Olli-Pekka Hilmola and Eugene Korovyakovsky (Editors)

FINAL REPORT OF CROSS-BORDER PROJECT CALLED "DEVELOPMENT OF LOGISTICS FOR SUPPLIER NET MODELS" (LOGNET)

Published with the Financial Support of European Union Tacis Neighbourhood Programme

EUROPEAN UNION

LOGNET

LAPPEENRANNAN TEKNILLINEN YLIOPISTO
LAPPEENRANTA UNIVERSITY OF TECHNOLOGY

TEKNISTALOUDELLINEN TIEDEKUNTA
TUOTANTOTALOUDEN OSASTO

FACULTY OF TECHNOLOGY MANAGEMENT
DEPARTMENT OF INDUSTRIAL MANAGEMENT

TUTKIMUSRAPORTTI 215
RESEARCH REPORT

LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
Department of Industrial Engineering and Management
Kouvola Research Unit
Research Report 215

Final Report of Cross-Border Project Called "Development of Logistics for Supplier Net Models" (Lognet)

In the Honour of St. Petersburg Transport University's 200 Year and Lappeenranta University of Technology's 40 Year Celebration

Olli-Pekka Hilmola and Eugene Korovyakovsky (Editors)

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Foreword

As Lognet project started roughly two years ago, we were living in entirely different world – economies were going through endless economic growth, and transportation sector was literally prospering. This could be observed through e.g. container handling numbers of the most important regional sea ports, during year 2008 St. Petersburg handled volume of 2 mill. TEU, Kotka 0.63, Helsinki 0.42 and Hamina 0.18. However, during year 2009 everything changed – handling volumes declined in St. Petersburg, Kotka and Hamina by the factor of 50-60 %, and in Helsinki 20 %. This decline is supported by other measures too: Transit car transport through Finland to Russia declined during the first six months of year 2009 by 80 %, border crossings by car in same period by 50 %, and railway traffic by 35 %. Interesting fact is that the number of Finnish metal industry companies during year 2008 interviews indicated that they do not want to optimize their transportation costs in the east direction – risk of owning transportation fleet is too high. Low cost of short-term hinders serious risk in case of demand collabse.

Where we proceed from here? Similarly with Sweden, Russia has been able to increase its export activity considerably during year 2009. For example, tonnage handling volumes at St. Petersburg harbour have increased from year 2008 (during the first 9 months), and especially export groups of steel (+36 %), iron (+70 %) and coal (+39 %) have shown impressive double-digit growth. During the project execution time we were able to identify that several warehouses have also started to offer services for further processed manufactured items being exported from Russia to Europe. So, collaboration will continue in cross-border region, but possibly as future direction we have export transit besides import transit. However, based on the project results, we have been surprised from the state of warehouses in St. Petersburg region – new complexes are similar to Finnish counterparts and IT systems (with bar codes, WLAN and ERP) as well as modern management techniques such as cross-docking are in the use already. Thus, warehouses in the region will have enough cargo handling to do in the future, if new custom regulations in Russia will materialize. Another possible change is the wider use of railway transportation in transit import of Russia; during the project warehouse visits we identified that in Finnish side railway traffic is often just an option, but among Russian logistics operators it is already in some sort of use.

As indicated in the title page, this publication is in the honour of PSTU's and LUT's celebration of their long journey as universities – as LUT has already turned 40, we are looking forward for PSTU to turn 200 years in Dec.2009. During early November 2009 we strengthened our university collaboration by executing distance learning course for logistics service providers in St. Petersburg: Altogether 12 students received certificate, and course feedback was clearly better than the average. We hold gratitude for all project staff for accomplishing this course, and also give sincere thanks for M.Sc. Milla Laisi and Dr. Juha Saranen for editing work concerning this final publication of our joint-project. Thank you!

In Kouvola, Finland & St. Petersburg, Russia during November 2009,

LAPPEENRANTA
UNIVERSITY OF TECHNOLOGY

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North European Companies and Major Eurasian Countries: How Logistics Flows Develop Over Medium-Term?

Olli-Pekka Hilmola

Lappeenranta University of Technology, Kouvola research unit, Finland

Компании Северной Европы и основные Евро-Азиатские страны: как будут развиваться логистические потоки в среднесрочной перспективе?

Олли-Пекка Хилмола

Abstract
During the previous decades container transportation volumes became first unbalanced between Asia and USA, but in recent years similar development has occurred with Asia and Europe. In this research work we analyze transportation volume development in major Finnish and Swedish companies using two times completed empirical survey (years 2006 and 2009). Findings indicate that companies are identifying medium-term volume growth of container transports in Russian and Chinese markets, and partially with India. However, most of concern is the traffic unbalance, particularly developing in unwanted direction with India and China. Interestingly, Russian market, with some exceptions, is still going to be served from European factories in the medium-term too. However, in limited amount of companies it seems that Russian factories start to serve also larger European demand.

Keywords: Container transportation, Eurasia, traffic balance, Finland, Sweden

Аннотация
В течение последнего десятилетия объемы контейнерных перевозок постепенно стали несбалансированны между странами Азиатско-Тихоокеанского региона и США, но в последние несколько лет аналогичные тенденции происходят и между Европой и Азией. В этой работе мы анализировали изменение объемов перевозок в основных Шведских и Финляндских компаниях, используя дважды проведенный опрос (в 2006 и 2009 году). Результаты показывают, что компании обозначают рост объемов контейнерных перевозок на Российском и Китайском рынках, и частично в Индии. Однако, большим препятствием является несбалансированность направления грузопотоков, в так называемых «нежелательных» направлениях с Индией и Китаем. Интересно, что Российский рынок, с некоторыми исключениями, до сих пор ориентируется на импорт из Европы в среднесрочной перспективе. Однако, ограниченное количество Российских компаний начинают также работать на экспорт на расширяющийся Европейский спрос.

Ключевые слова: Контейнерные перевозки, Евразия, баланс грузопотоков, Финляндия, Швеция

1. Introduction

Most often traffic flows between regions, their respective currency valuations, and in the end economic prosperity is not equally distributed (Ohmae, 1985). This leads to the situation, where transportation traffic is seldom in balance between major economies, and currency crises affect to the transportation flows enormously. For example, United Nations (1999a)

estimated that South-Korean port of Busan experienced from empty container handling significantly during Asian economic (and currency) crisis during year 1997. Similarly, current financial crisis has resulted in difficulties of freight operators – largest sea continental carrier of containers, Maersk, reported that volumes had decreased continent sea transportation with rates of 10-20 %, but at the same time freight rates have fallen 20-30 % (Maersk, 2009). So, overall effect for business actors is two-fold (vol. and price), and results in severe financial difficulties. In case of Russian currency crisis, occurred in year 1998, devaluation resulted in the free fall of imports to below half in only one year time period (Chiodo & Owyang, 2002) – similar situation occurred recently due to global financial crisis and smaller scale devaluation of Ruble, and therefore container handling during the first half in the main container harbour of Russia, St. Petersburg decreased with 64 % (SPB, 2009). Based on Krugman's (2005) findings, world faces every 19th month currency crisis, and eventually traffic flows and logistics systems will pay the price (rapid enlargement of trade unbalance between regions, increasing amounts of empty transports).

Even if earlier mentioned unbalance in transportation activity between continents and countries exist, and as world trade continues to grow, this situation will only foster (United Nations 2005a, 2005b, 2008). However, unbalance is not only volume based, but is also often transportation mode originated; e.g. some countries are more manufacturing export oriented, while the others export e.g. raw materials – volumes might be balanced, but transportation modes and used equipment is entirely different (Kilpeläinen, 2004; Hilmola et al., 2007). This mode unbalance is not the minor issue; so far economic growth has favoured sea containers and air transports, but concurrently railways have been unable to respond on international transportation demand (Shu, 1997; Lee, 2004; Vellega & Spens, 2006). However, railways have been under agenda of several international traffic development projects (United Nations, 1999a & 1999b; Molnar & Ojala, 2003).

Research problem in this paper concerns the North-European countries, Finland and Sweden, and their logistical operations with Russia and Asian countries, analyzed through larger company perspective. We are interested about the countries, which have significance in the trade and economic growth, and could be reached, if alternatives would be further developed, with all different transportation modes. So, from Asia we have picked China, Japan, South-Korea and India. The last country in the list, India, does not necessarily represent the most feasible alternative to plain rail or road transports from e.g. Europe, but majority of the

transportation operation could be completed through Russia, by near of Kazakhstan (with either train or road), ending up to Iranian harbour and continuing from there towards Mumbai harbour in India (Molnar & Ojala, 2003). Empirical material of this research work was gathered using online survey completed during years 2006 and 2009 – in overall findings should be giving valid picture, since the first survey was completed during the time of significant economic growth and prosperity, and latter one right after the global financial meltdown had occurred.

This research is structured as follows: In Section 2 we will review the world trade development, traffic flows and unbalanced nature of world transports – analysis incorporates also current financial meltdown effects. Our literature review concludes that developed countries (USA, Japan and European Union) still hold the significance in the world economy, but in transportation, the growing number of transactions indicates that "the fast phase" developing countries have already taken the lead, this particularly concerns Asia. As large world-wide corporations are the major cause of traffic flows in a world context, we have gathered empirical material with two different surveys from largest companies from Finland and Sweden. We will review the research methodology of these two surveys completed in Section 3. Empirical part is analyzed in Section 4, concerning first the results of year 2006 survey, which is thereafter followed by year 2009 situation. Findings show in part consistent findings, how traffic flows and balance is about to develop, and mostly Chinese and Russian directions still hold same level of significance despite major changes in world economy. In final Section 6 we will conclude our research, and propose further avenues for the research.

2. Literature Review – World Trade, Traffic Flows and Major Continents

As is known, world GDP has increased steadily during the last five decades. However, this growth has been enabled by increasing amounts of international trade, and eventually transports. The relationship between world trade and GDP growth was for a long time near of 1.5, meaning that every time the world GDP grew with one percent, trade increased correspondingly with 1.5 %. However, as globalization turned real during 1990's, this relationship has only fostered, so nowadays the multiplier is 2.5 (United Nations, 2005b). Emerging markets have shown during the years of economic growth even with higher multiples (e.g. Kovacs & Spens, 2006). This long-term trend was broken-down by USA led credit crunch, and as Figure 1 shows, world trade and GDP are both for the first time in

negative territory during last four decades time period. Although, this has been challenging time for countries being dependent on manufacturing exports as well as own currency, but also for private sector, e.g. transportation companies (e.g. sea vessel operators, which had massive amount of orders in for new sea vessels before this global meltdown started), it is encouraging to see small-scale recovery in this situation, as is shown in Figure 1 for forthcoming years.

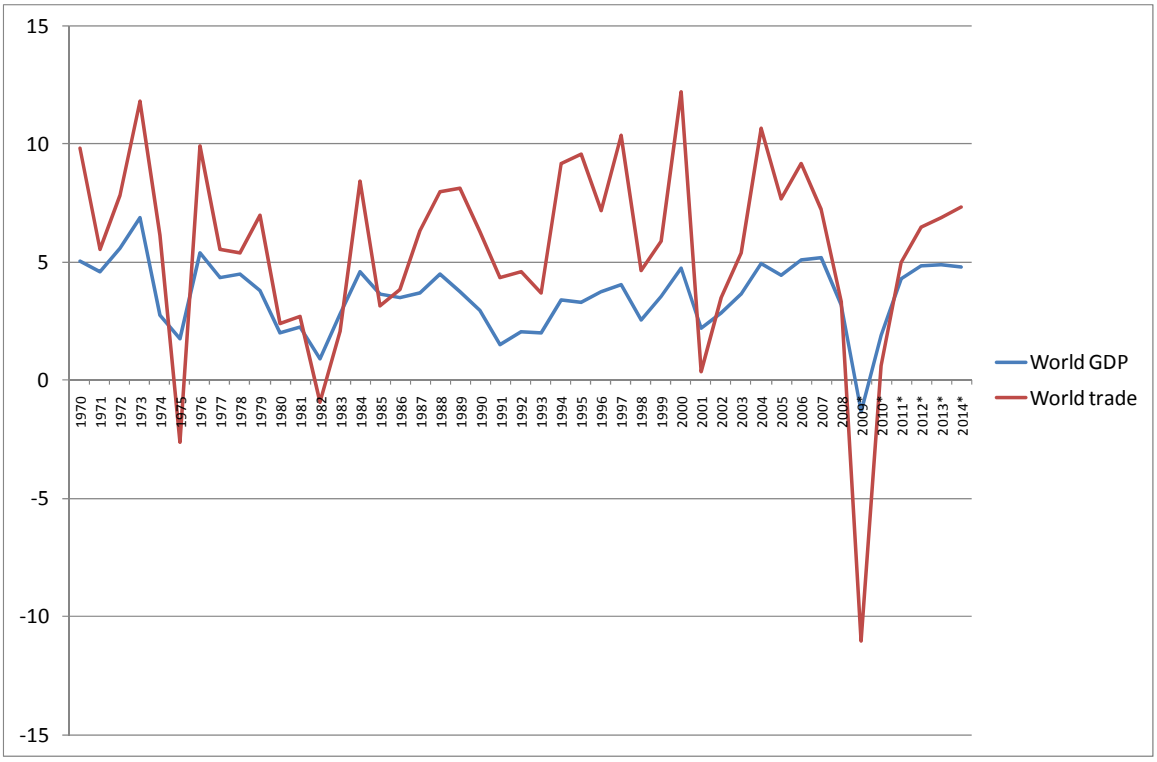

Figure 1. World trade and GDP development from 1970 to 2014 (percent change from previous year). Source: IMF (2009), denotation * is forecast.

It is not surprising to find out that all the other three transportation modes, namely road, sea and air freight has increased their total transportation amount for decades. Also infrastructure research related to transportation models supports this mode; infrastructure in air freight transportation is constantly increasing, while e.g. road transportation has started to fall, and rail infrastructure has been on the constant decline for several decades (Ausubel & Marchetti, 2001). Sea transportation was revolutionized after the 1950's with container transports, and volumes have followed similar rates with air freight (e.g. Platou Report, 2006); United Nations (2005b) estimates that the growth was 8.5 % per year during 80's and 90's, while in the forthcoming years we could expect slightly lower growth rates, 6.6 %. However, it is important to note that in railroad freights, although there exist a demand for increased

international transportation, the proportional share and absolute amount railroad freights have been in constant long-term decline, e.g. in Europe (Vassallo, 2005). A number of different authors argue that this decline has been due to the collapse of communism/socialism, and overall changed production structures as European economies have developed via agriculture to industrial and further on to information/service economies (e.g. see more in Hilmola, 2007; Hilmola 2008; Yu & Lin, 2008). We can not argue against these factors; however, the reason for this declining development in the business side has mostly been the lack of international cross-border scheduled routes (e.g. passenger transports, see Milan 1996) as well as the flexibility to connect railway freights to other transportation modes (Batisse, 2001).

Although, the developing nations, like China as well as India are showing remarkable GDP growth rates, our world still involves old three, namely European Union, USA and Japan (like Ohmae, 1985 argued). As is shown in Table 1, total GDP produced in these three latter regions still take share of 62-65 % from world GDP. So, emerging markets are growing, and will eventually take much more important role from the world economics, but this is happening with slow speed, and through export as well as transportation activity. In many respects emerging markets are already leading, like in container handling; from TOP20 container ports (United Nations, 2008), 13 are located in Asia, and eight in China alone. Correspondingly only seven ports from the economic triad make the list, four from Europe, and three from USA (Japanese sea ports have dropped from the list).

Table 1. European Union countries, USA and Japan, as well as emerging BRIC countries and their respective Gross Domestic Products, comparison to world total as a two groups during the time period of 2004-2008. Source: Statistics Finland (2009), note that 2008 world total GDP is an estimate (million USD).

Country / Region	2004	2005	2006	2007	2008
EU Countries	$13,176,795.00	$13,776,335.00	$14,665,210.00	$16,927,176.00	$18,394,117.00
Japan	$4,608,136.00	$4,560,671.00	$4,363,632.00	$4,384,380.00	$4,923,761.00
United States	$11,685,925.00	$12,421,875.00	$13,178,350.00	$13,807,550.00	$14,264,600.00
Total	$29,470,856.00	$30,758,881.00	$32,207,192.00	$35,119,106.00	$37,582,478.00
Share from total	71.22%	68.74%	66.52%	64.73%	61.75%
Brazil	$663,552.00	$881,753.00	$1,089,301.00	$1,333,502.00	$1,572,839.00
Russian Federation	$591,902.00	$764,256.00	$989,428.00	$1,294,383.00	$1,676,586.00
India	$669,407.00	$784,252.00	$874,771.00	$1,102,351.00	$1,209,686.00
China	$1,931,646.00	$2,235,750.00	$2,657,842.00	$3,382,445.00	$4,401,614.00
Total	$3,856,507	$4,666,011	$5,611,342	$7,112,681	$8,860,725
Share from total	9.32%	10.43%	11.59%	13.11%	14.56%
World Total	$41,382,657	$44,747,018	$48,420,629	$54,252,702	$60,863,149

Transportation traffic imbalance has been under interest in the continental perspective, since the starting of Japanese exports to US with significant manner in 60's and 70's. This in the end resulted in the legislation that e.g. Japanese car manufacturers were forced to establish own factories (could be characterized as screw-driving assembly places) to US soil to prevent increasing import taxes. However, traffic imbalance has continued in US case with both Asia, but as well with Europe. As Figure 2 illustrates, sea container traffic alone is three times higher from Asia to US than vice versa. However, in year 2007 from Europe sea container traffic was above 60 % more than from US to Europe. It should be remembered that the valuation of US currency during recent years has been in relatively low levels, as compared to Euro and Japanese Yen, and "traffic unbalance" should be at relatively low level then (since it favours US manufacturing units). Thus, until year 2005 Chinese Yuan was having fixed rate with respect of US dollar, and simplistically speaking China and US were the same "common" trade area. Chinese Yuan has also weakened lately among US dollar, mostly to protect Chinese massive manufacturing export industry. Notable is the fact that in four years time European and Asian container transport has turned from European export surplus to clear dominance of export from Asia (please see United Nations, 2005 & 2008).

Imbalances in world traffic flows result on the increased transportation costs, since empty transports increase significantly. For example, United Nations (2005 & 2008) has estimated that during previous years empty container movement has been on the range of 20 to 22 % in the world scale. Anyway, large world-wide corporations hold the key in transport decisions; their internal material movements account majority from foreign trade of USA, Japan and Europe (Barros & Hilmola, 2007).

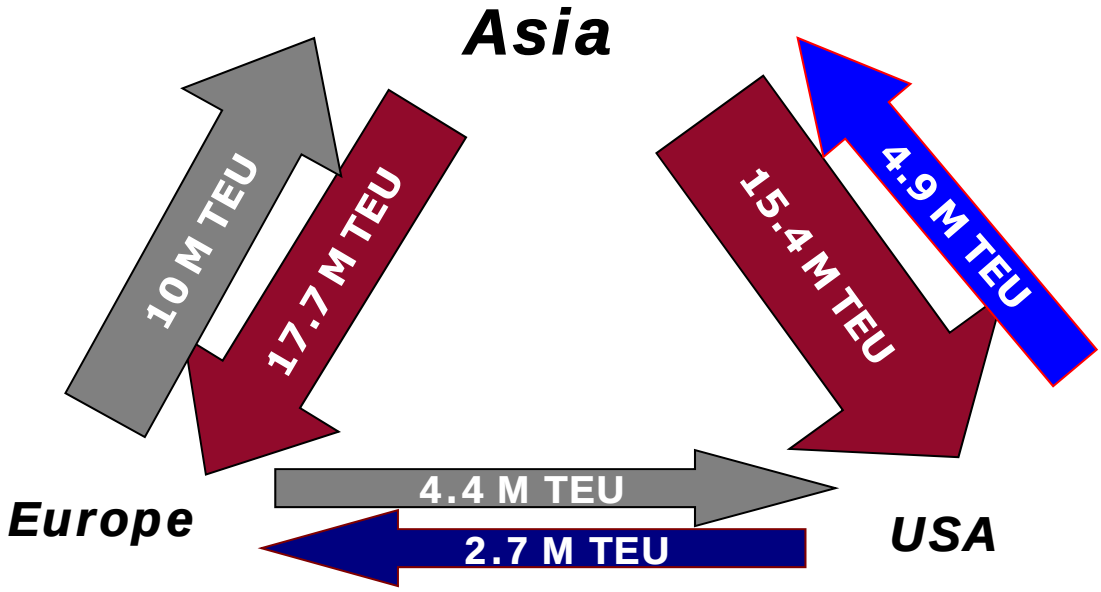

Figure 2. Trade imbalance between three major continents is great, container transports (Twenty-feet Equivalent Units) in year 2007. Source: United Nations (2008)

Among continents, traffic unbalance exists also between countries; for example, Finnish-Russian traffic could be considered as one good example. Kilpeläinen (2004) estimated that road transit traffic from Finland to Russia was 17.5 times larger than vice versa, and later Hilmola et al. (2007) gave estimate of more than 30. So, basically trucks traveled empty from Russia to Finland, in order to take the load from some harbour (e.g. Hamina, Kotka, Helsinki or Hanko), and continue with full load back to Russia. Traffic unbalance problem is created by the structure of Russian national economy and well-developed Northern Europe; prestigious raw material base favors sea (roughly half from the value of Russian import to Finland) and rail (roughly one fifth to one fourth) as transportation modes, and ignore road transportation (approx. 10 % share). In contrary Finnish export relies on the road transportation side (very significant part from the volume), and rail as well as sea has much smaller share (below 10 % each).

3. Research Methodology

For European warehousing of Finnish and Swedish companies we decided to target with a survey the largest companies of these two countries. We chose TOP500 lists from both of these countries (in Finland we used local business newspaper Talouselämä and in Sweden Affärsdata database), and searched contact information for logistics decision makers in these

largest companies. Similar questionnaire strategy in logistics has been used before by Häkkinen et al. (2004) and Lorentz (2008). It should be remembered that in web-based surveys the population reached is higher, and even with low response rate, as compared to ordinary postal surveys (Prajogo et al., 2007; Tian et al., 2008), they typically provide statistically sufficient amount of responses. However, all 1000 companies were not targeted with this survey, since financial (funds, investors, and banks), service, insurance, and electricity production and distribution companies were basically out of our interest (simply, no significant traffic flows). Also during the questionnaire we learned that a number of large retail companies, due to centralized and outsourced purchasing, do not have any connection to traffic flow decisions, and were unable to answer our questionnaire.

After these considerations we were left all in all with around 700 companies (750 during year 2006, 680 during year 2009), to whom we sent the questionnaire through email. Survey response form was available at web-pages in Finnish, Swedish and English. In order to increase reliability of responses, only individual codes of each company (given in the email) were accepted as answers in the form. We contacted companies mostly by email, either directly to the logistics director, to the corporate communications or to the general contact address. This email contact list required relatively large amount of work, since all of the addresses were collected via web search engine. As we launched our questionnaire, and sent first requests for answers, we were amazed that even emails sent to general info addresses reached logistics managers and directors. Also industrial contacts of the authors' institutions aided us to get answers from companies.

