm in warehouse management.

The third objective included analysis of the best practices in warehouse digitalization. Six international and Russian companies were investigated in terms of their digital solutions in warehouse management. The following criteria were chosen for the companies:

- Logistics providers (3PL) and distribution companies
- Experience in implementing digital solutions in warehouse management
- Russian companies or Russian branches of international companies

For the research within-case and multiple case study analyses were conducted. During the interviews and secondary data analysis in each company existing digital solutions in warehouse management were identified. In order to conduct within-case and cross-case study analyses certain dimensions were chosen by the researcher and approved during the interviews with digital solutions' integrators. These dimensions include reasons of implementing the digital solution in warehouse management, stages of implementation of the digital solution, duration of stages, responsible employees during implementation of the digital solution, problems during the digital solution implementation in warehouse management. Three companies company A, company B and company C were studied in terms of their WMS implementation and three companies company D, company E and company F were studied in terms of their pick-by-voice technology implementation. Based on the conducted case study analysis it was revealed that there can be found more similarities than differences among the observed companies. For instance, considering WMS implementation it was revealed that reasons of implementing WMS in warehouse management among companies are very similar as well as responsible employees of WMS implementation. Different problems, which companies had during the WMS

implementation, were identified, but in general it can be concluded that most problems are attributed to software errors and human factor, such as initial resistance of the new technology implementation. Differences were also identified among stages of implementation of WMS, which can be explained by several factors. Firstly, some of the analyzed companies implemented WMS without assistance such as company A and some companies cooperated with WMS providers such as company B and company C. Consequently, duration of the WMS implementation among observed companies also differed from 9 months to 1 year.

The last objective consisted of developing an algorithm of implementing digital solutions in warehouse management for Russian companies. Based on conducted case study analysis two algorithms for two digital solutions such as WMS and pick-by-voice were developed. For each algorithm specific stages and their duration were identified. In addition, for each stage responsible employees were specified and detailed stage content was presented.

During the research several limitations were identified, which refer mostly to the research sample. Moreover, some limitations were revealed, which were connected with the opportunity to provide generalization of the findings since as the limited number of analyzed case studies per each digital solution (three case studies for each solution) was investigated. Nevertheless, the current thesis holds value for the sphere of digitalization in warehouse management as it was possible to reveal similar patterns of implementing digital solutions in warehouse management for Russian companies.

Thus, the master thesis holds theoretical and practical value since it reveals digital solutions in warehouse management and provides an algorithm of implementing digital solutions (WMS and pick-by-voice) in warehouse management for Russian companies. The results of the master thesis can be useful for warehouse and IT managers and also for employees, who are involved in the implementation process of digital solutions. Moreover, the research provides the basis for future research on digital solutions in warehouse management. Further research can be conducted using quantitative approach regarding impact of digital solutions on warehouse management, for instance which digital solutions have the highest return on investment, which solutions are the most effective in order-picking process.

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Appendices

Appendix 1. Interview questions for Company A, Company B and Company C

1) Please describe company's warehouse logistics

2) Which digital solutions does company have in warehouse management?
3) What are the reasons of digital solutions implementation in warehouse management?
4) What is the typical implementation approach of digital solutions among the logistics providers: independent implementation or cooperating with consulting company/IT integrator?
5) Warehouse Management System:
    a. When Warehouse Management System was implemented?
    b. What are the elements of Warehouse Management System, its functions?
    c. How many employees have to manage Warehouse Management System?
    d. Which stages did the implementation of Warehouse Management System have?
    e. Which activities were included in each stage?
    f. Duration of each implementation stage?
    g. How many employees did participate in Warehouse Management System implementation?
    h. Which specialists did participate in Warehouse Management System implementation?
    i. Was there a trial of Warehouse Management System before its final implementation?
    j. Problems during Warehouse Management System implementation
    k. Economic effect of Warehouse Management System implementation?
    l. Did Warehouse Management System influence company's key performance indicators, warehouse operations? Was these decrease of time and personnel costs?
    m. Peculiarities of implementation of Warehouse Management System in Russia

Appendix 2. Interview questions for Company D, Company E and Company F

1) Please describe company's warehouse logistics
2) Which digital solutions does company have in warehouse management?
3) What are the reasons of digital solutions implementation in warehouse management?
4) What is the typical implementation approach of digital solutions among the logistics providers: independent implementation or cooperating with consulting company/IT integrator?
5) Pick-by-voice technology:
    a. When pick-by-voice was implemented
    b. What are the elements of pick-by-voice, its functions?
    c. How many employees have to manage pick-by-voice?
    d. Which stages did the implementation of pick-by-voice have?
    e. Which activities were included in each stage?
    f. Duration of each implementation stage?
    g. How many employees did participate in pick-by-voice implementation?

h. Which specialists did participate in pick-by-voice implementation?
i. Was there a trial of pick-by-voice before its final implementation?
j. Problems during pick-by-voice implementation
k. Economic effect of pick-by-voice implementation?
l. Did pick-by-voice technology influence company's key performance indicators, warehouse operations? Was these decrease of time and personnel costs?
m. Peculiarities of implementation of pick-by-voice in Russia