We sent two (year 2006) or three (year 2009) reminders for identified respondent population. During year 2006 we received 72 answers in total, of which five responses were returned as an empty. In reality, the total number of usable responses during year 2006 survey was 67 (8.9 %). It should be reminded that our questionnaire was rather long, and contained numerous detailed question areas. So, some of the companies answered only in general questions, and did not provide any data on specific areas. Therefore, in some of the cases the number of responses received was around 40, and in extreme maximum of 67. During year 2009 we were not able to reach as good response amounts, and 35 answers were usable for our analysis (approx. 5 % response rate). Similar situation holds with earlier survey responses that in some sub-items of the survey we were having approx. 20-30 usable responses. Although, these response rates could show very low proportional performance, they are rather

typical for web based surveys. Our sample is a bit biased for Finnish companies, since during year 2006 approximately 70 % of all answers were coming from Finland, and during year 2009 the share of Finnish responses was at the level of 60 %.

In the beginning of the survey form, we had some background questions regarding to the respondent itself, and the company. These revealed to us that responses were given with similar amounts from white-collar workers (29 %) and directors (26 %), while managers represented highest frequency (44 %). Only one percent from answers was given from administration position person. Respondents also showed relatively long experience working in the company, and also in the logistics function (most of the respondents had working experience of more than four years). Interestingly, quite many respondents were eager to receive survey research findings in the form of publication. All of these factors together support that survey responses are from valid persons, and should be reliable.

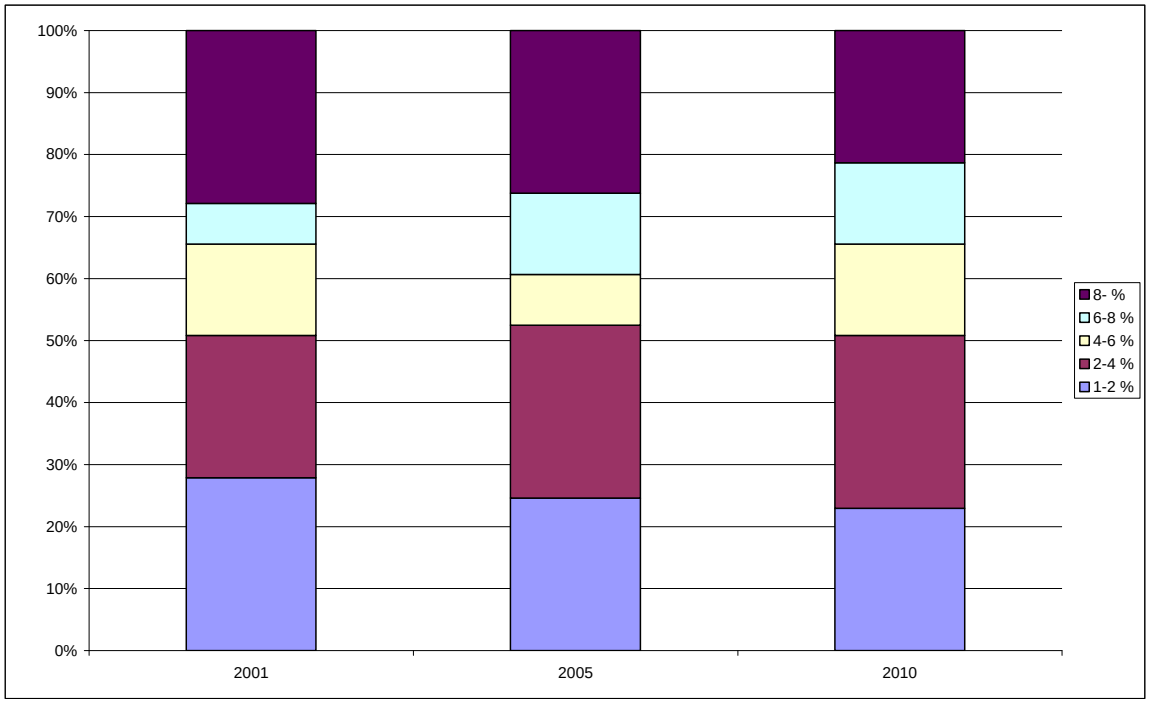

Figure 3. Share of transportation costs from revenues based on year 2006 survey (year 2010 estimate, n= 61).

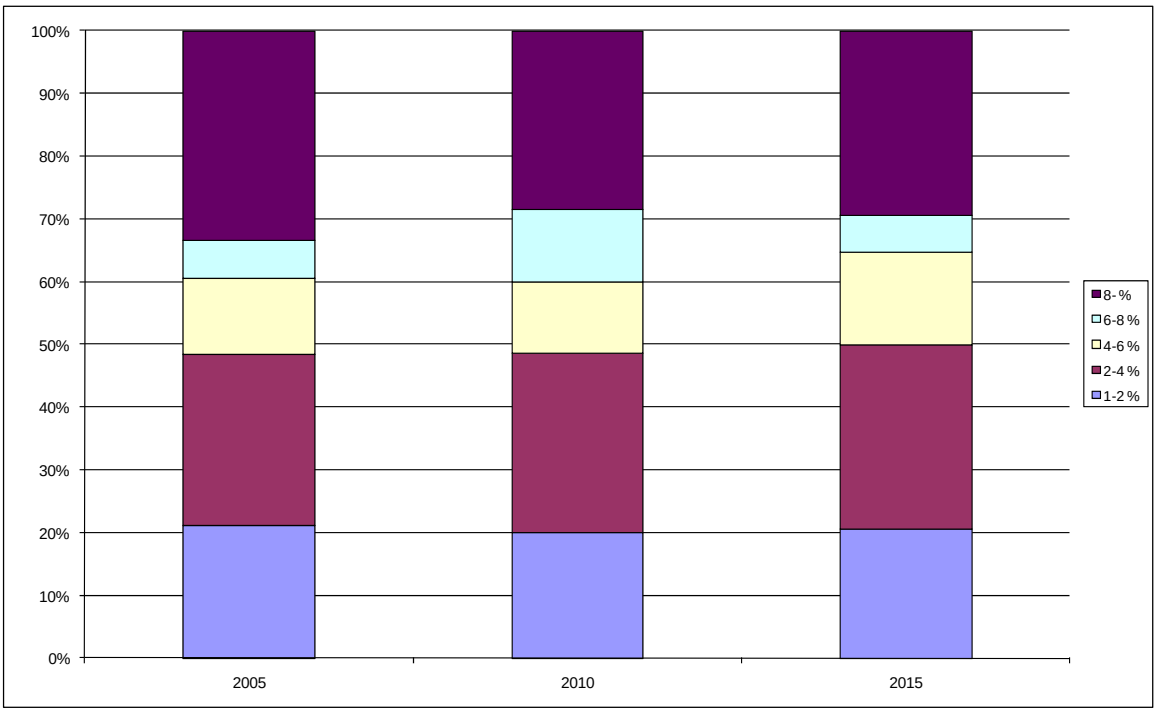

Figure 4. Share of transportation costs from revenues based on year 2009 survey (year 2010 and 2015 are estimates, n= 33-34).

As a background variable, share of transportation costs (not including warehousing) in respondent companies, shows interesting results too (Figures 3 and 4 in above). In three observation points (in Figure 3 two of these points are already realized upon responding moment, but in Figure 4 only first one is a such), companies do not indicate that large changes would happen in the transportation cost side. However, smaller interesting trends could be identified: (1) companies which had previously very low amount of transport costs, are having increasing development on these, (2) companies which had very high transportation costs are having a bit decreasing future, but (3) taking two lowest and two highest cost groups together, the total "big picture" situation will not change that much. Interestingly, in year 2009 survey companies identified that logistics costs in two highest cost groups would have higher share than in year 2006 survey. Although, world is experiencing one of the most difficult recession in decades time, and transportation price from Northern Europe to Central Europe, and further down to Asia is not that simple matter. If volumes decrease in north (e.g. consumption in respective countries and Russia, or factory production volumes decrease), it means lower frequency of sea transportation to European hubs, and correspondingly higher transportation costs for transported items. As recession typically decreases transportation prices, then we could assume that these two forces partially cancel each other, but leading into small cost increase.

4. Empirical Data Analysis

First Survey Results (year 2006)

Traffic flows within the companies, and selected five different countries and Northern European companies are shown in Figure 5. Just by following smallest container flow class (from 0 to 1000 TEU), it could be noticed that India, Russia and China were expected to gain most of the volume increases until year 2010. From these three, particularly Russia and China were presenting the strongest growth potential (since larger container flow classes have severe volume increase until year 2010). India is following more conservative volume growth. Not surprisingly, Japan and South-Korea are under minor growth in the future, and their relevance for logistics effectiveness of these companies is about to be smaller.

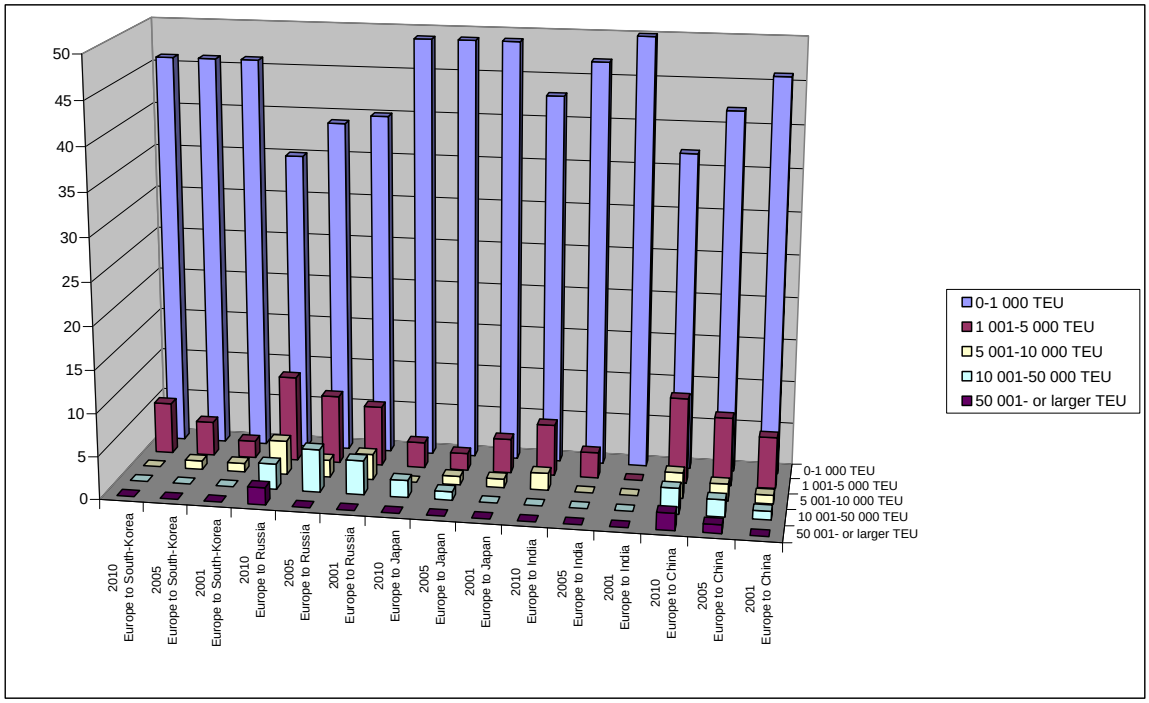

Figure 5. Traffic flows (Twenty feet Equivalent Units) between Europe and five selected countries (China, India, Japan, Russia and South-Korea), year 2006 survey responses.

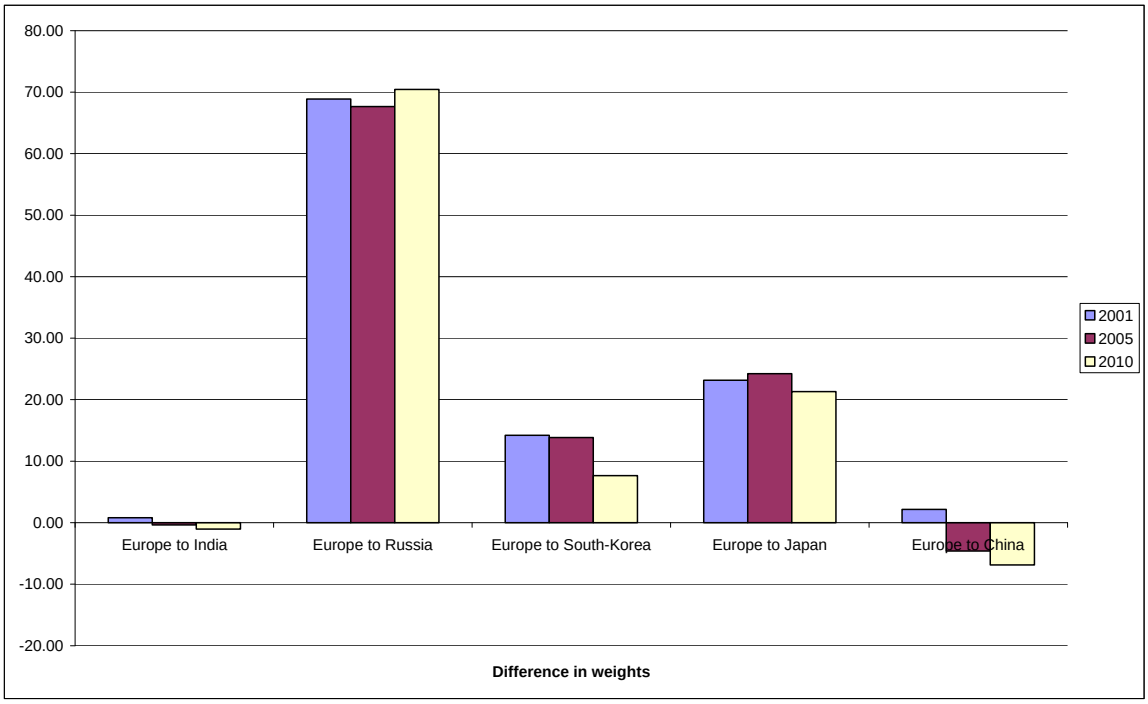

Figure 6. Traffic balance (percentage from Europe minus percentage to Europe from respective region) between Europe and five selected countries (average), year 2006 survey responses.

As in traffic flows we are able to observe number of different trends, in traffic balance the situation is more simplified. In all of the other countries, except Russia, the average (, also median, which is not available in Figure 6) traffic balance is quite near of zero (only Japan shows that from Europe to Japan there exists more traffic than vice versa). However, as we analyze the responses from individual companies a bit deeper, we recognize that in these four countries, companies either transport a lot from Europe to respective country or the other way around. This is particularly the situation in Swedish companies; in Finland traffic in both ways exist to a higher degree. Observation means that companies in both Sweden and Finland have integrated e.g. their factories poorly in a global scale, so factory (or factories) in Europe serve the entire demand of Asian countries or vice versa. However, in the future this will change a bit in some of the cases, especially with China and among Finnish leaden companies.

Most threatening overall development in company volumes is with China, as earlier we presented that volumes were on significant increase from North European companies, the balance even here is going to change from eastbound to westbound. So, based on this, traffic flow balance will only worsen in the future, since it could be assumed that Chinese companies do not have substituting volumes from Europe to China. With South-Korea situation is a little

bit similar (still positive one), but if India would gain similar significant volumes with China, balance would only get worse.

Russian logistics flow balance is an entirely different story from the others; currently Swedish and Finnish companies are basically transporting items from Europe to Russia, and traffic to other direction is very scarce. As average figures in Figure 6 also reveal, this situation will not greatly change in the near future. So, the transportation weight is on the European exports to Russia. However, interestingly some Finnish companies show different development, they might have plans to establish factories to Russia, which are serving more than the home market of that respective country. Thus, in the big picture, Swedish and Finnish companies both try to keep with their current export strategy, and only minor shifts exist in the direction that traffic flows (either from own manufacturing units or supplier network) will become more balanced. However, according to our survey this was still minor trend among companies during year 2006.

Second Survey Results (year 2009)

Similar findings as compared to the earlier survey were gained from year 2009 findings. As is shown in Figure 7, Chinese and Russian volumes are on the significant increase still, and based on survey findings this will only strengthen until year 2015. Second survey findings indicate that the significance of India in transportation flows is getting less important – although, some companies in this market are handling very significant volumes (which were not present in the earlier survey round).

However, all of the findings are not consistent with our earlier survey (year 2006); some companies are having very significant flows to South-Korea, and this market is even showing some small signs of increasing in the future (e.g. two largest container volume classes). Even if Japan remains as marginal product flow country, second largest container group is showing some minor positive changes.

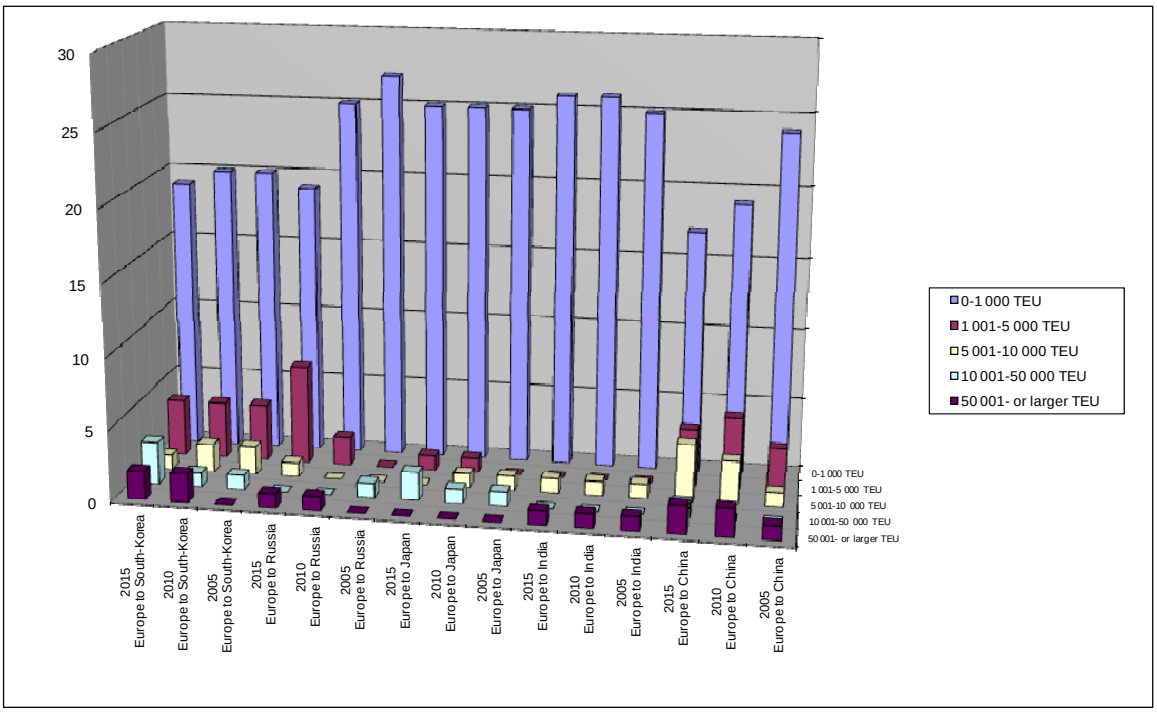

Figure 7. Traffic flows (Twenty feet Equivalent Units) between Europe and five selected countries (China, India, Japan, Russia and South-Korea), year 2009 survey responses.

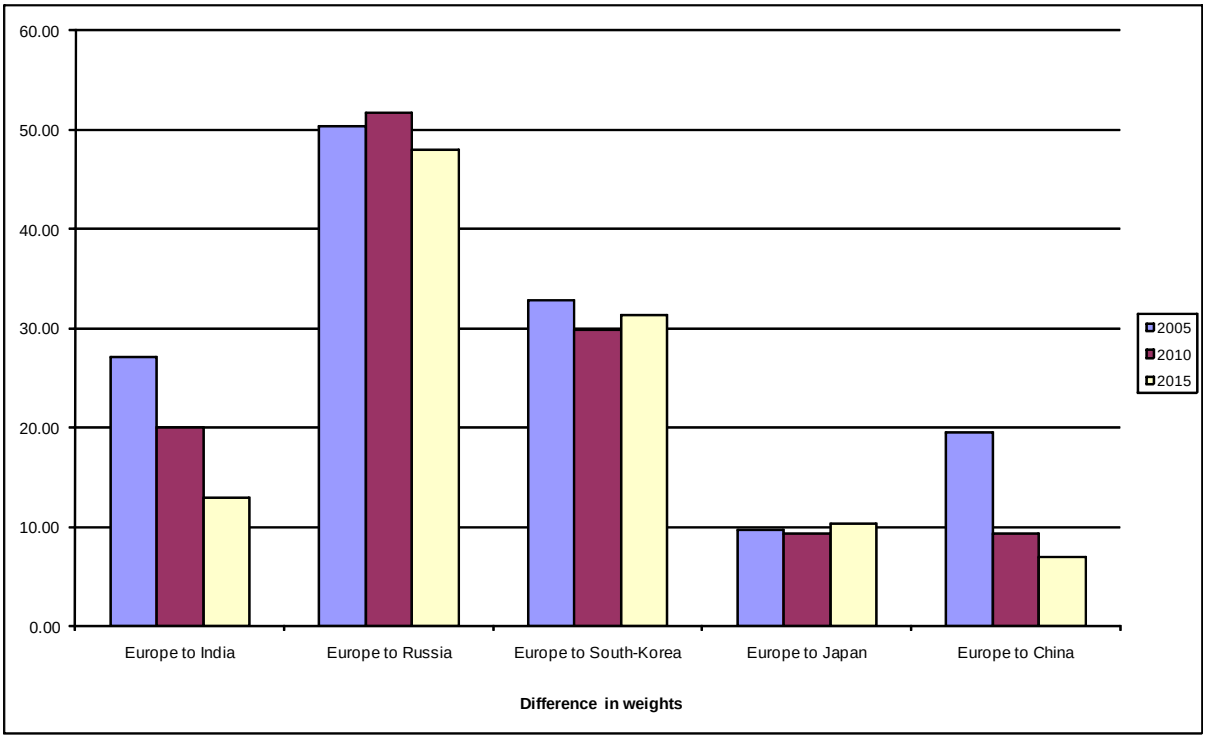

Figure 8. Traffic balance (percentage from Europe minus percentage to Europe from respective region) between Europe and five selected countries (average), year 2009 survey responses.

Interestingly, traffic volumes from North European companies remain in eastbound direction, even China or India is not showing at this time negative development (anyway, traffic balance will be difficult, since balance from North European companies is not great in positive side). However, similarly with earlier study, respondents of year 2009 survey indicated that traffic volumes from Europe to India and China are changes into other way around (towards westbound, see Figure 8). As we analyzed responses further, there was only small number of companies causing this change, and in significant parts built production network, and product volumes remained as the same (as compared to years 2005 and 2010). In Russia we found similar trend, some companies are planning to shift their volumes into Russian factories, and serving from these European demands. However, this only occurs in the limited number of cases.

As we analyzed responses further, it was revealed that European dominated production (100 % from Europe to the country of destination) was present for the markets of India, South-Korea and Russia. However, in Japan as well as in China situation is not that concentrated, and traffic flows are more distributed in company level into both directions. This is without a doubt caveat for the traffic volume balance sustainability in the future, since for-profit actors would most probably use weaker currency valuations, higher market demand in certain region and/or low costs opportunities; end result of these opportunities is allocation of production volumes into different places in short amount of time.

6. Conclusions

World's economic prosperity, world trade and transportation are tied upon together. In time before financial bubble of USA was witnessed very significant growth phase of transportation and trade all over the world, but thereafter economic meltdown resulted in very considerable as well as sudden trade and transportation activity decrease. However, even if state of the world was totally different during year 2006 (endless demand increase) and 2009 (demand disappeared and financial problems), our two surveys completed during these two years indicated that transportation flows are not that greatly affected between North European companies and Eurasian economies. During both survey rounds it was clearly shown that Chinese container flows are in the increase, and transportation unbalance is developing into very unfavorable direction from European perspective. Similar unbalanced development is occurring with India, but transportation volumes are having mixed future, and basically still

lack volume. Among these two, also Russian market was having very important role among North European companies. So, transportation volumes are going to continue their increasing trend, and in the future direction is mostly from Europe to Russia (with some exceptions among respondent companies, since new plant investments in Russia to serve also European demand). Two remaining countries of our study, South-Korea and Japan, have in the future important role in volume side, but these two countries do not experience that sudden and dynamic change as the others. Also two surveys did not provide that consistent picture from South-Korea and Japan.

As a further research, we would be interested to complete transportation flow survey once again, during spring 2010. It would be rather important to follow, how post-crisis environment is developing, and do companies just adjust their structures further to serve emerging markets. There is a danger that European companies increasingly shift their production into these countries due to lower overall costs, and significant demand provided by these new "domestic markets". For example, emerging Asian economies still provide relatively low costs, and most importantly increasing home market consumption. However, it would be too one sided to think only that larger Asian economies will take the lead in the world economy. We could also assume that Central and East European Countries (CEEC), and particularly Russia, could create booming economy based on manufacturing exports. Geographical position could not be better, having in near proximity China, India and Europe. Therefore, repeating this survey in the following years has an important role.

References

Ausubel, Jesse H. & Cesare Marchetti (2001). The evolution of transport. *The Industrial Physicist*, 7:2, pp. 20-24.

Barros, Lilian & Olli-Pekka Hilmola (2007). Quantifying and modelling logistics at business and macro levels. International Journal of Logistics Systems Management, Special Issue of ICIL, Vol. 3, No. 4, pp. 382-394.

Batisse, Francois (2001). The future of freight questioned by several European railways. *Japan Railway & Transport Review*, Vol. 26, February, pp. 18-27.

Chiodo, Abbigail J. & Michael T. Owyang (2002). A case study of a currency crisis: The Russian default of 1998. *The Federal Reserve Bank of St. Louis Review*, 84:6, pp. 7-18.

Hilmola, Olli-Pekka (2007). European railway freight transportation and adaptation to demand decline – Efficiency and partial productivity analysis from period of 1980-2003. *International Journal of Productivity and Performance Management*, 56:3, pp. 205-225.

Hilmola, Olli-Pekka (2008). Railway efficiency analysis from larger Europe during period of 1994-2003. *International Journal of Operational Research*, 3:3, pp. 255-280.

Hilmola, Olli-Pekka, Ulla Tapaninen, Erik Terk & Ville-Veikko Savolainen (2007). *Container Transit in Finland and Estonia – Current Status, Future Demand and Implications on Infrastructure Investments in Transportation Chain*. Publications from the Centre for Maritime Studies, University of Turku, A44.

Häkkinen, Lotta, Andreas Norrman, Olli-Pekka Hilmola & Lauri Ojala (2004). Logistics integration in horizontal mergers and acquisitions. *International Journal of Logistics Management*, Vol. 15, No. 1, pp. 27-42.

IMF (2009). *World Economic Outlook (WEO) – Crisis and Recovery, April 2009*. Available at URL: http://www.imf.org/external/pubs/ft/weo/2009/01/index.htm Retrieved: Oct.2009

Kovacs, Gyöngyi & Karen M. Spens (2006). Transport infrastructure in Baltic States post-EU succession. *Journal of Transport Geography*, 14:6, pp. 426-436.

Kilpeläinen, Jaakko (2004). *Development of Transit Traffic via Finland in 1997-2003.* Lappeenranta University of Technology, Northern Dimension Research Centre, Publication 8.

Krugman, P. (2005) 'Currency crisis', Available at: http://web.mit.edu/krugman/www/crises.html, Retrieved on May 11th of 2005, Originally published on October 1997.

Lee, J-Y (2004) 'Iron Silkroad: Prospects for a landbridge through Russia from Korea to Europe', *Post-Soviet Affairs*, 20:1, pp. 83-105.

Lorentz, H. (2008). Production locations for the internationalising food industry: case study from Russia. *British Food Journal*, 110, 3, pp. 310-334.

Ohmae, Kenichi (1985). *Triad Power*. Free Press, USA.

Maersk (2009). Interim Report 2009. Available at URL:

http://shareholders.maersk.com/en/Announcements/2009/Documents/Interim%20report%202009.pdf Retrieved: Nov.2009.

Milan, Janic (1996). The trans European railway network – Three levels of services for the passengers. *Transport Policy*, 3:3, pp. 99-104.

Molnar, Eva & Lauri Ojala (2003). *Transport and Trade Facilitation Issues in the CIS 7, Kazakhstan, and Turkmenistan.* World Bank Report.

Platou Report (2006). *The Platou Report. R.S.* Platou Shipbrokers a.s. Available at URL: http://www.platou.com/portal/page?_pageid=153,189039&_dad=portal&_schema=PORTAL

Prajogo, D.I., Laosirihongthong, T., Sohal, A. and Boon-itt, S. (2007), "Manufacturing strategies and innovation performance in newly industrialized countries", *Industrial Management and Data Systems*, 107:1, pp. 52-68.

Shu, X. (1997). The New Asia-Europe Land Bridge – Current Situation and Future Prospects. *Japan Railway & Transport Review*, No. 14, pp. 30-33. Available at URL: http://www.jrtr.net/backissue/index_backissue.html, Retrieved 06.07.2006.

SPB (2009). Группа компаний «Морской порт Санкт–Петербург» обработала более 8,5 млн. тонн грузов за 9 месяцев 2009г. Available at URL: http://www.seaport.spb.ru/press/release/173/ Retrieved: Nov.2009

Statistics Finland (2009). *World in Figures – Gross Domestic Product*. Available at URL: http://www.stat.fi/tup/maanum/taulukot.html Retrieved: Oct.2009

Tian, Y., Lai, F. and Daniel, F. (2008), "An examination of the nature of trust in logistics outsourcing relationship – empirical evidence from China", *Industrial Management & Data Systems*, 108, 3, pp. 346-367.

United Nations (1999a). Development of Asia – Europe container transport through block-trains. Northern corridor of the Trans-Asian railway. *Economic and Social Commission for Asia and the Pacific*.

United Nations (1999b). Development of the Trans-Asian Railway – Trans-Asian Railway in the Southern Corridor of Asia-Europe Routes. *Economic and Social Commission for Asia and the Pacific*.

United Nations (2005a). *Review of Maritime Transport 2005.* United Nations Conference on Trade and Development, New York & Geneva.

United Nations (2005b). *Regional Shipping and Port Development Strategies (Container Traffic Forecast).* Economic and social commission for Asia and the Pacific.

United Nations (2008). *Review of Maritime Transport 2008.* United Nations Conference on Trade and Development, New York & Geneva.

Yu, Ming-Miin & Erwin T.J. Lin (2008). Efficiency and effectiveness in railway performance using a multi-activity network DEA model. *Omega – International Journal of Management Science*, 36:6, pp. 1005-1017.

Vassallo, J.M. (2005). *Nature or Nurture: Why do Railroads Carry Greater Freight Share in the United States than in Europe?* Research Working Paper Series, WP05-15, Harvard University, USA.

Vellega, D.B., & Spens, K.M. (2006) 'Expansion of container traffic from Asia to the EU', in Hilmola, O-P (ed.), *Contemporary Research Issues in International Railway Logistics*, research report 171, Lappeenranta University of Technology, Finland.

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Logistics Relationship: A Literature Review

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Логистические взаимоотношения: обзор литературы

Пиа Ямса

Abstract
This paper has primary purpose to review criteria and goals when choosing a logistics service provider for logistics organisations or network. The idea is based on Matti Miettunen and Pia Jämsä (2004): Strategic partnership in logistics: Goals and Criteria, of which the view is extended to the power of relationships, type of relationship as well as strategies towards risks when choosing an actor to a strategic or non-strategic operation, also if and when risks and product returns are notified in the selection process.

Keywords: logistics relationship, logistics networks, alliances, industrial network

Аннотация
Эта статья имеет основной целью обзор критериев и целей при выборе логистического провайдера услуг для логистической организации либо сети. Идея основывается на статье Матти Миеттунен и Пиа Ямса, опубликованной в 2004 году: Стратегическое партнерство в логистике: Цели и Критерии; в которой акцент смещен на силу взаимоотношений, тип взаимоотношений, а также стратегии относительно рисков при выборе партнера для стратегических и нестратегических операций, в случае если риски и возврат товара учитываются в процессе выбора.

Ключевые слова: логистические взаимоотношения, логистические сети, альянсы, производственные сети

1. Introduction

Many researches show that business relationships are complex and diverse. The complexity has accelerated researchers to create business evaluation and segmentation tools. (See e.g. Das, 2005; Levary, 2007; Staughton & Johnston, 2005; Chen, 2008; De Lurdes Veludo, Macbeth & Purchase, 2006; Sarkis et al., 2007; Kakouris et al., 2006) The term network is an abstract notion of a set of nodes and relationships connecting them (Gómez Arías, 1995). Relationship, in this paper, starts from single transaction and ends to the model of strategic alliances and vertical integration. Strategic partnership is referred to as Third party logistics (TPL) containing long term plan (more than 3 years) and more than one outsourced operation. It allows partners to concentrate on core competence, it shares risks and benefits. Vertical

integration is the most extensive means of relations; the service provider offers to take over a whole of operation.

This paper reviews the power of relationships, type of relationship as well as strategies towards risks when choosing an actor to a strategic or non-strategic operation, and also if and when risks and product returns are notified in the selection process. The paper starts with an overview of existing literature of relationships and logistics networks. Secondly, findings are presented and later discussed. Finally, the paper provides conclusions and implications for further research.

2. Logistics Relationship Studies

Relationship studies and relationships have been hot topics in the academic literature. Whether companies are sourcing new products, solutions, innovation or just a part of their business, points the clock towards business relationships. Relationships can vary from single transaction to highly integrated processes (vertical integration). Companies have increasingly entered into strategic alliances, especially in technology-based industries. (Das & He, 2006) Many researchers point out the complexity of relationships. Skjoett-Larsen (2000) highlights the network theory to explain the dynamics in third party co-operations. According to Wang and Kess (2006), the dynamics of channel partnerships and their implications for managing on-going relationships has been under focus for many researches while little research focuses on the starting point of the relationship formation and design. Kannan and Tan (2004) pointed out the importance of links between the supplier management dimensions of supplier selection and assessment, and performance. Prajogo et al. (2004) argue that closer relationships in innovation relationships will open channels for better management of knowledge. Also, Sarkis et al. (2007) point out a company's inability to become internally agile unless its external relationships with the supply chain are also agile.

Todeva and Knoke (2005) explain the formation, implementation, and consequences of strategic alliances among autonomous actors in an organizational field. They also show that alliances provide opportunities for participants to tap into the resources, knowledge, and skills. Walters and Rainbird (2007) introduced the importance of upstream and downstream in supply chain management including supplier relationship management. In the mid 1990s the

market context changed again with the advent of large-scale outsourcing and the market entry of specialist outsourcing organizations.

Das and He (2006) researched the intrinsic and alliance differences in entrepreneurial and established firms. They found nine (9) intrinsic factors:

- resources,
- innovativeness,
- status in competition,
- legitimacy,
- history/track record,
- economic/political power,
- organizational characteristics,
- business focus products and services, and
- planning horizon;

and six (6) alliancing factors:

- control over technology,
- confidence in technology,
- inter-organizational interfacing,
- criticality of alliancing,
- strategic objective, and
- consistency of commitment.

However, De Lurdes Veludo, Macbeth and Purchase (2006) highlight that actors operate with a portfolio of different types of relationships and that each type of relationship is affected by different factors. Knoppen and Christiaanse (2007) argue that due to the limited cognitive capacity of organizational actors, understanding and management of a partnership is facilitated by separating the concerns and shifting their importance in time. One important issue in relationship studies have been the supplier selection and segmentation criteria. Even though it has been widely studied, the content of motivations and criteria as well as their priority and weightings may vary with different kinds of alliances or situations. (Chen, 2008)

Supplier selection criteria have also become crucial in order to achieve an appropriate evaluation of suppliers (Svensson, 2004). Miettunen and Jämsä (2004) studied the criteria and goals of outsourcing transportation, however, the criteria and goals were changing depending on the actors. Al-Khalifa and Peterson (1999) argue that the partner selection motivation must be distinguished from the motivation to enter into a joint venture. Banks Pidduck (2006) concentrated on how and why supply chain partners are chosen. The research is carried out through alliance motivation, formation and decision-making. Ounnar and Pujo (2005) cover the factors of costs, reliability of services, and responsiveness in partner selection criteria. Staughton and Johnston (2005) identify the underlying criteria of management decision making regarding the gaps of current and desired situation.

Van Weele (2000) presented a portfolio of different supplier segmentation strategies which bases on two dimensions: (1) supplier's impacts on financial results; and (2) supply risk. However, few studies have shown longitudinal results on selection criteria, and many highlight it as complex as business relationships. Kakouris, Polychronopoulos and Biniori (2006) pointed out four key attributes: price, quality, delivery and service. Kannan and Tan (2004) argue that disconnect sometimes exists between the perceived importance of supplier selection criteria and practice.

The most often used approach is an analytical network process (ANP) approach which is based on Markov chain. Sarkis et al. (2007) conducted an ANP based model for evaluating and selecting competent and compatible business partners. Also, Chen (2006) conducted an ANP model while Levary (2007) conducted an analytic hierarchy process (AHP) model. Wang and Kess (2006) selected seven motivation criteria to partner selection:

- risk reduction,
- economies of scale and/or rationalization,
- complementary technologies and patents,
- co-opting or blocking competition,
- overcoming government-mandated investment or trade barrier,
- initial international expansion, and
- vertical quasi integration.

Many other researches have highlighted similar criteria. Few studies concentrate on the power of relationships. Kim et al. (2005) explores the impact of IT adoption on partner coordination. They point out the power of IT in both success and failure of the relationship. Das (2005) places importance on the potential for deceit in partner organizing. Many studies point out the importance to understand the relationship and the criticality of mutual operation or product. Often considered issue is whether buyer or seller has more power on the existing relationship, or if the power has turned against the actors. Cooperation between the parties has become more long-term in nature, mutually binding and is often combined with changes. (Skjoett-Larsen, 2000) Few studies have pointed out the risk management in relationships. Relationship strategies to a strategic or a non-strategic operation are also cited but not heavily studied.

Levary (2007) provide insight on evaluating potential suppliers and to consider the risk of disruption to the manufacturer's assembly operation associated with the characteristics of the potential supplier. Delerue (2005) brings an empirical support to risk management problems in alliances, and places an important question; how is the risk to be managed? The firms favoring strategic behavior prefer a past working relationship with the potential partner, while those favoring learning did not. (Tokman et al., 2007)

If the decision to be involved is in a too close strategic relationship, it is not an easy issue. (Zineldin & Bredenlöw, 2003) Emerging biotechnology firms rely on a network of socio-economic partnerships that can be classified as close, collaborative but relatively short-lived. (Ferguson et al., 2005) However, many actors tend to ignore the importance of the strategy. According to Kannan and Tan (2004) actors tend to only improve their ability to respond to market pressures.

It can be said that fast changes in business environment force companies to seek for different options in order to become successful and to encourage changing. (Bagchi & Virum, 1998) Cost-effectiveness seems to be the indicator of the day, where business is based on market governance. In perfect market situation buyer and seller meet where the market is. However, in reality, there seldom exists a perfect market. The modern economics highlights also the different aspects of decision-making. Each party may have different relations in negotiations because of the differences in size, lack of information or irrational choices.

In long-term business relationship, partners have collaborated with each other for a longer time period. If partners do not share any joint ventures or production, the relation is comparable to arm's length relations. In this model there is no remarkable information sharing, neither there will be any dependencies nor future commitments. Price is often an issue in negotiations, and provider is relatively easy to substitute. (Dyer et al., 1998; Webster, 1992) The main indicators are information sharing, joint goals, and shared risks and incomes. (Dyer et al., 1998) The line between partnership and strategic partnership is fluctuating. (Webster, 1992 vs. Bowersox, 1990) In the other hand, the market governance has been eliminated from cooperation of vertical integration (Seppälä, 2001).

Partnership requires same kind of expectations from both sides. For example Choy and Lee (2002) divide these criteria into three groups:

1) Technical know-how evaluation,
2) Quality evaluation, and
3) Organisation profile.

All in all, these criteria can be used as main criteria according to the literature reviewed in this paper. In some point all paper point to the question of being cost effective, have enough capacity (resources) and market situation of the company. Criteria when choosing a partner will move on in detailed and precise evaluation. (Carter, Carter & Swan 2000)

3. Methods

A literature review on criteria and goals of logistics relationships, alliances and industrial network is conducted by the search of the following journal databases (1990 to current): ScienceDirect, EbsconHost, Emerald, and ABIInform. These databases cover both the mainstream journals in logistics and supply chain management as well as enterprise development. The focus was placed on "logistics relations" and "logistics networks", "alliances", and "industrial network" in order to find research questions, methods, topics and key elements in goals and criteria. Goals and criteria were not found as a keyword, since the articles were driven by types of relationships rather than their indicators.

There were several overlaps with the database journals, and the final amount of reviewed academic papers was forty-four (44).

4. Frame of Reference

The literature review on goals and criteria on logistics partnership with the extended view from the power of relationships, type of relationship to strategies towards risks when choosing an actor to a strategic or non-strategic operation, also if and when risks and product returns are notified in the selection process is verified the frame of reference. Figure 1 shows the frame of reference.

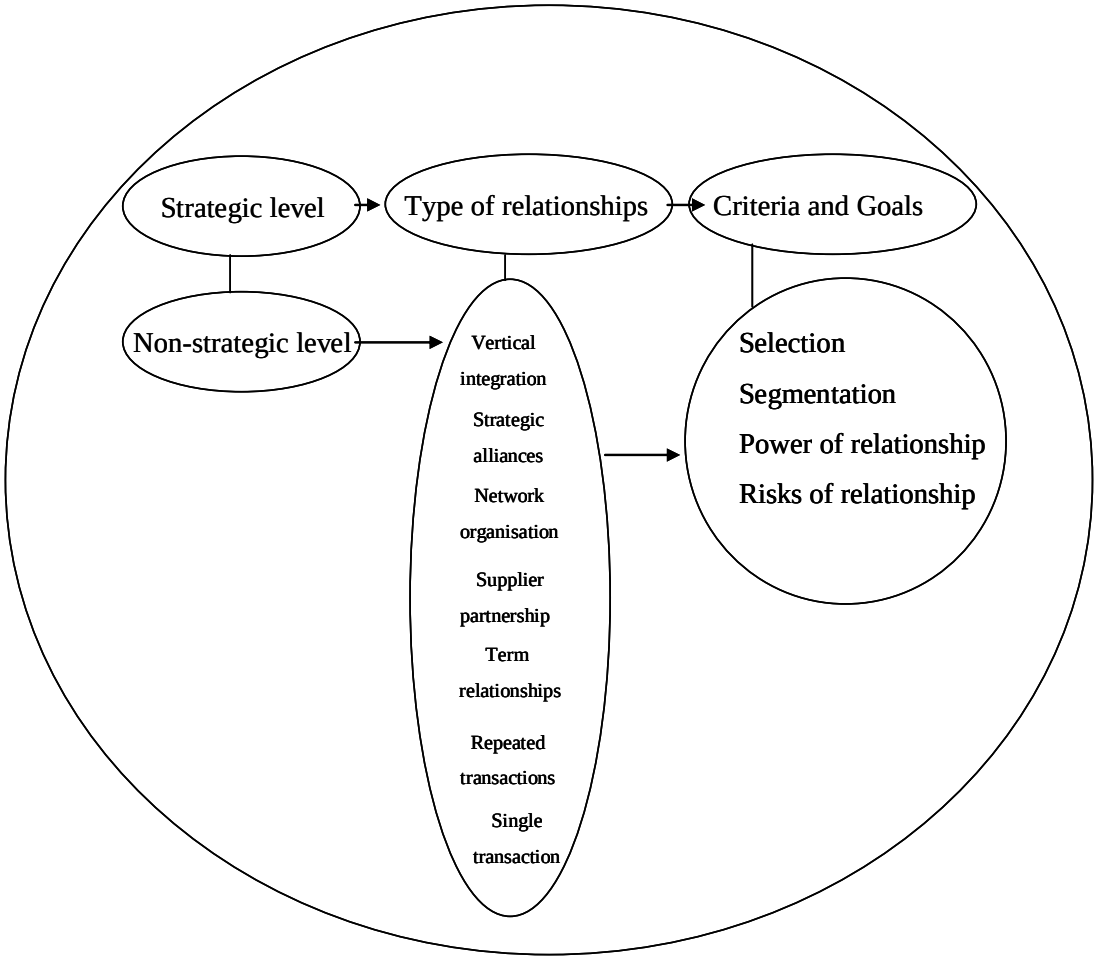

Figure 1. Frame of reference.

Each party may have different relations in negotiations because of the differences in size, lack of information or due to the irrational choices. There are two different levels, strategic or non-strategic, when analysing the data. Secondly, the type of relationship is under focus and thirdly, the main criteria of the relationship.

5. Findings

There were several actors (buyer – supplier) and processes included in this study through literature. The type of sourced/outsourced operation, processes, type of relationship, power of relationship, and the main criteria found in the literature review in selection are listed in Table 1.

Table 1. Review of the relationship studies.

Type of sourced/ outsourced operation	Process	Type of relationship	Power of relationship	Main selection criteria
Strategic	Supply Chain management	Strategic alliance	High	Important, cost effectiveness
Non-strategic	Supply Chain operation	Partnership or single transaction	Low	Mainly financial issues

Depending on the issue of strategic or non-strategic outsourcing, the studies highlighted clear results. If the operation was not strategic, the power of relationships as well as type of it, were of low value. Also, the economic aspect was then highlighted. Risk of outsourced operation was more often evaluated within strategic operation than with non-strategic operation. However, there were no indicators showing that returning goods or reverse logistics in general was in question when selecting suppliers.

Webster (1992) and Cox (1996) have examined relationships of partners and circumstances. Figure 2 shows these relations as tentative mapping of the relationship (Webster, 1992). However, the power of the relationship has been ignored in the mapping. This paper argues that the power of relationship depends on the type of relationship rather than market governance or the volume of transactions. Therefore, it has been added into the tentative mapping.

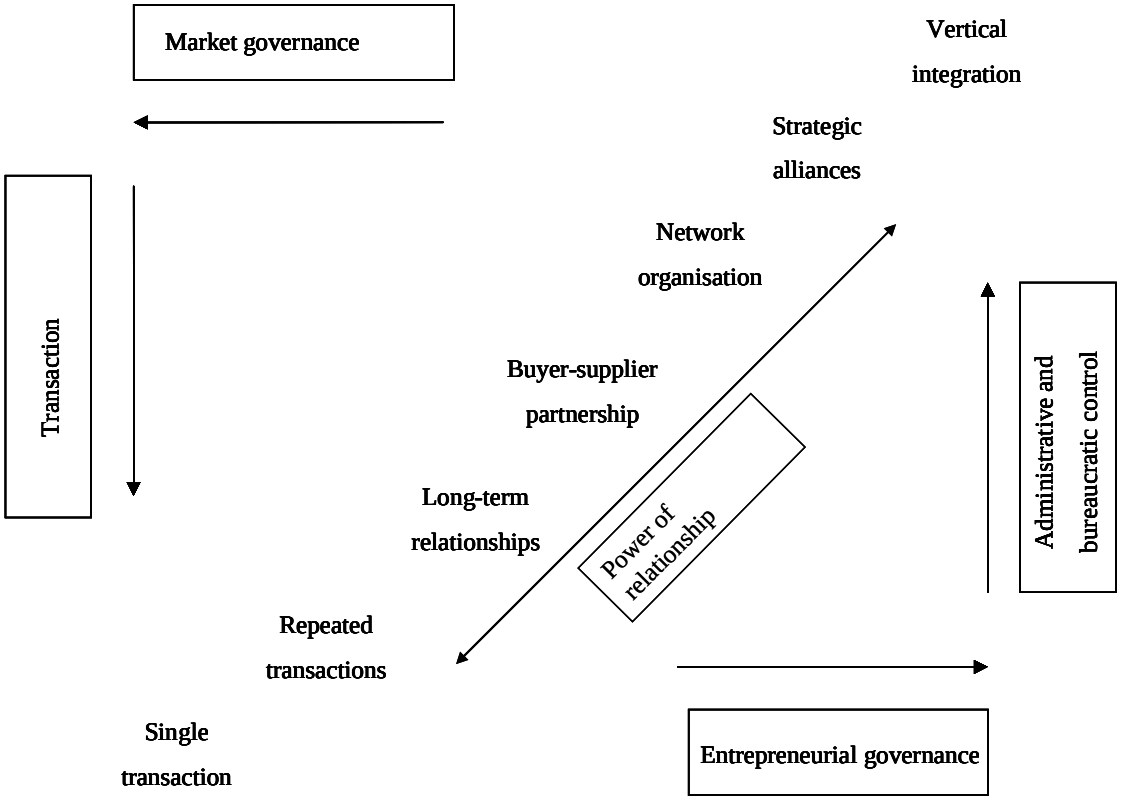

Figure 2. A tentative mapping of buyer-supplier relationship (amended from Webster, 1992).

When going up from the left into the right side corner, the effect of market governance is reduced and the effects of own choices are raised. Companies tend to minimise the cost of transaction and production (including administrative cost) by choosing the right business relationship model suitable for each situation. Still, each modification requires time when the resistance to change is met, not only inside the company but within partners that prefer the old relationship model. The more complicated the operation or product is, the more likely these companies strive towards more integrated business relationship. Still, relationship based on single business operation is very common, and it can be impugned, if there even is a relationship (Webster, 1992). It can be argued that the power of relationship depends on the type of relationship rather than market governance or the volume of transactions.

6. Discussion

Outsourcing has several advantages of partnering. It allows companies to concentrate on core competence, and to elaborate further. (Choy & Lee, 2002) It allows service provider to balance its load and profit in order to serve more than one customer. Outsourcing is recommended when focusing on manufacturing industry. (Lankford & Parsa, 1999) Relation models of outsourcing are partnership or strategic alliances. They are depended on three resources: technology, information and relationship network. (Lieb & Randall, 1999) Supplier segmentation is one fundamental business activity to improve the outcome of a company's efforts to maintain and enhance its position in the marketplace, as well as customer segmentation, market targeting, and positioning (i.e. strategic marketing). (Svensson, 2004) Kraljic (1983) is often considered as a pioneer in developing a model of supplier segmentation, Kraljic Matrix.

In close cooperation, partners share information, risks and profits, and either fail together or succeed. (Lambert et al., 1996; Bowersox, 1990) There exists a wide amount of operations which outsiders can manage cheaper and faster. (Lankford & Parsa, 1999) Van Weele (2000) highlighted two dimensions: (1) supplier's impacts on financial results; and (2) supply risk. (van Weele, 2000)

Besides cultural differences, earlier experiences, company size and corporate structure have an influence when choosing a logistics partner. National culture and culture heritage have an effect on corporate strategy and problem solving skills. If partnership fails companies tend to look for new criteria and metrics to re-evaluate the situation. According to Dacin and Hitt (1997) from 50 to 60 % of partnerships tend to fail. Also, Parks and Ungson (1997) argue that 50 % of logistics partnerships fail. Both of the arguments state that the common reason for failure comes from cultural differences or incompatibility with organisations. Failure process is time consuming. To minimize the risk of failure, each actor should define and detail their goals. The most common reasons for failure are lack of commitment in management level, undefined goals, lack of control, and different levels of commitment from both sides. (Bowersox, 1990)

Globally companies are outsourcing widely. Since partners are used for rationalising the business and raising standards in competition, outsourcing process opens the door for closer

cooperation. (Bagchi & Virum, 1998) Alliances and industrial networks are sought through low overhead costs, increased responsiveness and flexibility and greater efficiency of operations. (Gómez Arías, 1995) In traditional logistic services such as forwarding, transportation, material and inventory management the profitability is low. (Berglund, 2000) It has been forecasted in the 1990's that European logistic services will be more centralised than today. (Peters & Jockel, 1998) Therefore, mergers and acquisitions (M&A's) have been common in the field, and small amount of logistics companies rule the market. At the moment there is still a wide amount of service providers in the market. (Gordon, 2003) Transportation operations have primary purposes on cost saving, and logistics service providers often seek for solution with effects on reducing costs but still fulfilling the delivery accuracy requirements. The aim is to maximise own profitability with price, and high and regular volumes. In transportation operations volumes and frequencies play a key role. Single logistic operations have often decentralised organisation, which causes lack of coordination. By integrating the logistic operation a company may gain remarkable cost savings. (Bowersox & Daugherty, 1987) However, this concentration is commended for internal logistics, as the solution has limits and is far from the real problem – lack of coordination. External logistics integration, such as outsourcing and logistics alliance, concentrates on assumption that the logistic operations are build upon corporate borders. (Stock et al., 1999)

7. Concluding Remarks

This study analyses literature of logistics network. The purpose is to understand the different types of relationships, and goals and criteria of an actor. Literature review is based on phenomenon of outsourcing, and partnership and their goals and criteria of which the view is extended to the power of relationships, type of relationship as well as strategies towards risks when choosing an actor to a strategic or non-strategic operation, also if and when risks and product returns are notified in the selection process. Partnership models are analysed based on extended Webster's model of partnership.

When outsourcing, buyers have centralised operations with even fewer providers. Development follows ideas of outsourcing with specialised companies. Centralising has been a start for logistics partnership. (Lieb & Randall, 1999; Bagchi & Virum, 1998) Companies seek fastness, flexibility and cost savings with partnerships. Service providers seek long-term

business relationships and commitment through partnership. Business is easier to forecast, and investments have secured basis. Advantages tend to arise from supplier's effectiveness, organisation loping, and capital saving when outsourcing. The purpose is often to affect on changing fixed costs into flexible cost. These results are agreed with Choy and Lee (2002). Also, economies of scale are achieved, as agreed with LaLonde and Cooper (1989) and Morphy (2000).

Partnership is achieved with careful negotiations and with limited amount of service providers. Bowersox (1990) also emphases selective matching for the selection process. According to literature many companies chose their partners by themselves without external business consulting. Logistics service providers as partners are mainly chosen using the same criteria as choosing other business partners. There did not arise any particular criteria for only logistics partners. Partner is assumed to have stable economy, adequate size and liable ownership. Logistics cost present remarkable cost for companies. Instead of integrating inner logistics, companies seek for optimised outbound logistics or the whole supply chain.

If cooperation goes smoothly with single working level, then the cooperation is easier also with partner level. Communication is facile and operation becomes flexible. Often, logistics provider is required to have earlier experiences with same type of customers, preferably as reference customers. When companies have agreed with partnership, the measured metrics are agreed at the same time. They can be measured daily with operative level, or monthly in management level. Therefore, criteria concerns both partners' personnel and supplier's network. A professional buyer knows that supply chain is as strong as its weakest link. Still, even if the above criteria is handled carefully, it seems unclear how the return network would work, and which indicators should accelerate it. Growth and profitability were listed as future challenges. When investments are remarkable, then also the partnership is seen as long term strategic choices. If partnership is successful, the service provider can raise the amount of goods flow, and can get its profitability on higher level.

References

Al-Khalifa, A.K. and Peterson, S.E. (1999) The partner selection process in international joint ventures, *European Journal of Marketing*, Vol. 33, No. 11/12, pp. 1064-1081.

Bagchi, Prahib K. and Virum, Helge (1998) Logistical alliances: Trends and prospects in integrated Europe, *Journal of Business Logistics*, Vol. 19, No 1, 1998.

Banks Pidduck, A. (2006) Issues in supplier partner selection, *Journal of Enterprise Information Management*, Vol. 19, No. 3, pp. 262-276.

Bowersox, D.J. (1990) The strategic benefits of logistics alliances, *Harvard Business Review*, July-August, pp. 36-45

Bowersox, D.J. and Daugherty, P.J. (1987) Emerging patterns of logistical organisation, *Journal of Business Logistics*, Vol. 8, No. 1, pp. 46-60.

Carter, P.L., Carter, J.R. and Swan, A.J. (2000) The future of purchasing and supply: a ten-year forecast, *Journal of Supply Chain Management*, Vol. 36, No. 1, pp. 14-36.

Chen, S-H., Lee, Ho-T. and Wu, Y-F. (2008) Applying ANP approach to partner selection for strategic alliance, *Management Decision*, Vol. 46, No. 3, pp. 449-465.

Choy, K.L., Lee, W.B. and Lo, V. (2002) An intelligent supplier management tool for benchmarking suppliers in outsource manufacturing, *International Journal of Expert Systems with Applications*, Vol. 22, No. 3, pp. 213–224.

Cox, A. (1996) Relational competence and strategic procurement management, *European Journal of Purchasing and Supply Management*, Vol. 2, No. 1, pp. 57-70

Dacin, M.T. and Hitt, M.A. (1997) Selecting partners for successful international alliances, *Journal of World Business*, Vol. 32, Issue 1, pp. 3-17.

Das, T.K. (2005) Deceitful behaviors of alliance partners: potential and prevention, *Management Decision*, Vol. 43 No. 5, pp. 706-719.

Das, T.K. and He, I.Y. (2006) Entrepreneurial firms in search of established partners: review and recommendations, *International Journal of Entrepreneurial Behaviour & Research*, Vol. 12 No. 3, pp. 114-143.

De Lurdes Veludo, M., Macbeth, D. and Purchase, S. (2006) Framework for relationships and networks, *Journal of Business & Industrial Marketing*, 21/4, pp. 199–207.

Delerue, H. (2005) Relational risk perception and alliance management in French biotechnology SMEs, *European Business Review*, Vol. 17 No. 6, pp. 532-546.

Dyer, J.H., Cho, D.S. and Chu, W. (1998) Strategic Supplier Segmentation: The next "best practise" in supply chain management, *California Management Review*, Vol. 40, No. 2, pp. 57-77.

Ferguson, R.J., Paulin, M., Möslein, K. and Müller, C. (2005) Relational governance, communication and the performance of biotechnology partnerships, *Journal of Small Busniness and Enterprise Development*, Vol. 12, No. 3, pp. 395-408.

Gordon, B.H. (2003) The changing face of 3rd party logistics, *Supply Chain Management Review*, Vol. 7, Issue 2, pp. 50-57.

Kakouris, A.P., Polychronopoulos, G. and Biniori, S. (2006) Outsourcing decisions and the purchasing process: a systems-oriented approach, *Marketing Intelligence & Planning*, Vol. 24, No. 7, pp. 708-729.

Kannan, V.R. and Tan, K.C. (2004) Supplier alliances: differences in attitudes to supplier and quality management of adopters and non-adopters, *Supply Chain Management: An International Journal*, Vol 9, No. 4, pp. 279-286.

Kim, D., Cavusigil, S.T. and Calantone, R.J. (2005) The role of information technology in supply-chain relationships: does partner criticality matter?, *Journal of Business & Industrial Marketing*, Vol. 20/4/5, pp. 169–178.

Knoppen, D. and Christiaanse, E. (2007) Supply chain partnering: a temporal multidisciplinary approach, *Supply Chain Management: An International Journal*, Vol. 12/2, pp. 164–171.

Kraljic, P. (1983) Purchasing must become supply management, *Harvard Business Review*, September/October, pp. 109-17.

La Londe, B.J. and Cooper, M.C. (1989) *Partnerships in providing customer service: a third-party perspective*, Oak Brook, IL: Council of Logistics Management.

Lambert, D.M., Emmelhainz, M.A. and Gardner, J.T. (1999) Building successful logistics partnerships, *Journal of Business Logistics*, Vol. 20, Issue 1, pp. 165-178.

Lankford, W.M. and Parsa, F. (1999) Outsourcing: a primer, *Management Decision*, Vol. 37, pp. 310-16.

Levary, R.R. (2007) Ranking foreign suppliers based on supply risk, *Supply Chain Management: An International Journal*, Vol. 12, No. 6, pp. 392-394.

Lieb, R.C. and Randall, H.L. (1999) Use of third-party logistics services by large US manufacturers in 1997 and comparison with previous years, *Transport Reviews*, Vol. 19, Issue 2, pp. 103-116

Morphy, E. (2000) Quality measurement best practises made perfect?, *Export Today's Global Business*, Vol. 16, Issue 5, pp. 60-64.

Ounnar, F. and Pujo, P. (2005) Evaluating suppliers within a self-organized logistical network, *The International Journal of Logistics Management*, Vol. 16, No. 1, pp. 159-172.

Park, S.H. and Ungson, G.R. (1997) The effect of national culture, organisational complementarity, and economic motivation on joint venture dissolution, *Academy of Management Journal*, Issue 40, pp. 279-307.

Peters, M and Jockel, O. (1998) The day of the mega-carrier, *Logistic Europe*, June, pp. 16-25.

Prajogo, D.I., Power, D.J. and Sohal, A.S. (2004) The role of trading partner relationships in determining innovation performance: an empirical examination, *European Journal of Innovation Management*, Vol. 7, No. 3, pp. 178-186.

Sarkis, J., Talluri, S. and Gunasekaran, A. (2007) A strategic model for agile virtual enterprise partner selection, *International Journal of Operations & Production Management*, Vol. 27, No. 11, pp. 1213-1234.

Seppälä, T. (2001) *Buyer-supplier relationships and sourcing of strategic components*, Publication in the Turku School of Economics and Business Administration, Series D-1:2001.

Skjoett-Larsen, T. (2000) Third party logistics - from an interorganizational point of view, *International Journal of Physical Distribution & Logistics Management*, Vol. 30, No. 2, pp. 112-127.

Staughton, R. and Johnston, R. (2005) Operational performance gaps in business relationships, *International Journal of Operations & Production Management*, Vol. 25, No. 4, pp. 320-332.

Stock, G.N., Greis, N.P. and Kasarda, J.D. (1999) Logistics, strategy and structure - A conceptual framework, *International Journal of Physical Distribution & Logistics Management*, Vol. 29, No. 4, pp. 224-239.

Svensson, G. (2004) Supplier segmentation in the automotive industry - A dyadic approach of a managerial model, *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 1, pp. 12-38.

Tatoglu, E. (2000) Western joint ventures in Turkey: strategic motives and partner selection criteria, *European Business Review*, Vol. 12, No. 3, pp. 137-147.

Todeva, E. and Knoke, D. (2005) Strategic alliances and models of collaboration, *Management Decision*, Vol. 43, No. 1, pp. 123-148.

Tokman, M., Elmadag, A.B. and Uray, N. (2007) Exploring the development of supply chain international joint ventures, *International Journal of Physical Distribution & Logistics Management*, Vol. 37 No. 6, pp. 442-453.

van Weele, A.J. (2000) Purchasing and Supply Chain Management, Business Press, Thomson Learning, London.

Walters, D. and Rainbird, M. (2007) Cooperative innovation: a value chain approach, *Journal of Enterprise Information Management*, Vol. 20, No. 5, pp. 595-607.

Wang, L. and Kess, P. (2006) Partnering motives and partner selection Case studies of Finnish distributor relationships in China, *International Journal of Physical Distribution & Logistics Management*, Vol. 36, No. 6, pp. 466-478.

Webster, F.E. Jr. (1992) The changing role of marketing in the corporation, *Journal of Marketing*, Vol. 56, pp. 1-17.

Zineldin, M. and Bredenlöw, T. (2003) Strategic alliance: synergies and challenges - A case of strategic outsourcing relationship "SOUR", *International Journal of Physical Distribution & Logistics Management*, Vol. 33 No. 5, pp. 449-464.

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Russian Customs Initiatives and Supply Chains for Saint-Petersburg

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Инициативы Российской Таможни и цепи поставок для Санкт-Петербурга

Михаил Пимоненко

Abstract
The Finnish-Russian project LOGNET besides educational issues deals with investigation of supply chains. Custom procedures occupy very important place in logistics of foreign trade and improvement of appropriate supply chains. That's why it was reasonable to pay attention to nearest future processes in Russian Custom.

Keywords: Russia, Russian Customs, supply chains

Аннотация
В Финляндско-Российском проекте ЛОГНЕТ кроме образовательной части выполняются исследования цепей поставок. Таможенные процедуры занимают очень важное место в международной логистике и улучшении цепей поставок. Именно поэтому очень важно обратить внимание на ближайшее будущее процессов, происходящих в Российской таможне.

Ключевые слова: Россия, Российская таможня, цепи поставок

Not so long ago this year Russia Federal Customs Department presented three initiatives, which will enhance the future logistics of international trade, especially for Saint-Petersburg. These three initiatives are:

1) Concept of customs goods clearing and control in the places near to state border of Russian Federation (sometimes it is named "Concept of custom goods clearing transfer to external borders of Russia till year 2020");
2) RF Government Enactment draft about foundation of cross-border points for goods, coming at Russian custom's territory in universal and special containers of 20 feet or larger (in fact it is quoting of container transportation through terrestrial automobile cross-border points);
3) The project of North-West Custom Administration reforming (joining of Baltic Custom to Saint-Petersburg Custom).

Let us consider in more detail the sense, time of realization and some possible aftermaths of these documents implementation.

1) As declared: “The aim of Concept – to make sure economic security of Russian Federation by improvement of Custom’s procedures in conditions of near border regions infrastructure development necessity and diminish in Russian big cities the transport charge, enforced by growing international trade”. The Concept proposes to remove the main part of cargo customs clearing from internal departments to near border ones. In Moscow and Saint-Petersburg territory this must be done already in 2009. For automobile and maritime transport custom’s procedures ought to be transfered close to border till 2014 year, and for railway – till 2020 year.

In this case existing custom’s order wouldn’t be changed for:

- raw materials imported by Russian industry enterprises, having continuous technology cycle of manufacturing,
- goods for important invest projects (e. g. Sochi),
- goods for foreign trade actors, for whom were permitted special, more simple custom’s procedures,
- goods at Free Economic Zone territories and
- goods for individual usage.

The concept realization assumes:

- moving of main accent at the control before goods import and after custom clearing,
- custom clearing of goods, related to risk profiles of risk management system, in near border regions and
- passing goods and transport units through Russian state border in cross-border points with minimum time loses and avoiding the whole custom procedures cycle.

Some possible aftermaths for Saint-Petersburg:

a) Concept realization will lead to reduction of custom procedures places, so will decrease the competitiveness (and as a result a period of pay off) for terminal-warehouse facilities, whose business-models were partly oriented to possible custom clearing at this terminal. It will “help” to make crisis a little deeper.

b) Saint-Petersburg terminal-logistics infrastructure will lose some share of cargo flow.
c) It can be noticed, that aftermaths of this concept are not so significant for Saint-Petersburg. More significant was transfer of Custom points to Ring Road. The transit flow practically wouldn't change due to this Concept.
d) Investors, who already participate in construction of terminals with bond warehouses in central part of Russia will lose there profit.
e) It is unknown now, what would be with export from Russia. In concept is said nothing, that it is only for import. Russian market actors exporting raw materials can get into difficult situation.

2) As was mentioned above, the matter of this enactment is to introduce quoting for container transportation through Russian state border in international automobile cross-border points. The draft of the document is agreeing now with all organizations that it is concerns. Information of its introduction is not announced yet.

Some possible aftermaths for Saint-Petersburg:

a) Saint-Petersburg automobile carriers, possessing great share of North-West Russia foreign trade cargo transit, will lose.
b) Maybe Saint-Petersburg container terminals will win.
c) Saint-Petersburg terminal-logistics complex will lose some part of business, connected with container loading/unloading. Finland and Baltic states simply will change packing.
d) The rate of containerization in Russia (being very low) will occur much slower.
e) The risk of responded measures is rather high, because the sense of this document is in contradiction with existing international conventions.

3) The very core of proposed custom's reform in Saint-Petersburg:

- to join Baltic custom to Saint-Petersburg one,
- to reorganize maritime border custom posts of Baltic custom in transit posts (where only shipment cargo goes through custom procedures), and all other cargo, arriving to Saint-Petersburg by sea, to send by scheme "internal custom

transit" at inland custom posts of Saint-Petersburg custom, which would be re-qualified for such cargo and cargo, transported by automobiles,

- it is proposed to reserve only 12 custom posts of 20 now existing in the structure of Baltic and Saint-Petersburg customs, among it:
    - 7 transit border posts (**Turukhtanny, Kronshtadsky, Lomonosovsky, Timber port, Gavan, Central, Maritime façade** (instead of Vasileostrovsky) and
    - 5 inland posts for cargo custom clearing (**Vyborgsky** (bonded warehouse of "Konkord" company), **Peaskarevsky (**bonded warehouse of "Transsphere International" company), **Yaninsky** (bonded warehouse of "Logistic park Yanino" company with capacity of 10 000 TEU), **Moskovsky** (bonded warehouse of "Logistica Terminal" company with capacity of 15 000 TEU) and **Shusharsky** with railway cargo specialization**.**

- **Priozersky** post is proposing to include in Vyborgsky custom, **Volkhovsky**-in Novgorod custom, **Kirishsky –** in Central energetic custom;
- **North and South-West** posts to combine, include in Vyborgsky custom and locate at bonded warehouse of "Voskhod" company (International Motorway Cross-Border Point "Torfyanovka"), **South** custom post include in Sebezh custom and locate at bonded warehouse of "RUS-SERVICE Terminal" company (International Motorway Cross-Border Point "Burachky"), the staff of **Gatchina** and **Avtomobilny zavod** custom posts direct for strengthening of **Pytalovsky** custom post of Pskov custom at bonded warehouse of "ROSTEK-Pskov" company (International Motorway Cross-Border Point "Ubylinka"), **Krasnoselsky** custom post include in Vyborgsky custom and direct to bonded warehouse of "ROSTEK-Vyborg" company (International Motorway Cross-Border Point "Svetogorsk") and the staff of **Zheleznodorozhny** custom post to use for strengthening Pechorsky custom post of Pskov custom at bonded warehouse of "ROSTEK-Pskov" in city Pechory (International Motorway Cross-Border Points "Kunichna Gora" and "Shumilkino")
- It is assumed that reduction of custom procedure places in Saint-Petersburg arise the necessity of custom procedures in near border regions of Leningrad and Pskov region, where 5 custom-logistics terminals will begin to act in whole format at Russia-Finland, Russia-Latvia and Russia-Estonia borders.

After considering in different organizations and taking into account other proposals the document have to begin realization in the first half of 2010 year. It seems to be the most deleterious initiative by its possible aftermaths for Saint-Petersburg.

a) Anyone wants to believe, that the “dry ports” model would be really implemented.
b) Customs procedures would be transferred very far from Ring Road, but it wouldn’t relief the city from congestions. Moreover, it would be difficulties along Ring Road.
c) There is high degree of probability for Saint-Petersburg port to lose significant share of consolidated and especially RO-RO cargo.
d) Competitiveness of Saint-Petersburg container terminals in the model of “dry ports” wouldn’t raise in compare with terminals of third states, because additional costs will appear.
e) The competitive conditions for operators of transport-logistics market have to become unequal, because “dry ports” have only two owners of three container terminals in Big Port of Saint-Petersburg.

It is obvious, that custom initiatives presented in this article will never bring “sweet life” to business. But, the sooner anyone will be acquainted even with bad news, the better for his position in logistic business.

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Developing Collaboration with the European Union via Combined Railway Systems between Finland and the Russian Federation

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Развитие сотрудничества с Европейским Союзом через комбинированные железнодорожные системы между Финляндией и Российской Федерацией

Юлия Панова

Abstract
The Trans-Siberian Railway (Trans-Sib) is the main transport corridor from West to East on Russian territory covering the distance of 9 244 km. It is an important backbone of the Russian Railway logistics. The unique geopolitical location of the Trans-Siberian Railway is to play the role of international bridge connecting countries from different continents. First and foremost are China, Japan, Republic of Korea and Russia with Finland. But transit potential of the Trans-Siberian Railway is under used currently. The transporting of containers with involving Russian transport system remains incompatible due to bottle necks in the Train-Siberian Railway. Despite the efforts of rail and sea transport companies interested in attracting transit container traffic.

Keywords: Newer transport distributing centers with higher standards, lead time, just in time, transport logistic system, freight forwarder, integrated executive center, stevedoring company

Аннотация
Транссибирская магистраль – основной транспортный коридор с Запада на Восток на территории России, имеющая протяженность более 9240 км. Уникальное геополитическое местонахождение Транссибирской магистрали играет роль международного моста, соединяющего страны нескольких континентов. Основные страны это Китай, Япония, Республика Корея, Россия и Финляндия. Однако возможности Транссибирской магистрали используются недостаточно. В статье рассмотрены «узкие места» Транссибирской магистрали, которые препятствуют развитию транзитных контейнерных перевозок между Финляндией и Российской Федерацией. Также систематизированы причины отсутствия транзита на Транссибе и предложены мероприятия по их устранению.

Ключевые слова: Новые распределительные центры, построенные по современным стандартам, срок доставки, «точно-в-срок», транспортная логистическая система, экспедиторские компании

1. Introduction of Trans-Siberian Railway Activity

The efforts to develop the transport infrastructure of Trans-Sib in our country must harmoniously fit in on one hand with Finland and on the other hand with Asian neighbors. In 2008, approximately 13% of Russian import value was transported through Finland. Eastbound Finnish transit consists mainly of high-value goods from the European Union to

Russia. These high value goods include mainly private cars, electronics, machinery, equipment and other valuables. During the planning perspective volumes of container transit for “General system of developing Joint Stock Company RZD for 2015, 2020” was installed volumes of attracting cargos to Russian railway system between different countries. For example, Finland will share with other countries about 40% container traffic in connection with China, Japan and Republic of Korea.

According to this plan, the total volume of transit cargo in containers through the system of Joint Stock Company RZD in 2015 was expertly defined and accounted to more than 560 thousand containers in which the container transit between Finland and North- East Asia will exceed 45 thousand (Table 1).

Table 1. Forecast of container transit through the system Joint Stock Company RZD in 2015, thousand containers

Country	China		Republic of Korea		Japan	
	Export	Import	Export	Import	Export	Import
Finland	8	22	1	4	0,5	10

According to the Economic and Social Commission for Asia and the Pacific (ESCAP), by 2015 the container traffic from Asia is going to exceed 365 million TEU. The amount of container traffic is measured in TEU’s. One TEU is a “twenty feet equivalent unit” which refers to the standard length of containers.

With a growth of container traffic on Trans-Sib, it is needed to offer high quality transport and logistics solutions to neighboring countries. As a rule, it is about the system multimodal solutions in the modern world. The cargoes shipped by sea to Russia can be delivered further by Trans-Siberian railway. This is a perfect logistics solution which is the best in terms of the price and time of delivery against deep-sea transportation in the international east-west trade. In case of the switching sea route to the Trans-Siberian Railway, the volume of transit

container traffic by rail transport will increase by 4.5 times as compared with volume of 2008 year.

Nearly always the container transit by Trans-Sib starts its trip in port-terminals. Two main container terminals in Russia, Vostochny of the Pacific Ocean and St. Petersburg in the Gulf of Finland, serve 50 percent of all containerized imports, and 90 percent of containerized exports. With the exception of St. Petersburg, which is currently expanding its container capacity, the other Russian container gateways are currently operating below their Soviet-era capacity in spite of that flow of containers steadily rising. The volume container handling in Far Eastern ports has been amplifying. In comparison with year 2006, the total number of handled containers in container terminals in Vladivostok, Nakhodka, Vostochny and Vanino increased by 33%. In addition, the increasing takes place in each port of Primorsky Krai.

In total trade traffic volume of Primosky Krai ports the export quota dominates (more than 80%), import quota increases 15% and transit quota is roughly invisible (1%), which means the loss of transit container traffic for Far Eastern Railway.

It all comes of some negative factors. First, there is take place internal reasons. The infrastructure of the some Russian Pacific ports sometimes cannot work with the shipping companies, which expect perfect and accurate work from the ports. Misbalanced work of these cooperating transports causes wasting time with waiting rolling stock and sea ships, which increases considerable losses in this area. That is why the cooperation between railway and sea transport in supplying economics international links is one of the strenuous task of JSC RZD. Secondly, it connects with negative external factors. Competition with sea transport and energetic activity of Russian neighbors in developing the traffic corridor parallel to Trans-Siberian Railway, which means a precarious situation. Sea route is valid only from Japan because Korea is planning to turn the sea route to the rail transport. These plans have every reason to believe in light of current agreement between the ministers of Democratic People’s Republic of Korea and Republic of Korea about the beginning cooperation in railway traffic since 2008.

By transportation distance the shortest routes for Korean and Japanese transit quote are 2 and 3 (less than 11 thousand km) with outlet to Trans-Siberian Railway through the railway station Zabaikalsk (Figure 4). In this case the Trans-Siberian Railway (TSR) is mostly

involved in transportation, but the transit for Far Eastern Railway can be considered as a practically lost. In my opinion the Russian government needs to heavily invest in the structure, technology of the Far Eastern Railway to increase container activity. The transit goods should pass through Far Eastern Railway instead of the 2 and 3 routes, because it will bring an economic growth to Russian Federation and fast transit goods from countries of North-East Asia to Finland.

The Far Eastern ports are in a good situation but need new technologies in transportation in order not to divest Primorsky Krai of Japanese transit. There is a ferry between Japan and Korea which might be used to transit goods ahead through the Korean Railway system.

The attraction of transit to the Trans-Siberian Railway is becoming an acute problem. Nowadays due to this the Russian railways system is trying to eliminate one of the main bottle necks in the Far East for transit container traffic from North-East Asia to Finland via the Trans-Siberian Railway. Solving of the strategic problem of current importance takes innovations. It can be variously systematized the reasons of absence transit on the Trans-Siberian Railway in order to find out the arrangements for managing them (Figure 1).

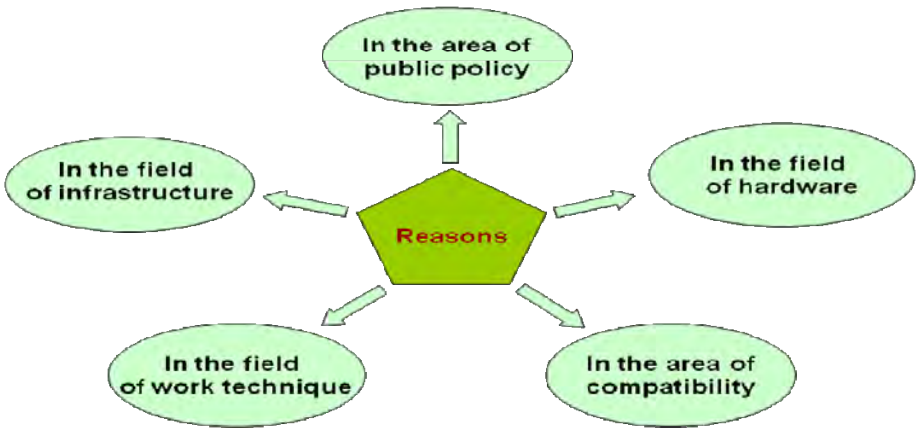

Figure 1. Classification of the reason by influence on the developing of container traffic through Trans-Siberian Railway

2. Solution to the Covering Problem

Can we say what is more important – logistics or infrastructure? I think the answer is clear. If we have infrastructure we will have logistics. The quicker we build the infrastructure, the more we will be able to offer to cargo owners, the more competitive our logistics products will be. That is why I am going to analyze the rectangular component – infrastructure and connected with it work technique and compatibility.

A. To revelation the working balances in the area of improving of compatibility Trans-Siberian Railway it is necessary to review the timing. We have to refuse from classical dividing the Lead Time of container in Russia into two parts, the time in port and transport time. It is considerably better to operate with 3 elements of time:

- Duration of container in the sea port
- Standing idle of flat cars in the departure station under accumulation for the full train
- Duration of traffic by rail transport through the territory of Russia

On average duration of container in the sea port Nakhodka-Vostochnaya amounts 10 days. The average standing idle of flat cars in the departure station under accumulation for the full train is 3 days (45 containers per a day, 140 containers in the train). The transit through the Russian territory on average takes 10-12 days. The total time roughly equals 25 days. As alternative the using sea transport for delivering containers takes 45 days. Why do not use Trans-Siberian Railway for transit containers traffic? Because in logistics there is no phenomena's like quicker, quick and etc. But principle Just in Time (JIT) exists. Thus, choice of the route through Russia imposes freight forwarder to operate on average figures while the sea transport guarantees exact time delivering. It is already negotiated the law "About transit", at which besides the other principles should be installed the exact time of containers on different steps of delivering. I support the enactment "About transit".

B. While the container staying in port the procedures of customs and traffic documents are being process. Then container entrains on flat cars and removals to a railway station where it stands idle on average 3 days. Cannot we accumulate containers on the ground and at the same time fill the traffic documents, pass custom and when the

amount of containers will be enough to make up a train, dispatch the train immediately? No, we cannot in the terms of current work technique. Because port will not take it on its own as it has their function and technologies. It is needed to create newer transport distributing centers with higher standards, which will be a consignee on Russian territory as well. It will allow unshipped in bond cargo removals to this center and make the remaining operations there.

C. Currently became a common situation when ready to dispatch containers not to entrain due to lack of flat cars and at the same time on the nearest stations stay flat cars in waiting the containers. It is because of the forwarding agents make a deal with the owner of transport fleet and flat cars stand idle in waiting on containers and not loading by other containers. On the assumption of creating newer transport distributing centers with higher standards could be organized an integrated executive center which will be responsible for the deals with owners of transport fleet. It will bring elimination of forwarding agents duties and provide the container dispatching at the required time without extra postponement of deficit flat cars.

The projecting ahead transport logistic system of the Primorsky Krai will include transport distributing centers with higher standards located near the railway stations:

1. On the way of Vladivostok transport junction (railway station Nadezgdinskaya)
2. Near Nakhodskinsko-Vostochny transport junction (railway station Hmylovsky)
3. In Khasan transport junction (railway station Malakhino)

Using the complex method for developing the transportation system of Primorsky Krai has a list of advantages:

- The consolidated transport logistic system of Primorsky Krai will be the international trade junction and attract cargos of North-Eastern Asian countries
- The creation of consolidated transport system of Primorsky Krai will initiate the developing of new areas in economics in krai, supply the steady expansion of transport infrastructure, open a new vacancies in work and tremendous increase to the revenue budget
- It will rise the throughput of ports because of releasing expensive territories of ports thanks to removing the extra logistic operations with cargo (bulk

storage, customs clearance, container picking/unpicking, order picking, container load/unload, order palletized) to the cheap places of transport distributing centers with higher standards, which will increase the production of stevedore operation and open the places in ports for building a highly technological complexes

- Optimization the plan of freight train schedule of the Far Eastern Railway which will be achieved due to building the distributing railway station included in transport distributing centers with higher standards
- The improving of mutually beneficial cooperation of ports in transport logistic system
- Decreasing the prime cost for intangible service in ports because of concentration the logistic operation in transport distributing centers with higher standards
- Ecological effect which bases on removing the systems of distribution and warehouses out of the cities territory which reduce the overloading federal and local roads because of banned access trucks into the city.

3. Conclusions

Despite of permanent developing of transport system of Far Eastern Railway of Russia the amount of increasing is still insufficient. That is why between the transport systems of neighboring countries and Primorsky Krai there is a gap. In North-East Asia the transport system of Japan, China, and Korea are able to meet competition. These countries form the structure of international trade, offer the traffic routes and set tariff politics in krai. Implementation of this project will increase the compatibility of Far Eastern Railway which will respectively amplify the transit traffic through this way via Trans-Sib to Finland.

References

Bakkal1, V., Kurennoy, V., Ledyaev, A., Korovyakovsky, E. and Chubukov, A. (2009) ‘About the level of development intermodal transportations in Russia and in the world’, Fifth International Railway Logistics Seminar: *North-European Logistics in the Era of Global EconomicTurmoil*, Research Report 213, May 2009.

Balalaev A.S. (2006) *Bases of logistics*, published by Far Eastern state transportation university, 2006

Chartier, P. and Jamshed, M. (2007) *Transport and Communications Bulletin for Asia and the Pacific*, No.77 "Container Transportation by Railways", 2007

Economical and social commission for Asia and the Pacific (2005) *Development of shipping and ports in north-east Asia*, New York, 2005

Hämäläinen, E. (2007) *Impacts of Price Revisions on the Trans-Siberian Railway Logistics*, Third Research Meeting Held at Kouvola -Value Adding Role of Logistics in Northern Europe, May 2007.

Inkinen, T., Ruutikainen, P. and Tapaninen, U. (2009) *Development and future prospects of Finnish transit to Russia*, Fifth International Railway Logistics Seminar: North-European Logistics in the Era of Global Economic Turmoil, Research Report 213, May 2009. Available at http://kouvola.lut.fi/files/download/Research_Report_213.pdf

Ivanova, O. (2007) *Wagon Manufacturing Industry in Russia: Current Status and Challenges for Tomorrow*, Research Meeting Held at Kouvola -Value Adding Role of Logistics in Northern Europe, May 2007. Available at http://kouvola.lut.fi/files/download/ResearchReport_183.pdf

Ivanova, O., Toikka, T. and Eklund-Karvonen, H. (2008) *Perspective analysis of freight wagon market in Russia, Finland and Estonia*, Railway Wagon Market Analysis and New Multi-Purpose Wagon Solution for Freight Transports - Finnish Manufacturing Perspective., Research Report 194.

Kilpeläinen, J. (2004) *Development of Transit Traffic via Finland in 1997-2003*, Publication 8, NORDI series, Lappeenranta, 2004. Available at http://www.lut.fi/en/NORDI/publications/publicationslist/2004/Pages/publication8.aspx

Tapaninen, U., Inkinen, T. and Ruutikainen, P. (2007) *Business Expectations and Bottlenecks of Finnish-Russian Transport*, Third Research Meeting Held at Kouvola -Value Adding Role of Logistics in Northern Europe, May 2007.

The conception of invest project of Yuzhny Primorsky terminal (2007) Vladivostok.

The program of actions in developing railway container traffic via the Trans-Siberian Railway on the period until 2015 (2009), Moscow.

The project of decision by Science Technical Convention JSC RZD in task about necessary rising of efficiency railway container traffic including transit container traffic (2009), April 2009.

Waters, D. (2003) *Logistics: an Introduction to Supply Chain Management*, first published 2003 by Palgrave Macmillan, 175 Fifth Avenue, New York.

Implementation of Quality Management System in JSC RZD: QMS Actually Applied by Railways of the Russian Federation

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Внедрение системы менеджмента качества в ОАО «Российские железные дороги». СМК на железных дорогах Российской Федерации в настоящее время.

Георгий Алиев

Abstract
The main principles of quality management system (QMS) are discussed in this article. Stages, purposes and results of implementation of QMS in JSC RZD on Oktober and Northern railways are described. The conclusion on expediency of creation of corporate quality management system (CQMS) is drawn.

Keywords: Quality management system, railways, quality of services, ISO 9001:2000, GOST P ISO 9001:2001, client service.

Аннотация
В статье рассмотрены основные принципы системы менеджмента качества (СМК). Описаны этапы, цели и результаты внедрения СМК в ОАО «РЖД» на Октябрьской и Северной железных дорогах. Сделан вывод о целесообразности создания корпоративной системы менеджмента качества (КСМК).

Ключевые слова: Система менеджмента качества, железные дороги, качество услуг, ISO 9001:2000, ГОСТ Р ИСО 9001:2001, обслуживание клиентов.

1. Introduction

At the background of Russia's entry into the World Trade Organization and access to the international market of transport services, including integration into Euro-Asian transport system, the image of the company JSC RZD takes great importance in possibility to provide competitive and safe services in cargo transportation. In the program of strategic development of JSC RZD considerable milestones are set, which achievement requires not only investments and mobilization of resources, but also implementation of the modern management system based on quality criteria.

The considerable contribution to research of theory and practice in the field of quality management system was made by Russian and foreign scientists: V.G.Versan, A.V.Glichev, J. Goldsmith, E.A.Gorbashko, L.Y.Donchak, K.Isikava, M.G.Samuelson, G.Taguti, F.Taylor,

A.Fayol, R.D.Shonbenger, L.Y.Shuhgalter et al. There are works of scientists, experts in the field of:

- economy and management in railway transportation: A.P.Abramov, V.G.Galaburda, A.V.Davidov, A.F.Ivanenko, M.N.Larina, N.P.Tereshina, M.F.Trihunkov et al.;
- quality management: A.V.Glichev, E.Deming, J. Juran, K.Isikava, V.A.Lapidus, V.V. Okrepilov, A.V.Feigenbaum, J. Harrington et al., including in railway transportation: I.P.Isaev, V.T.Strelnikov, A.D.Shishkov et al.;
- quality economy: Y.P. Adler, K.M.Rakhlin, L.E.Skripko, J. Schotmiller and others, including in railway transportation: V.G.Voronin, T.A.Bulokhova et al.

2. The Goals of the Company JSC RZD

Proceeding from the goals of the company, such as:

- increase in scope of business, integration into Euro-Asian transport system – impossible without high-quality marketing and provision of quality service in transportation complying with international standards;
- increase of production and economic efficiency – impossible without improvement of quality and efficiency of management, development of human resources, introduction of modern standards and corporate management principles;
- improvement of quality of work and operation safety – impossible without use of new types of rolling stock with increased reserve maintenance periods, use of units and components with extended service life, without improvement of procurement, introduction of new technical processes in line companies based on quality management system, transition to the processor principle at all levels of management of the JSC RZD;
- increase of financial stability of the company – impossible without high-quality management of finances, improvement of budgeting system, reduction and liquidation of unprofitable manufactures, improvement of credit rating of the company.

It is possible to conclude that the key directions are creation of management system and maintenance of operation safety of trains, as well as creation of corporate quality control system. And the keyword for successful realization of the above-named goals is “quality” – quality of business, quality of services and quality of technical processes. But for today in the

official reporting of JSC RZD at all levels of management, from structural division to JSC RZD branch and department, there are no systematized criteria and indicators reflecting quality of service of consignors, quality of performance of internal technical and business processes of the company. Other weaknesses are:

- high level of deterioration of basic production assets (and maintenance capacity of rolling stock several times exceeds the indicator of western equivalents);
- low-quality factory and repair base;
- low investment appeal, lack of investments, especially last decade;
- insufficient orientation to the market and needs of consumers;
- insufficient “transparency” of corporation;
- high-cost technologies in comparison with western equivalents;
- tendency of decrease in safety of transportations.

Finally, if previous management system on the railway was aimed at provision of reliability, safety and security in course of transportation, now with unconditional performance of the specified requirements, consignors, for example, want to get such transport services, which would provide delivery of cargoes “door-to-door” and “just-in-time”. Service maintenance is also very important for consumers.

3. QMS Principles

There are eight principles of quality management:

- Consumer orientation; JSC RZD depends on its customers and for this reason should understand their current and future needs, to meet their requirements and aim at exceeding their expectations.
- Leadership of the director; The management personnel provides unity of railways purpose and direction of activity. It should create and maintain the internal environment, in which employees could be completely involved in solution of company’s problems.
- Involvement of employees; Employees of JSC RZD divisions of all levels make the company basis, and their full involving gives the company the chance to use their abilities to the benefit.

- Process approach; The desirable result is reached more effectively when activity (transportations, etc.) and appropriate resources of the company are managed as a process.
- The system approach to management; Detection, understanding and management of interconnected processes as a system promote productivity and efficiency of the company in achievement of its purposes.
- Constant improvement; Constant improvement of activity of the company as a whole should be considered as its eternal purpose.
- Decision-making based on facts; Effective decisions are based on the analysis of data and information.
- Mutually advantageous relations with suppliers; railways and its suppliers are interdependent and mutual benefit relations increase ability of both parties to create values.

4. Corporate Quality Management System (CQMS) in JSC RZD

The analysis of QMS principles allows drawing a conclusion, that their realization is a difficult complex project aimed at improvement of production processes, activity of directors and personnel, interaction of the company with customers and partners for improvement of quality of production and provided services. The QMS provides creation in management personnel and at enterprises of JSC RZD of few structures (departments, sectors, councils) for management and coordination of activity in the field of quality, as well as service of internal audit in which employees of these enterprises are involved. The main subjects of management in QMS are interested directors of all levels and staff which activity is connected with maintenance of quality of products and services. In well working QMS issues of quality are matter of vital importance for all staff.

According to ISO 9001:2000, the QMS is a part of general management system and purposes and policy in the field of quality should comply with organization purposes. On the other hand, the QMS is the universal tool of maintenance of quality of any administrative solutions, including formation of the organization purposes. Therefore, in JSC RZD it is necessary to create quality management system not only at the line enterprises but to build the corporate system of quality management covering all levels of management from top to down, from

central staff of JSC RZD to its structural divisions, affiliated and subordinate companies. Now there is a concept which contains basic principles of methodology of development and introduction of corporate quality management system in JSC RZD on the basis of international standards of ISO 9000 series.

The project approach to creation of CQMS provides determination of results (objectives) which can be achieved by introduction of this system as well as modeling of variants for achievement of these results and selection of best of them. Achievement of result by implementation of CQMS is based on stabilization and improvement of processes, development of their interaction and improvement of resource maintenance (see Table 1).

Table 1. Generalized results and economic effect of CQMS implementation

Improved processes	**Economic effect components**	**Generalized economic effect**
1. Improvement of quality and competitiveness of transport services		
Improvement of interaction of processes of transportation and maintaining processes	Increase of value of services and work. Increase in share of the market of transport services (acquisition of additional customers)	Increase in incomes and profitability
2. Reduction of nonproductive activities and increase level of implementation practice		
Improved organization of interaction with customers	Reduction of nonproductive expenses. Growing labour productivity. Saving of material and human resources	Cost price decrease
3 Reductions of time and improvement of quality of management decision making		
Regulation of staff activity. Improvement of administrative and production processes	Improvement of preventive measures for control of faulty work. Reduction of time for elimination of noncompliances	Reduction of losses and saving of working costs
4. Increase of transparency of activity of the company and its investment appeal		
Regulation of management processes. Improvement of system of training of directors	Expansion of activity in international markets of transport services. Attraction of external sources of financing	Increase of income and profitability

Owing to structural complexity of management of JSC RZD, some strategic variants of CQMS creation can be defined (see Table 2); each of those provides achievement of various results. The comparative analysis of the shown variants of development and implementation of CQMS allows concluding that the 4^{th} variant, which accumulates advantages of all specified strategies and lays emphasis on improvement of the general system of management of the company, is preferable.

The main principle, on which functioning of the created quality management system is based, is the process approach. In the company the mechanism of achievement of high quality of technical processes on the basis of formation of system of consumers and manufacturers of internal services that will provide creation of system of working relations management preventing from deviations in realization of intermediate operations resulting in poor-quality service of customers. Creation of effective quality management system in the company will demand the maximum involvement of all employees into process of creation and functioning of the system as well as increase in share of employees with leadership abilities, capable to work most dynamically, creatively, to create and organize work of teams for implementation of specific projects.

Development of leadership system will become one of directions of long-term development of the company staff and even at the initial stage will provide involvement and participation in construction of new system of work of both top management and company management at all management levels. Each employee of JSC RZD within the limits of official duties should have possibilities, conditions, methods, which is the main thing, and incentives for creation of quality products and services. For this purpose the company will build the appropriate system of staff motivation in which criteria of estimation of quality of performed work, responsibility and appropriate incentives for achievement of required degree of quality will be well defined. Implementation of QMS in domestic enterprises is carried out, as a rule, by one of first three variants (see Table 2) depending on complexity of the enterprise and presence of subordinated branches. From among the domestic enterprises which obtained certificate of compliance of QMS to requirements of ISO 9001:2000, according to experts, only 20 % have achieved real improvements. The main cause of low efficiency of certified QMSs at the enterprises is insufficient coordination of these systems with the general management as scope of QMS does not cover processes of preparation and making of management decisions. Experience of “Railways of Germany” confirms necessity of adjustment of all system of corporate management during implementation of QMS that complies with the fourth variant. Such approach allowed this company in a period from 1993 to 2000 to increase 15 % of cargo turnover and passenger turnover to raise labour productivity by 2.5 times. At the Russian enterprises, which had successfully implemented QMS, economic indicators improved on the average level by 15–20 %.

Table 2 Variants of creation of CQMS in JSC RZD and expert judgement of their effectiveness.

Variant No.	Variant of implementation of CQMS	Achieved results
1	CQMS is implemented in line enterprises	1) Regulation of internal activity of the enterprises
2	CQMS is implemented in management structures of the company	2) Adjustment of procurement processes 3) Formation of partner relations on all chain of management 4) Regulation and reduction of control checks, audits, commission surveys
3	CQMS is implemented in management structures of the company (on all chain of management) and in line enterprises	5) Improvement of quality of target products and services, attraction of new customers 6) Reduction of non-productive costs by "putting everything in order" 7) Increase of labour productivity by regulation and formation of constantly operating system of staff motivation
4	CQMS is implemented by the third variant with adjustment of corporate management system of JSC RZD on the basis of ISO 9000 principles and ISO 9004 recommendations	8) Increase in output of investment projects by reasonable target-setting and planning of activity for achievement of goals 9) Labour productivity increase by decentralization of management by delegation of powers to branches and structural divisions of the company 10) Expansion of scope and increase of efficiency of transport business by improvement of marketing and reasonable target-setting. 11) Reduction of administrative staff by adjustment of activity and elimination of backup links 12) Maintenance of improvement of all indicators of activity

5. Implementation of CQMS by the Example of the Northern Railway

Implementation of the corporate integrated quality management system (CIQMS) of JSC RZD is described by the example of the Northern railway. In the course of development, analysis and implementation of the QMS on the railway application of models, methods and instruments of management are planned, such as:

- integrated system of evaluation of indicators of activity during project implementation
- innovative process of improvement with attraction of soilid investments
- continuous process of improvement in which all project areas - top managers, medium-level managers and workers are involved
- policy management, including intentions, objectives and priority approaches should focus attention on formation of unified objectives of divisions by procedure of their coordination at different levels
- strategy of detection and elimination of losses in resources

Practicing of methodology will be applied, firstly, in railway equipment (test area), including all elements of production cycle – maintenance, repair of rolling stock, equipment, infrastructure etc. Creation of quality management system of railway complex is a basis of quality management system of the Northern railway, which by growth and expansion will embrace other kinds of activity and railway divisions. The program of the project implementation includes:

1. Organization stage

- Order on development and implementation of QMS;
- Formation of Coordination council for quality;
- Training of directors and experts of QMS, including internal auditors;
- Analysis of management current system for compliance with requirements of ISO 9001:2000.

2. Development of organizational structure and production basis

- Placing of orders for development of projects;

- Development of production basis;
- Formation of human resources taking into account infrastructure of railway complex;
- Formation of quality management structure.

3. Formation of modules of processes and documentation of QMS

- Development of quality instructions, definition and description of processes;
- Development of system of interaction with suppliers according to requirements of ISO 9001:2000;
- Development of system of internal audits, motivation and involving of staff;
- Development of criteria of estimation of process efficiency.

4. Evaluation of conformity QMS to ISO 9001:2000 requirements and working out of the program of further development

5. Notification of certification agency about readiness of QMS to certification

6. Implementation of QMS on the Oktober Railway

In world practice, there are few examples of implementation of QMS in the companies of such scale and complexity as JSC RZD. According to policy of achievement of strategic goals taken by the management of JSC RZD Scientific Research Institute of Quality Management in Railway Transport together with consulting firm “Conflax” (Saint Petersburg) in 2004 began implementation of international standards ISO series 9000 in several line enterprises of the Oktober railway. Four line enterprises of the Oktober railway got the status of pilot enterprises: Locomotive depot TCh-8, Wagon depot VChD-8, Motor car depot TCh-10 and the Moscow station.

According to the contract on creation of QMS at the pilot enterprises of the Oktober railway, performance of work in full was planned for one or two years. It should be noted that it is the shortest term for implementation of such a difficult organizational administrative innovative project what introduction of ISO series 9000 standards actually is. As the world experience shows, this work requires more time, especially for the enterprises beginning creation of

quality management system according to requirements of these standards, so to say “from point zero”. Complexity of work was aggravated with two more circumstances:

1. The decision of introduction of standards was initiated by management not of the line enterprises, but of the Oktober railway. Such approach was for pilot enterprises of not voluntary but compulsory nature, which is contrary to main principles and market ideology of ISO standards.
2. Preparation of QMS to certification was included in the plan of work. It resulted in the fact that certification of quality management system was wrongly considered as the final goal of work. Being the instrument of objective estimation of compliance of QMS of an enterprise with requirements of ISO 9001:2000, in itself certification cannot be the basic purpose of introduction of ISO standards. Improvement of quality of their services and creation of preconditions for improvement of the general control system of JSC RZD should become such purpose for the line enterprises.

According to the approved plan of work in 2004 preliminary check of management systems operating at the pilot enterprises for compliance with ISO 9001:2000 was conducted. Results of this check showed that control systems of all pilot enterprises do not meet many of significant requirements of ISO 9001:2000. In particular, all enterprises have no policy and objectives in the field of quality, system processes are not identified, structure and composition of documents of quality management system are not defined, there is no quality service or required documentary procedures, internal auditors of quality management system are not trained, etc. The first action carried out at the pilot enterprises by experts of Scientific Research Institute of Quality Management in Railway Transport according to approved schedules of work was training of top management. The carried out training of management and staff informing allowed starting identification of QMS processes and construction of process model at the enterprises.

In March 2005, at all pilot enterprises the structure of QMS internal documents was defined and schedule diagrams of their development were established. The centralized training of experts of the pilot enterprises on the course “Internal audit of QMS” was organized. Trained experts obtained certificates confirming their right to perform functions of internal auditors. Appropriate programs were developed for carrying out of internal audits at all enterprises. Carrying out of pre-certification audit at the pilot enterprises became a significant step to

development of auditor activity. For carrying out of pre-certification audit at each enterprise the detailed plan of audit was prepared in which as criteria of audit requirements ISO 9001 were used, and as objects – top management and nearly all services of the enterprise. During audit all noncompliances were detected and recorded. According to the report showing results of audit, general estimation of condition of quality management system and recommendation for its improvement were made.

During analysis of efficiency of development and implementation of QMS at the pilot enterprises in December 2005, it was noted that development of QMS is conducted with high degree of intensity and actual results were achieved for rather short period of development. The performed analysis showed that experiment of implementation of QMS at the pilot enterprises had proved its value. Creation of QMS at the pilot enterprises proved basic possibility of use at the enterprises of JSC RZD of ISO international standards. Carrying out of this work allowed to detect problems typical of the majority of the line enterprises, in terms of requirements of ISO standards which soultion is beyond possibilities of these enterprises. It should be noted that implementation of quality management systems meeting the requirements of international standards ISO series 9000 is one of key conditions of the Concept of improvement of management system developed now in JSC RZD.

In April 2009, it three years from the date the Oktober railway began implementation of quality management system (QMS). The preparatory period, which took 14 months, came to the end with certification of six base locomotive depots in July 2007. On the railway the quality policy according to mission of JSC RZD and strategy of development of railway transport at are worked out, the objectives of QMS in 2007 and in 2008 in segment of repair, maintenance and operation of locomotives were defined and reached. Preparation for implementation on the railway of the integrated management system including standards of labour safety, industrial and ecological safety is now conducted.

The work showed that at the first stage the quality management system should be implemented in the most significant processes of JSC RZD where economic losses are maximum, i.e. not only in railway equipment (test area) but also in repairs, procurement, management of finance, projects and programs, quality of services in freight traffic, quality of performance of budgets of all levels as well as in transportation process in management of classification yards, freight and port terminals.

7. Results of Implementation of QMS in JSC RZD, Opportunities

In case of implementation of quality management system in large corporations there is always a risk that great work of modernization of business processes of the company, improvement of staff motivation for quality performance of technical processes, introduction of modern principles of management in the companies, turns into competition in obtaining of quality certificates, that by no means brings the company to the strategic objective - to become the highly effective and competitive company. As the world experience shows, quality management systems allow with higher efficiency to provide achievement of strategic objectives and promote business development. Besides, in relation to interested parties the quality management system of JSC RZD is designed to provide new quality not only of services in transportation, but also new quality of the company. In relation to the company and the state it means: increase of transport coverage of the country, meeting of growing demand in transportation of economy and the company; increase of macroeconomic efficiency of railway transportation, decrease in transport load of economy, stimulation of economic growth; acceleration of social development by growth of mobility of the population, strengthening of social and economic unity of the country. For consumers - increase of transport availability and quality of railway transportation; possibility of non-discriminatory access to railway infrastructure and conducting of own business in the field of rail transportation and associated work and services; transparency of formation and predictability of railway tariffs, their relative decrease for the end consumer. For JSC RZD and its employees – operation efficiency increase; increase of investment appeal and, on the basis of it, modernization of material basis, decrease in capital consumption; increase of real wages of employees, social status and prestige of work in the company.

Quality management systems can also help JSC RZD to improve customer satisfaction. Customers need transportation which characteristics would meet their requirements and expectations. That is, it should be safe, secure and cargo should be delivered in time. In any case the transportation acceptability is finally defined by the customer. As requirements and expectations of customers’ change JSC RZD is also under pressure caused by competition and technical progress, it should constantly improve quality of products and processes.

References

Eurasia Vesti, (2007) Efficient quality management systems of JSC RZD: dreams or reality?, http://www.eav.ru/

Kraskovskiy A.E. and Matsuta V. D. (2006) 'On experience of development and implementation of quality management systems at the line enterprises of the Oktober railway', *Transport of the Russian Federation*, No. 6, http://niiuk-pgups.ru/

Kraskovskiy A.E. (2006) 'On methods of improvement of management system of JSC RZD', *Transport of the Russian Federation*, No. 2, http://niiuk-pgups.ru/

Kraskovskiy A.E. (2007) 'Concept of formation of corporate quality management system in JSC RZD', *Science and transport*, http://www.rostransport.com/

Krylova K. (2008) 'Development of holding structures in Russia. Stage of construction of quality management system', Quality Forum, http://qualityforum.ru/

Mikhailov M.Y. (2008) 'Quality management system as an integral part of planning mechanism at the industrial enterprise', *Vestnik MGTU*, Vol. 11, No. 2, pp. 294-296, http://vestnik.mstu.edu.ru/

Mokhonko V., System quality management - key mission of development of JSC RZD, http://www.poria.ru/

Management of October Railway (2006) Branch of JSC RZD sums up the 1st stage of implementation of Quality Management System, http://www.advis.ru/

Management of Oktober railway Organization and conduct of internal system audits of the corporate integrated quality management system of the Northern railway, http://szd.rzd.ru/

Quality management system of Northern railway, http://szd.rzd.ru/

Stepov V.V. (2009) Within the limits of the integrated system, http://www.zeldortrans-jornal.ru/

Strategic directions of scientific and technical development of JSC RZD for the period from 2015, http://doc.rzd.ru/

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Comparative Characteristic of Systems of High-Speed Passenger Land Transport

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Сравнительная характеристика систем высокоскоростного наземного пассажирского транспорта

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Abstract
In this paper, as an alternative system a wheel-rail a magnetic suspension is considered, because in spite at the great number of directions of scientific searches of new types of high-speed transport, only the system wheel-rail can be used in the next 10-20 years for commercial purposes for carrying passengers with speeds over 250 km/h.

Keywords: system a «wheel-rail», magnetic suspension, «magnetic levitation», abbreviated Maglev, Russia, Finland

Аннотация
В настоящей статье в качестве альтернативы системе колесо-рельс рассматривается магнитный подвес, так как при множестве направлений научных поисков новых видов высокоскоростного транспорта лишь эта система может быть в ближайшие десятилетия использована в коммерческих целях для перевозки пассажиров со скоростями свыше 250 км/ч.

Ключевые слова: система «колесо-рельс», магнитный подвес, «магнитная левитация», Маглев, Россия, Финляндия

1. Introduction

Over the semi-centennial history of high-speed passenger land transport railways on the basis of the traditional system a wheel-rail demonstrated many competitive advantages over other types of passenger communications. Among these advantages are speed of delivery of passenger, comfort, safety, environmental friendliness and economic efficiency. At distance of a journey 300-800 km and durations to three hours, high-speed railway magistrals (HSM) – where they are built, almost completely displace out of the logistic chain of passenger transportations air and road transport.

However, these results of HSM and systems a wheel-rail does not stop the process of search of alternative. Science and technological progress do not stand still. Perhaps, for high-speed

transport at the beginning of the third millennium may be offered another framework, yet more rapid, economical, safe? Such a question is asked first of all in countries which have not yet established its network of HSM, and who are at the stage of choice of main technical parameters and the initial stages of design, Russia and Finland among them. At meetings in JSC «RZD» and the Ministry of Transport of Russia in recent years, the participants periodically are returning to the question of a basic platform for high-speed passenger network. In his speech at the scientific-technical council in April 2009, the President of JSC «RZD» – V. I. Yakunin called the HRM «new type of transport, not previously existing in Russia». At the same time the system a «wheel-rail», which is the basis for building networks of HSM, is used to transport almost two centuries. Can a fundamentally new mode of transport based on the old basis?

In this paper, as an alternative system a wheel-rail a magnetic suspension is considered, because in spite of the great number of directions of scientific searches of new types of high-speed transport, only the system wheel-rail can be used in the next 10-20 years for commercial purposes for carrying passengers with speeds over 250 km/h.

2. Magnetic Suspension and System of “Wheel-Rail”

Under term «magnetic suspension» (or «magnetic levitation», abbreviated Maglev) presently understand two systems, using the different technical methods of creation of levitation. In Germany, an electromagnetic suspension system based on the principle of attraction located on the carriage of electromagnets to ferromagnetic rails was developed. Corps of the crew covers the waypoint structure so that the electromagnets are under the rail and on each side of it (the last for the transverse stabilization of the crew). Thus, the electromagnetic suspension is carried out fact under the track structure. For the operation of this fundamentally unsustainable system powerful and high-speed automatic current regulator of windings of electromagnets based on the latest computers are designed. System of the electromagnetic suspension requires the highest precision construction and erection works (a tolerance of 1 mm), because an air-gap at hanging makes only 10-20 mm.

In Japan, the system of electro-dynamic suspension using force, repelling train from the path and raising it was adopted. The advantages of this class of brackets are the stability of the spatial confinement of the crew and less stringent requirements for the design track structure,

because an air-gap at hanging is 150-200 mm. However, the system requires more powerful superconducting magnets, and wheels (commonly used pneumatic) for motion of train on low speeds, when the electromagnetic forces are not big enough for hanging. Driving and braking force in both systems of the magnetic suspension, implemented by linear motors, is the stator which is mounted in the ground trestle. For comparison with the system a wheel-rail electromagnetic and electro-dynamic suspension are discussed below as variety of construction of magnetic suspension. For convenience of comparison information is given in a brief, concentrated table form.

Table 1. Comparative characteristics of high-speed passenger land routes on the basis of the systems wheel-rail and magnetic suspension.

Wheel-rail	**Magnetic suspension**
Stages of development of the systems in the world and the realized projects	
The special speed railway rolling stock was developed yet on steam traction from the end of a 19 age. Absolute record of train on steam traction - 202 km/h (England, 1938y.). Since the early 30-ies of the twentieth century in many countries speed trains were developed on thermal, gas-turbine and electric traction. The record speed by the beginning of the 90 years has exceeded 500 km / h, in the present - 570 km / h (France). In 1964 year commissioned the first specialized high-speed passenger magistral (HSM) Tokyo - Osaka length of 515 km. Successful experience of its safe and effective exploitation served a shove for creation of analogical networks of HSM in many countries of the world. In the middle of 2008 general operational length of HSM in the world exceeded 10 thousands of km [4]. Polygon of exploitation of high-speed trains in view of the reconstructed high-speed lines - more 25 thousands km.	1922 – the first ideas and the beginning of studies of the magnetic suspension in Germany. [1], [5]. 1934 – basic patent for a magnetic suspension was obtained. 1969 – in Munich, the first prototype model trains in the magnetic suspension was created. 1971-1977 – in Munich, the first test ring 2,4 km was built , speed of the train had reached 258 km / h. 1977 – first 7 km test polygon in Japan was built, on which during 20 years crews on the magnetic suspension of four generations were tested. In 1979 at the polygon reached the speed of 517 km / h. To date, the polygon is finished building a to 18,4 km. 1988 – test polygon in length 31,5 km and costing more than $ 1 billion built in Emsland, Germany.[2], [5], [7]. 1994 – the government of Germany has approved idea of building 290 km of line Berlin-Hamburg by a cost 10 milliards of brands and planning began (1996). Work suspended for financial reasons. 2001 – beginning of pre-work to establish lines of Munich-Airport, Munich - Central Station (37.4 km) 2001 – beginning of pre-work on the line Tokyo - Osaka in connection with the exhaustion of the capacity of the railway HSM (in peak-hours Skipping to 11 pairs of trains per hour).

	2002 - Start of operation of the first commercial line of Shanghai - Pudong Airport, 30 km long and cost 1.2 billion dollars. The road is built on the basis of Germanic system «Transrapid».
Research and development in the USSR and Russia in recent decades	
1988 – The program «High-speed environmentally clean transport», in which the task of establishing in the USSR high-speed rail transport for passenger traffic at speeds up to 350 km / h was adopted. 1991 - research project HSM Center - South was approved and the technical feasibility of building the main section of this highway Leningrad - Moscow has been developed. 1992-2001 - the creation of RAO «HSM» and CDB «Rubin» high-speed train «Sokol» with design speed of 250 km / h. The pre-production model of train developed the maximum speed 236 km/h. [2]. 2008-2009 – the certification tests of high-speed train «Peregrine», built by «Simens». In the tests 2 May 2009 the record speed of 281 km / h was reached.	1970-1980 y.y. - Theoretical studies of the role of the magnetic field of linear asynchronous traction motors in the efforts of levitation conducted in Leningrad, Kiev, Dnipropetrovsk, Donetsk, Novocherkassk, [5]. 1976-1993 y.y. – VNIIPItransprogress (after reorganization INC «TEMP») in Ramenskoye, Moscow region were working to build and test on the polygon of domestic transportation system for magnetic suspension [10]. The model of experimental crew was created for the suburban Moscow-Sheremetyevo [2]. The works were stopped due to the termination of funding.
Passenger traffic	
Over the period 1964 – 2000 y.y. by SHM carried 6 billion passengers. In 2006, having 0,9% of the total length of railways of the world, HSM had	On the German test polygon in Emslande for 20 years more than 0,5 million passengers was transported. In the line of Shanghai - Pudong for the first 3 years 8 million passengers was transported.

performed 7,3% of the total passenger traffic.	
Safety of exploitation	
Exploitation of the HSM showed their 100% security, i.e. on these highways for 43 years one passenger was not perished (excluding cases of terrorism).	In the history of the development of magnetic suspension - the collapse of the pilot trains in Germany (September 2006, died 23 people) and a fire on a train in China (August 2006, there were no casualties). The reasons in both cases recognized as «human factor», weaknesses in systems management and automation of security.
Speeds	
Record values – 574,8 km/h (France). Realized commercial speed – to 300-350 km/h. This speed limit is now recognized as the best, taking into account economic, environmental and social causes.	Record values – 581 km/h (Germany). Realized commercial speed – to 430 km/h. [1], [2]. The project speed for a commercial line of Munich center - airport - up to 350 km / h.
Comparative parameters of trails	
Radiuses of curves are a 5500…7000 m (at speed to 300 km/h). Maximal slopes of longitudinal profile – 30…40‰. R of vertical curves are 25...40 km [2], [4], [6].	Relatively smaller radius of curves due to the possibility of more cross-slope (at a maximum speed of 300 km / h the estimated radius of the curve make 2800 ... 3300 m). Maximal slopes of longitudinal profile can theoretically reach 100 ‰. The required Territory for the construction of overpasses and tunnels is equivalent to the territory for laying the railway line and a 30 ... 50% less than needed for the construction of the highway [2], [7].

Noise	
The width of a protective zone for residential for motion of trains at speeds of 300 km / h should be 250 ... 300 m, and when the trains moves at night – 500 ... 1000 m. In areas of large towns and the entrances to the city for reduce the country traversed by railway, cut, including the overlap, and tunnels can be used.	With the same level of velocity noise level is much lower than that sistem wheel-rail does not exceed standards for residential development and does not require a protective zone to the speed of 250 km / h. At speeds over 250 km / h the aerodynamic noise would require the use of protective equipment [8].
Electromagnetic influence (magnetic induction)	
The special protective measures are not required.	Inside the car protective screens provide the level of the magnetic field of 100 mT (the natural background of the Earth is 50 mT and the background of a color TV is 500 mT). Outside of the construction of railway international standards are provided [8].
Cost of building and exploitation	
Construction 1 km HSM costing 12-30 million euros. [4]. Average cost of the current contents of 1 km of HSM is 70 thousand euros per year, cost of maintaining one high-speed train is 1 million euros per year with mileage of 500 thousand kilometers per year.	Construction 1 km line of Shanghai - Pudong Airport worth $ 40 million. In new projects the Chinese engineers plan to reduce the cost of a 1 km in two times (all ground infrastructure the Chinese are building themselves, buying technology, equipment and rolling stock in Germany. Cost of 1 km of track in project Munich Center – the airport is 49,5 million euros [8]. In the mountainous and cramped conditions at the expense of more flexible parameters of the magnetic suspension tracks the difference in capital investment with a system of wheel-rail is significantly reduced. In addition, should assess the value of «know-how», because Russia does not have its own technologies of

	construction of lines and rolling stock on the magnetic suspension. Estimated operating costs associated with the movement of trains in Munich will make about 0,2 USD per 1 passenger-kilometers. [8]. Cost of content the permanent device is relatively small because of practical absence of wear. The main component of the costs - energy, therefore at the increase of distance of journey the cost of passenger-km goes down insignificantly.
Prospects of development	
On the prognoses of International Union of railways to 2025 in the world will be exploited 36 tkm HSM [4]. Building of pilot VSM is conducted in PEOPLES Republic of China, Turkey, project works on new highways are conducted in the USA, Brazil, Argentina, India, Russia and many other countries.	In Japan, the double-tracked polygon is completed to 42,8 km. In Munich, is designing and seeking funding for the project Munich Center – Airport 37,4 km in length and cost 1.85 billion euros. In China, by the construction line of Shanghai – Changzhou length of 170 km and $ 4 billion, and Shanghai – Beijing length of 1200 km $ 22 billion is planned.

3. Conclusions

Comparative advantages and disadvantages of high-speed passenger transport on the magnetic suspension and on the basis of wheel-rail make it possible to identify the most appropriate scope of each of the systems. Magnetic suspension softens the limits of design in the plane and profile, provide greater operating speed, high level of comfort for passengers due to the smoothness of motion, a significant reduction in traffic noise of the train. The most significant deficiencies of transportation systems on magnetic suspension, besides the obvious is currently higher cost of construction and operation, should include incompatibility with the existing network of conventional railways, as well as the lack of significant experience in their construction and the safe efficient operation, not only in Russia but also in world.

Therefore sufficiently obvious, that first in Russia high-speed passenger Railway Saint Petersburg – Moscow must be created on traditional basis wheel-rail, that will allow in future with the least expenses of facilities and time to build strategically necessary for our country a high-speed transport network. Transport in magnetic suspension is most advisable to use as a supplement to the rail system wheel-rail. It may be short corridors with greater stability of passenger traffic, allow the installation of a sufficiently high cost of travel (up to 1-1.5 Euros per 1 km). Such cases should include the line to transport passengers to the airports, especially in the exhaustion of the capacity of other modes of transport (road and rail) as well as having recreational and tourism value, particularly in confined and mountainous terrain (for example, sea and ski resorts).

In Russia, under the criteria come first line center Moscow – Sheremetyevo Airport, Domodedovo Airport, St. Petersburg Center – Pulkovo Airport, Ekaterinburg Center – Airport Koltsovo; Center of Sochi – Adler Airport-Krasnaya Polyana. The latest project at the Olympic Games will also enhance the international prestige of Russia and its transport sector. In Finland, the line of Helsinki Center – Vantaa airport can become a pilot transport project on the basis of magnetic suspension.

It is time to renew the research, including fundamental, in the field of transport projects on the magnetic suspension. The practical use of superconductivity, the creation of new nanotechnology-based materials with desired properties can soon qualitatively to reduce energy consumption and cost of equipment in maglev systems. Then, in the history of this transport of the future will begin a new phase.

References

Cherevaty, A.V. (2006) Transport Systems for Magnetic Suspension (Транспортные системы на магнитном подвесе), Available at http://mag-lev.narod.ru.

Gorin, N.N. (1993) ‘The Results of Development and Prospects of the Magnetic Transport’ (Результаты разработок и перспективы магнитного транспорта), Herald VNIIZhT, No. 4, pp. 42-44.

‘In 10 Minutes – Every 10 Minutes. The hight-speed magnetic train between Munich Central Station and Munich Airport’, Die Magnetbahn GmbH, 2007.

Kantor, I.I. (2004) *High Speed Railways: Track, Rolling Stock, the Magnetix Suspension* (Высокоскоростные железнодорожные магистрали: трасса, подвижной состав, магнитный подвес), M.: Route.

Kim, K.K. (2002) *The Use of Magnetic Suspension in the Transport and Electromachine* (Использование магнитного подвеса на транспорте и в электромашиностроении), St. Petersburg, PGUPS.

Kiselev, I.P. (2008) ’Results and Prospects of Development of High-Speed Highways’ (Итоги и перспективы развития высокоскоростных магистралей), *Railway Transport*, No. 8, pp. 47-54.

Kovalev, V.I. (2007) High-Speed Operations of the Railways; the Main Directions of Scientific and Technological Advances in Rail Transport (Скоростное и высокоскоростное движение на железных дорогах//Основные направления научно-технического прогресса на железнодорожном транспорте), *Management of the Council for Rail Transport for CIS Countries*, pp. 104-107.

Kovaleva, V.I. (2003) *High-speed Rail. In the Past, Present and Future* (Скоростной и высокоскоростной железнодорожный транспорт. В прошлом, настоящем и будущем), St. Petersburg, Information Centre ”Select”.

‘Operational and Technical Parameters of the Specialized High-Speed Passenger Lines’ (Эксплуатационные и технические параметры специализированных высокоскоростных пассажирских магистралей) (1989) Eds. Sotnikova, E.A. and Zhabrova, S.S., *Scientific tr. VNIIZhT*, Moscow, Transport.

System Transrapid – Technology of the XXI Century (Система Transrapid – техника XXI века) (2003) *J. World Population*, No. 2, pp. 2-3.

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Improvement of Document Circulation and Information Technology in the Field of Transportation of Large-Sized Cargoes

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Улучшение документооборота в сфере перевозок крупногабаритных грузов

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Abstract
In article idea of changing the permit process for oversized transportation is described. Comparative analysis has been made in two cases: in Finland and in Russia. In Finland there is possibility to prepare all needed documentation by experts of main railway company. In Russia situation is still not the same. Recommendations for changing this structure are given.

Keywords: large-sized cargoes, motor transport, railway transport, Russia, Finland

Аннотация
В статье описывается идея изменения процесса разработки технологической документации для крупногабаритных грузов. Сравнительный анализ был сделан в двух случаях: в Финляндии и России. В Финляндии существует возможность подготовить всю необходимую документацию силами железной дороги, в России грузоотправитель самостоятельно вынужден готовить весь комплект документации. В статье даны некоторые рекомендации по изменению технологии этой разработки.

Ключевые слова: крупнеогабаритные грузы, автомобильный транспорт, железнодорожный транспорт, Россия, Финляндия

1. Introduction

Lately there has been a tendency of increasing the transportation of large-sized cargoes across Russia and the CIS countries. It is caused by the economic revival of Russia and the CIS countries. Economy growth leads accordingly to the growth of building new factories and reconstruction of the large industrial enterprises in all cities which, in turn, require transportation of large-sized cargoes (turbo - and hydrogenerators, details of steam and gas turbines, transformers, steam boilers, nuclear reactors, ferro-concrete blocks, equipment on wheels, etc.). As an example it is possible to note the construction of large car assembly plants in Saint-Petersburg region. Even in conditions of ongoing crisis there are still many projects that will “collect” oversized cargoes nearby. Many of these projects will proceed independently from any crisis.

Development of transportation in the field of interstate trade promotes increase in transportation of similar cargoes at the international level. An example is the industry of St.-Petersburg which, in turn, is strong in mechanical engineering. It is enough to mention such plants as Izhorsky, "Electrosila", "Turboatomgaz". The considerable share of their production is export orders, for example, for the development of power engineering of China. The railway transport is the basic carrier of large-sized cargoes; its share is more than 60 % from all transported large-sized cargoes on territories of the Russian Federation and the CIS.

2. Large-Sized Cargoes

According to the instruction on transportation of oversized and heavy cargoes on railways of the state-participants of CIS, the Latvian Republic, the Lithuanian Republic, the Estonian Republic DCH-1835 confirmed at the thirtieth session of the Council of railway transportation on October, 19th, 2001: «Cargo, including packing and fastening, is oversized if it is placed on the open rolling stock which is on a straight horizontal permanent way and at combination of a longitudinal vertical plane of symmetry of the car with an axis of a railway track, it exceeds an outline of the basic dimension of loading, or its geometrical carrying out in curves behind the limits of the basic dimensions of loading exceeds geometrical carrying out in corresponding curves of a standard car (a standard car is a car with a frame length of 24 meters and base of 17 meters)».

Growth in demand for transportation of large-sized cargoes leads to the growth in supply in this sphere of services, and every year it is more and more difficult for the railway transport to compete with other types of transport. It is caused by a number of problems to be solved in this area. Along with the technical condition of tracks, bridges and an out-of-date rolling stock, there is a problem in document circulation, delivery terms, difficulties in making and coordination of drawings, the working documentation and technology of reception and the process of the organisation of transportation of large-sized cargoes as a whole. As an example it is possible to compare transportation of large-sized cargoes by rail and by motor transport. These types of transport possess the advantages and disadvantages. The advantages of motor transport are:

- as well as in other kinds of transportation, a door –to- door technology is carried out;

- a set of firms, rendering services;
- a large fleet of cars and the trailers for transportation;
- the absence of necessity to make and co-ordinate drawings;
- the absence of restrictions on a dimension and weight of cargoes;
- and, at last, the most important advantage today is delivery term.

The disadvantages of motor transport are:

- low safety;
- the absence of possibility of long-distance transportation;
- the high cost of transportation;
- the dependence on weather conditions (seasonal prevalence);
- the difficulty of drawing up a route as not all roads, bridges and tunnels can be used transportation of large-sized cargoes.

The advantages of railway transport are:

- the possibility of long-distance transportation;
- high safety;
- the independence of weather conditions;
- the low cost of transportation.

The disadvantages of railway transport are:

- the shortage and a bad condition of car fleet, conveyors;
- the existence of dimension and weight of cargo restrictions;
- the difficulty of drawing up and the coordination of the working documentation;
- the long term of delivery.

In the modern world the important criteria in any area of manufacture and granting of services are speed, price and safety. Transportation of large-sized cargoes is not an exception. According to it as it has been noted above, the most important lack of railway transportation at transportations of large-sized cargoes are the big terms of delivery.

It is known that term at transportations is time from the moment of application for transportation. Here also it is possible to add and time necessary for drawing up of drawings, their coordination in corresponding instances of railway transportation, on what leaves to 40

% of general time. It is provided three stages of the coordination of transportation of the oversized or heavy cargo shown to transportation. The first stage of the coordination of transportation is the preliminary coordination of transportation of cargo. “The demand” (special document) for the preliminary coordination of transportation within railways of one state is given by the consignor to railway administration of that state. Thus, for the cargoes transported on a universal rolling stock with small degree of over sizing of bottom 1-2nd, lateral 1-3rd, top 1 2nd degree, the demand is represented in regional branches of JSC RZD. At higher degrees of over sizing and super bulky goods, and also by transportation on demand conveyors are represented to Department of transportation of JSC RZD. In transportation cases in the interstate message the demand is represented Department of transportation of JSC RZD.

The second stage of the coordination of transportation is the coordination the sender of the technological loading documentation with railway administration of railway of departure. The technological documentation on transportation of oversized and heavy cargo is developed by the consignor on the basis of imprisonment before trail and according to the conditions specified in it and should include:

- the drawing and calculations of placing and the fastenings of oversized (heavy) cargo executed according to requirements and the Instruction;
- the drawing of a control frame for supercargoes within loading range and cargoes of the bottom and lateral over sizing of 6th degree;
- the drawing (scheme) of placing and fastening of transport adaptations (transport equipment) on conveyors or specially equipped platforms in case of planned by the consignor and their return co-ordinated preliminary after an unloading on station of initial loading (departure). Thus, if under the scheme fastening of the multi-turnaround adaptation on empty transport (car) same, as well as at its following with cargo its description is put to the drawing (scheme) with transfer of requisites of fastening without calculations only.

On the coordination it is given four copies of drawings of placing and cargo fastening in three projections, calculations of over sizing, cross-section stability and cargo fastening, a copy of the document on the preliminary coordination of transportation. The documentation consider and co-ordinate in services of transportation, cargo and commercial work, a way, a carload

economy. If cargo has vertical super over sizing involve experts of service of electrification and a power economy.

The drawings of placing in one copy co-ordinated by railway administration and fastening of cargoes on conveyors, and also bulky goods on platforms and in semicars of oversizing of bottom 4-6th, lateral 5-6th degrees and super-dimensional the coordination goes to Department of transportations of JSC RZD on definitive. The coordination railway administration of drawings of placing and fastening of cargoes on platforms and in semicars of oversizing of bottom 1-3rd, lateral 1-4th, top 1-3rd degrees is definitive. Thus, if transportation single on the drawing the permission to loading to concrete station of appointment in addition is underlined. On platforms and in semicars of oversizing of bottom 3rd, lateral 4th and top 3rd degrees the railway administration informs Department of transportations of JSC RZD on the coordination of drawings of placing and fastening of bulky goods the telegramme or by fax. Besides, after application it is necessary not less than two weeks for calculation of cost and a transportation route. As a result time for loading and along the line occupies no more than 25-30 % from the general.

In this connection for the purpose of increase in a share of the railway in this area of transportations expedient it is represented:

- to organise the centre at JSC RZD and on the basis of each railway which would be engaged in work directly with the consignor, passing all intermediaries (fig. 1 and 2);
- to equip this centre with the software for drawing up of drawings and calculation of the necessary data;
- to create a powerful database under already earlier developed drawings and to provide to this data of the corresponding workers who are engaged in process of transportation;
- at drawing up of drawings of earlier not transported cargoes to enter them with explanatory notes into this database;
- as much as possible to simplify search of already existing drawings and calculations for workers of this centre;
- for the purpose of acceleration of process of the coordination of drawings and demand consideration it is expedient to accelerate document circulation between this centre and corresponding departments;

- to apply bonus discounts to consignors who have addressed directly to this department, and constant clients and depending on operation time of the consignor from JSC RZD;
- and, at last, to develop and improve technology of loading, transportation of large-sized cargoes.

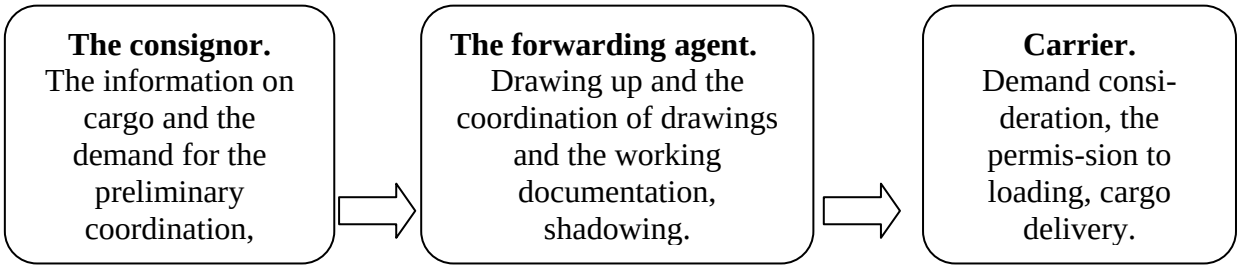

Figure 1. The standard scheme, at work of the client with firms forwarding agents.

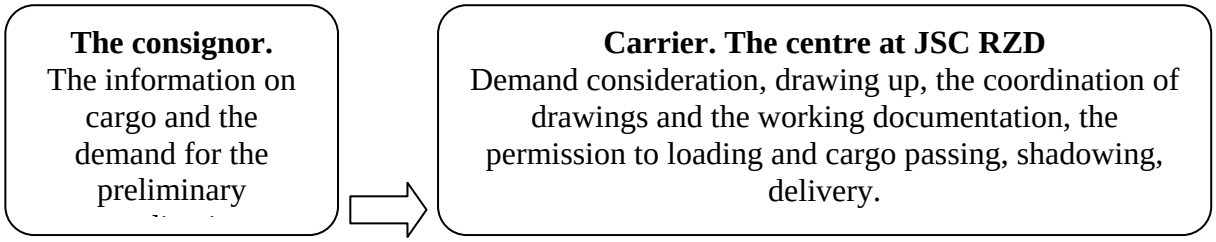

Figure 2. The offered scheme, at work of the client on a straight line from JSC RZD

3. Conclusions

- terms will considerably be reduced to drawing up and the coordination of drawings and demand consideration that any more will not be an obstacle at a railway transportation choice as carrier;
- quality drawing up of drawings as their qualified engineers of this centre owing to what safety of transportation raises also will make will raise;
- the payment for transportation considerably decreases, as transportation process will occur without participation of intermediaries;
- the consignor gets rid of necessity to make drawings and to co-ordinate them.

- Owing to what competitiveness of the railway as much as possible raises and its share in the field of transportations of large-sized cargoes increases.

Summing up all aforesaid, there is a question, the requirement for centre existence on transportations of large-sized cargoes, after all, despite uniqueness, complexity and growth of transportations of such types of cargo is how much justified, all of them still remain not numerous?

References

Brzhezovsky, A.M. Unification of calculations of stability and oversizing of cargoes. / bulletin ВНИИЖТ, 1/95/.

Gromadin, D. (2004) 'Negabarit – is favourable, but risky', *The Russian Railway the Partner*, No. 7, p. 71.

Ilyin, J. (2007) 'Negabarit: to whom is it necessary?', *The Russian Railway the Partner*, No. 6 March, p. 106.

Oversized transportations in Russia: the Sight from within (2007), Transport, No. 10, available at http://loginfo.ru/.

Specifications on placing and fastening of cargoes in cars and containers. The instruction on transportation of oversized and heavy cargoes on railways of the state-participants CIS, the Latvian Republic, the Lithuanian Republic, the Estonian Republic.

Turanov, H.T. and Sitnikov, S.A. (2007) 'Modelling of tension in flexible elements of fastenings of bulky goods at train movement on a curve site of a way', *A Science and Technics on Ttransport*, No. 1.

Vinnichenko, R.J. (2006) 'Perfection of reception to loading of heavy bulky goods on an open railway rolling stock. / actual problems management of transportation process', the Collection of proceedings. Release 6, Sankt – Petersburg.

The Electronic Market of Innovations and Knowledge on a Railway Transport

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Электронный рынок инноваций и знаний на железнодорожном транспорте

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Abstract

The paper describes the electronic market of innovation and knowledge development on railway transport as well as E-learning Logistics system which have been created in frame of Lognet project as open training environment and may accumulate these innovation and knowledge for staff development of different logistics companies via Internet.

Keywords: E-learning, E-learning logistics, electronic market, open training environment, professional skills, staff development, innovation, knowledge.

Аннотация

В статье описывается развитие электронного рынка инноваций и знаний в сфере железнодорожного транспорта. Внимание уделяется уже апробированным инновационным системам, а также описанию возможностей применения системы электронного обучения в области транспортной логистики как открытой виртуальной учебной среды. Система способна аккумулировать инновации и знания ведущих экспертов (как российских, так и международных) для повышения квалификации и развития персонала, работающих как в частных логистических компаниях, так и в государственных структурах, обслуживающих железнодорожный транспорт.

Ключевые слова: электронное образование, электронный рынок, профессиональный уровень, развитие штата, инновации, знания.

1. Introduction

The railway transport is one of the major elements of supply chain management not only for the Northwest of Russia and the whole transport complex of Russia, but also for many countries of the world, which economy is directly connected with development of railways and trade. Economic efficiency and development of the Russian railways in modern

conditions of a global competition in the world markets directly depends on integration and coordination of the intellectual resources of the research and design organizations, the professional educational institutions and the industry. Main purpose of such actions are reception and distribution of new knowledge and innovations, that is high technologies, new materials and essentially new products, which allow creating the condition for competitiveness of the Russian railways.

Nowadays from the point of view of country economic development acceleration, the process of innovation creation and new knowledge reception in Russia are characterized by week single–minded motivation. That means reception of desirable results during certain time at expenses of predicted volumes of resources. All can be carried out to the problems of development of the Russian railways.

Possible way to solve the problem includes a chance to use modern management technologies. On the basis of information communication technologies Russian and foreign innovations in railway transportation sphere can be widely circulated. These matters are considered within the limits of project LogNet, which is a combined project between Russian and Finnish researchers. Research topics are:

- direct use of innovations and knowledge for development of electronic business on the railway transport;
- improvement of professional skills of experts on the basis of application of innovative methods of training (the distance methods, the methods, based on the application of information-communication technologies, ICT).

2. Electronic Market on Railway

Nowadays the information communication technologies are actively used by the state and private transport companies, in order to create and optimize business processes and to develop electronic business. The special part is assigned to such a significant sphere of electronic business as electronic commerce. Electronic commerce is a component of electronic business which provides performance of functions of marketing, registration of orders of the goods and

services, carrying out of payments, a choice and realization of the scheme of delivery of the goods, realization after sale service through the Internet. At first, the electronic commerce was used in the railway transport to organize orders and sales of tickets through the Internet. Sales of electronic tickets started in 2007, and from that time the amounts of sales are constantly rising.

The electronic trading platform of the transport services, integrated with automated system ETRAN (Electronic TRANsport invoice), has been working for more than 4 years in the Russian railways. The centre of the organization of competitive purchases in the Internet in 2009 opened the electronic trading-purchasing platform, allowing holding competitions on deliveries through the Internet. On the 30th March 2009 the first demands for competition among the organizations, which have passed qualifying selection, have been received in electronic form. Therefore, it is possible to claim, that the information technologies and electronic commerce are widely used in the Russian railways, and every year they get the increasing weight in the organization of transportations.

3. Electronic Tickets

There has been a possibility since May 2007 to purchase tickets for a train through the Internet. To choose a route and pay a trip, web-site of the Russian railways can be used. Before registration of the order for purchase of tickets, the registration procedure is carried out. The personal password, which is necessary to remember to be able to view the order information, is entered. At order registration requisites of a trip and the personal data of the passenger are brought in offered fields. The person, who is drawing up the order, is responsible for correctness of requisites of a trip and the personal data of the passenger. If there are empty seats in the system “Express”, tickets can be purchased:

- from 45 days and before departure of a train from points of formation or a train turn;
- from 3 days and before departure of a train from way station.

Ticket sale is carried out:

- on the trains following on territory of the Russian Federation;
- on the trains following in the Union of Independent States (Azerbaijan, Kazakhstan, Kyrgyzstan, Belarus, Ukraine, Tajikistan, Turkmenistan, Uzbekistan, Moldova);
- on the trains going to Latvia, Lithuania, Estonia;
- on the trains belonging to companies «Гранд Сервис Экспресс» and «Тверской экспресс».

Order payment is carried out only by means of bank cards Visa, Visa Electron, MasterCard and Maestro and via international payment systems Visa International and MasterCard International. Payment on a bank card is made after the check and acknowledgement of the order with readdressing on a payment lock of "TransCreditBank". There are only 10 minutes to make a decision about payment and to input the requisites of a bank card. In case of excess of established time, the order is cancelled. After order payment, the order form, in which order number (14 numbers) is specified, is formed. It is necessary to print the order form, because the ticket will be issued only at its presence. Tickets are issued in booking-office of the Russian railways or on a registration rack of "the electronic ticket". In addition, there is a possibility to issue the ticket by means of self-service terminals. Similar terminals are established to stations of Moscow, St.-Petersburg and other big cities in Russia. It is necessary to enter order number and personal data of one of the passengers into the terminal in order (a surname, a name, a patronymic and number of the document proving the identity). In case of correct data, terminal prints the ticket. However, the electronic tickets cannot be passed to full value in Russian railways (system is already operating in passenger air traffic). The problem is that train conductors do not have mobile terminals for reading a stroke-code from printing of the electronic ticket and its verification through a company database.

There are certain restrictions while purchasing the tickets:

- ticket sale system through self-service terminals provides to buy tickets to no more than 4 passenger during one session of interaction;
- ticket sale is made only under "full" and "children's" tariffs;

– it is not possible to purchase tickets to international traffic, on trains of alternative carriers, penniless (for example, under military requirements) and preferential tickets.

Thus, the given service is calculated via mass consumer and service of the most demanded directions of trips. However, every year sales of tickets through the Internet is increasing. On the basis of the data about sales of electronic tickets for the first half of the year 2008 and 2009 the diagram presented in Figure 1 is constructed.

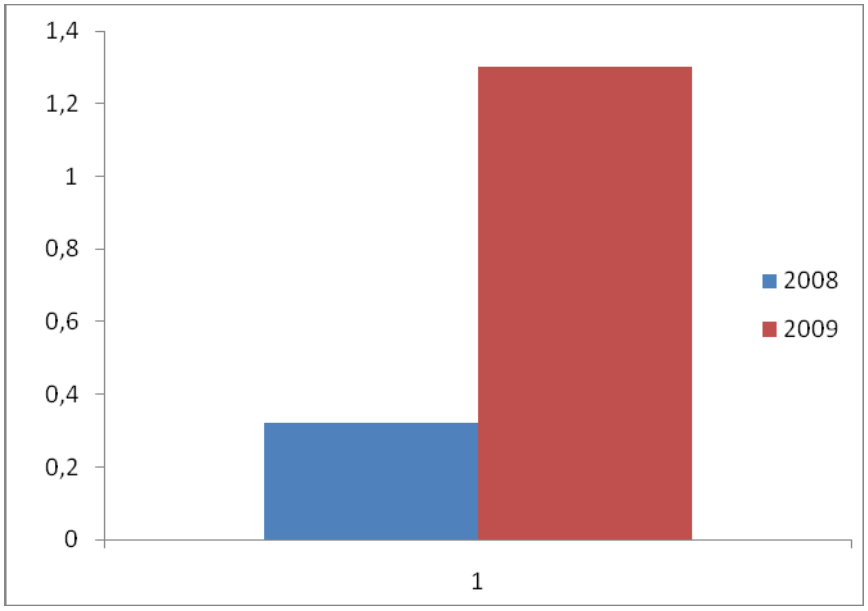

Figure 1. The amount of sold tickets.

4. The Electronic Trading Platform of Transport Services

The electronic trading platform of transport services (ETP TS) is the specialized information system that allows, by means of the Internet technologies, to receive information about transportations carried out by the Russian railways. ETP TS appeared in 2005, and nowadays more than 600 organizations and more than 1000 users are presented on it. The users of ETP TS are offered the following services:

- informing on a dislocation and operations with cargoes, cars and containers;
- preliminary calculation of fare in an operative mode;

- the check up of the reliability of number of the container or the car;
- viewing of the news and the services rendered through ETP TS;
- service of acquaintance with a course of complained works;
- the technical user support.

To work with ETP TS the representative of the organization, wishing to receive services of ETP TS, should make an application on organization registration. After acknowledgement of registration and reception of the login and the password for an access to the web-site, it is necessary for representative of the organization to come on ETP TS and to conclude the contract on use of the ETP TS in the section "Conclusion of contracts". For the conclusion of the contract it is necessary:

- to familiarize with an existing form of the contract in the section "Samples of contracts";
- to enter the registration data of the organization in the section "Requisites";
- to make an application on the contract conclusion (the reference "New contract"), then to download a package of documents on the computer and to issue the contract from its part in duplicate;
- to send a package of documents in center of the firm trade by the means of the certified mail, an express delivery service or personally;
- to wait for a notification about the successful coordination of the contract and its signing by e-mail or by phone.

For the personification of the actions of the staff the user of ETP TS can register some of the employees and delegate them rights in ETP TS. In this case every employee gets his own password and his actions are registered in the system.

5. Distance Learning System (E-Learning Logistics)

Specialists and other people who have to work in electronic market can receive needed information quickly. E-Learning systems can help to organize these processes via Internet in

any comfortable place at any time. Applying this knowledge via Internet specialists can also learn to work on the electronic market.

Logistics has an important role in developing the new business in Russian market including cross border regions (such as for example Saint-Petersburg and Leningrad region – East-West of Finland). In frame of LOGNET[1] project the E-learning logistics system (E-LEARNING LOGISTICS[2]) have been created for integration and co-ordination of Intellectual resources and knowledge about railway logistics. E-learning logistics includes:

- Logistics training courses were developed by project experts and researchers from Finnish and Russian universities, and other research, development and educational organizations working on that sector (http://lognet-project.ru/moodle/course/index.php)
- Research library (which includes results of LOGNET research, seminars/workshops results as well articles of project experts from both Finnish and Russian side)
- Training exercises
- Possibility of connection with simulation railway system.

E-LEARNING LOGISTICS was realized on the Open Source Software[3] – MOODLE. Moodle (modular object-oriented dynamic learning environment) is web-based open source software, which is a course management system designed to help online course management in schools, universities and companies. Scheme of E-Learning Logistics realization on the base of Moodle is presented in Figure 2.

[1] Development of logistics for supplier net models – LOGNET proje(http://www.intermodal-lognet.eu/fi/lognetprojectct, INTERREG IIIA

[2] www.lognet-project.ru/moodle

[3] Explanation of Open Source refers to software programs that are distributed with the source code and license allows user the freedom to run the program for any purpose, to study and modify the program, and to freely redistribute copies of the original or modified program.

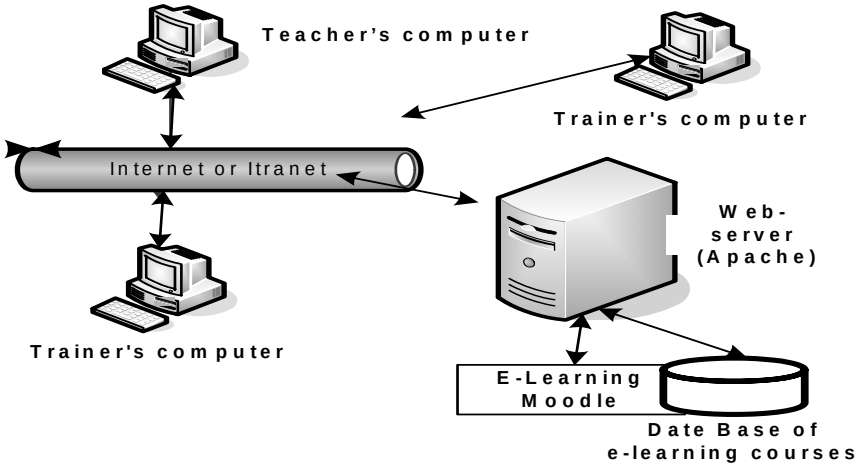

Figure 2. Scheme of realization of E-learning logistics.

Support E-learning logistics consists of specialists from Lappeenranta University of Technology and Petersburg State Transport University and includes:

- E-learning logistics system administrator
- Group of experts for library and courses support.

After the project finishes E-learning logistics will be supported in order to strengthen the sustainability. Target groups of E-learning logistics are specialists from October railway (Russia) and specialists of logistics companies. Another important groups are local authorities in charge for logistical solutions, local administration in region and municipalities, companies working on logistics, their subcontractors, agents and research centers. During this project and training process the project purpose is also to develop other co-operation and networking among above mentioned groups. There are two types of users in system:

1. The teacher or expert who can create new course, support of this course developing training materials, training exercises and tests (see Figure 2).
2. The trainer who can do the registration, to choice the course and teacher and study the training materials (see Figure 3).

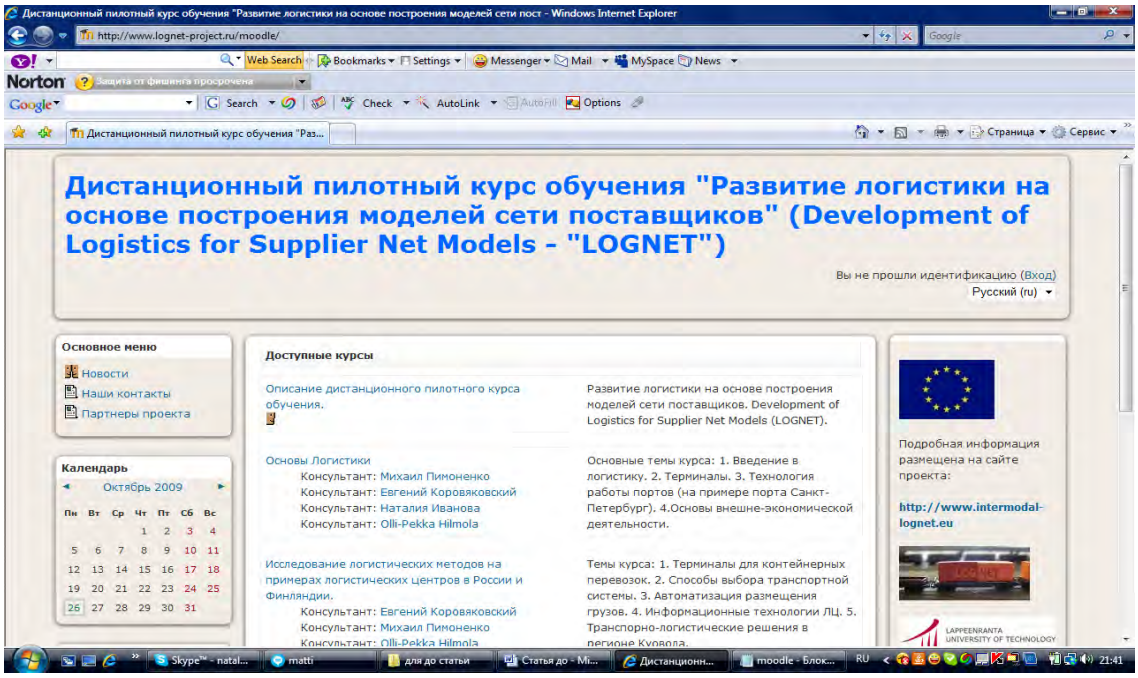

Figure 3. E-learning logistics.

Lognet E-learning logistics includes courses:

- Basic logistics
- Terminals and warehouses
- ICT on railway and Information Logistics Centers
- Cross border logistic co-operation (about Saint-Petersburg, Leningrad region and Kouvola region)
- Logistics methods research on the examples of both Logistics centers in Finland as well in Russia (comparing technology, planning, logistics and product development methods used in Finland and Russia)
- Modern tendencies of logistics development and so on.

After LogNet project realization, project experts and researchers will support E-Learning logistics in order to confirm project's sustainability. This also develops know-how and contents of further training programs for the participating educational organizations. The teaching materials will be developed utilizing new distance learning methods and e-Learning material for electronic market development in logistics. Next step for E-Learning logistics

development could be co-operation with different simulation organization which develops computerized training systems and dynamic simulation models (training simulators). Computerized technologies can help in real time to create situations for control, monitor and optimize the rail traffic necessitates drastic changes in methods and aids for training of a wide range of specialists. Active training methods will be a good alternative for traditional tutoring procedures.

6. Conclusions

The growth of the global electronic market and information society shows that E–learning systems can accumulate the innovation and knowledge in its contents and become important for specialists. E-learning Logistics can become the open environment of common rules and principles for specialists in railway logistics as well supply change management and aggregate of all participants of this process. In the future the E-learning logistics can be included to Innorail forum.

References:

Ivanova, N., Ivanova, K., Danilov, A., Mitov, I. and Markov, K. (2006). 'Basic interactions between members of the knowledge market', *Information Theories & Applications*, Vol. 13, 11 pages
Lognet project webpage, available at http://www.intermodal-lognet.eu/fi/lognetproject
Lognet distance learning course webpage, available at www.lognet-project.ru/moodle
Moodle, available at http://moodle.org/

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Technical Aspects of E-learning Systems for the International Programs in the Field of Logistics

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Технические аспекты систем электронного обучения для международных программ в области логистики

Андрей Симушков, Евгений Коровяковский, Милла Лайси

Abstract
Although the focus of Moodle project is always on giving educators the best tools to manage and promote learning, there are many ways to use the system. Moodle has features that allow it to scale to very large deployments and myriad of students, as well as it can be used for a primary school or an education hobbyist. Many institutions and organizations use it as their platform to conduct fully online courses, while some use it simply to augment face-to-face courses (known as blended learning). Many E-learning users enjoy to use the many activity modules (such as Forums, Wikis, Databases and so on) to build richly collaborative communities of learning around their subject (in the social constructionist tradition), while others prefer to use it as a way to deliver content to participants. Moodle is free to download and registration is voluntary. According to experiences presented in this article, Moodle is an ideal system for transferring academic knowledge to business people.

Keywords: Moodle, E-learning, logistics learning systems, SCORM, education IT-solutions

Аннотация
Проект ЛОГНЕТ сфокусирован вокруг логистических и транспортных процессов компаний Северо-запада России и Юго-восточной Финляндии. Однако основным фактором развития любой сферы деятельности являются люди, их знания и умения. Именно поэтому в рамках проекта была реализована система и сайт дистанционного обучения на основе программного продукта Moodle. Система дистанционного обучения предназначена для донесения в простой и удобной форме сложных, теоретических материалов до сотрудников различных транспортно-логистический компаний. Дистанционное обучение дает исчерпывающую информацию для дальнейшего развития тех направлений логистики, актуальность которых очерчена требованиями рынка.
Объединение на одной информационной площадке представителей компаний разных стран поможет полнее представить вызовы, встающее перед логистикой в современном мире. В соответствии с полученным опытом реализации проекта, Moodle является идеальной системой для трансфера академических знаний в деловую среду.

Ключевые слова: Moodle, электронное обучение, системы обучения логистике, SCORM, образовательные ИТ-решения

1. Introduction

E-Learning (also called electronic learning or eLearning) is a term which may be used to encompass all forms of technology-enhanced learning (TEL), or in some cases very specific types of TEL such as online or Web-based learning. The term does not have a universally accepted definition; actually, it has been discussed in the e-learning industry whether a technology-enhanced system can be called e-learning if there is not settled pedagogical objectives, as some argue e-learning is: "Pedagogy empowered by digital technology" (Dublin, 2003; Nichols, 2008). The term e-learning is ambiguous to people outside the e-learning industry, and even within its diverse disciplines it has different meanings to different people (Dublin, 2003). For instance in companies, it often refers to the strategies that use the company network to deliver training courses to employees. Lately in universities, e-learning is used to define a specific mode to attend a course or study programs where the students rarely or never meet face-to-face, nor access on-campus educational facilities, because they study online.

This paper presents the Moodle system and describes how it can be utilized in developing education industry. Although the concentration is on Moodle system, also other e-learning methods are shortly presented. Paper is structured as follows: section 2 describes the goals and benefits e-learning systems can offer. In section 3 we scrutinize the e-learning technology. Section 4 discusses and carefully presents Moodle system. In section 5 we present a distance learning course, which was organized via Moodle system. Ideas are concluded in section 6, which finalizes the article.

2. Goals and Benefits of E-Learning

E-learning method can provide major benefits to organizations, field of education and individuals. Recent studies have noticed that e-learning improve performance: a 12-year meta-analysis of research by the U.S. Department of Education found that higher education students in online learning generally performed better than those in face-to-face courses (Means et al., 2009). Additionally, the learning method improves students' possibilities to access to high-level courses; highly recognized instructors can share their knowledge across borders, allowing students to attend courses across physical, political, and economic boundaries. The experts have opportunity of making information available internationally, to

anyone interested at minimum costs. For example, the MIT Open Courseware program has made substantial portions of university's curriculum and lectures available online for free. Furthermore, e-learning provides convenience and flexibility to learners. In many contexts, students can choose the time and place for learning as the learning sessions are available 24/7. Learners are not bound to specific day/time to physically attend classes. They can also pause learning sessions at their convenience.

3. E-Learning Technology

Learning management system (LMS) is a software application that manages the administration, documentation, tracking, and reporting of training programs, classroom and online events, e-learning programs, and training content (Ellis, 2009). LMSs range from systems of managing training/educational records to software for distributing courses over the Internet and offering features for online collaboration. In many instances, corporate training departments purchase LMSs to automate record-keeping as well as the registration of participants for classroom and online courses. Student self-service (e.g. self-registration on instructor-led training), training workflow (e.g. user notification, manager approval, wait-list management), the provision of on-line learning (e.g. Computer-Based Training, read & understand), on-line assessment, management of continuous professional education (CPE), collaborative learning (e.g. application sharing, discussion threads), and training resource management (e.g. instructors, facilities, equipment) are dimensions to Learning Management Systems. Most LMSs are web-based to facilitate access to learning content and administration. LMSs are used by regulated industries for compliance training. It is also used by educational institutions to enhance and support classroom teaching and offering courses to a larger population of learners across the globe. For the commercial market, some Learning and Performance Management Systems include recruitment and reward functionality.

LMSs can cater to different educational, administrative, and deployment requirements. The characteristics shared by all types of LMSs include:

- Manage users, roles, courses, instructors, facilities, and generate reports
- Course calendar
- Learning Path
- Student messaging and notifications

- Assessment/testing capable of handling student pre/post testing
- Display scores and transcripts
- Grading of coursework and roster processing, including wait listing
- Web-based or blended course delivery

Corporate learning, including e.g. franchisees and other business partners, have more specific characteristics. LMSs are based on a variety of development platforms, like Java/J2EE based architectures, Microsoft .NET, PHP, and usually employ the use of a database as back-end. Some systems are commercially developed and have non-free software licenses or restrict access to their source code, other systems are free and open-source and frequently used. Other than the most simple LSMs with basic functionalities, cater to and focus on different educational, administrative, and deployment requirements.

A learning content management system (LCMS) is software for authoring, editing and indexing e-learning content (courses, reusable content objects). A LCMS may be solely dedicated to producing and publishing content that is hosted on LMS. A common standard format for e-learning content is SCORM whilst other specifications allow transporting of "learning objects" (Schools Framework) or categorizing metadata (LOM). Today many technologies can be and are used in e-learning, from blogs to collaborative software, e-portfolios and virtual classrooms. Most e-learning situations use combinations of these techniques. Especially in higher education, the increasing tendency is to create a Virtual Learning Environment (VLE), which is sometimes combined with a Management Information System (MIS) to create a Managed Learning Environment. In VLE all aspects of a course are handled through a consistent user interface standard throughout the institution.

4. Moodle

Modular Object-Oriented Dynamic Learning Environment (MOODLE) is a free and open-source e-learning software platform, also known as a Course Management System (CMS), Learning Management System (LMS), or Virtual Learning Environment (VLE). To work, it needs to be installed on a web server, either on one of your own computers or one at a web hosting company. It has become very popular among educators around the world as a tool for creating online dynamic web sites for the students; it has a significant user base with 52,153 registered sites with 30,176,528 users in 2,770,832 courses (as of March, 2009). The largest

live Moodle installation at time of writing (Open Polytechnic of New Zealand) handles 45,000+ students and 6,500+ courses registered.

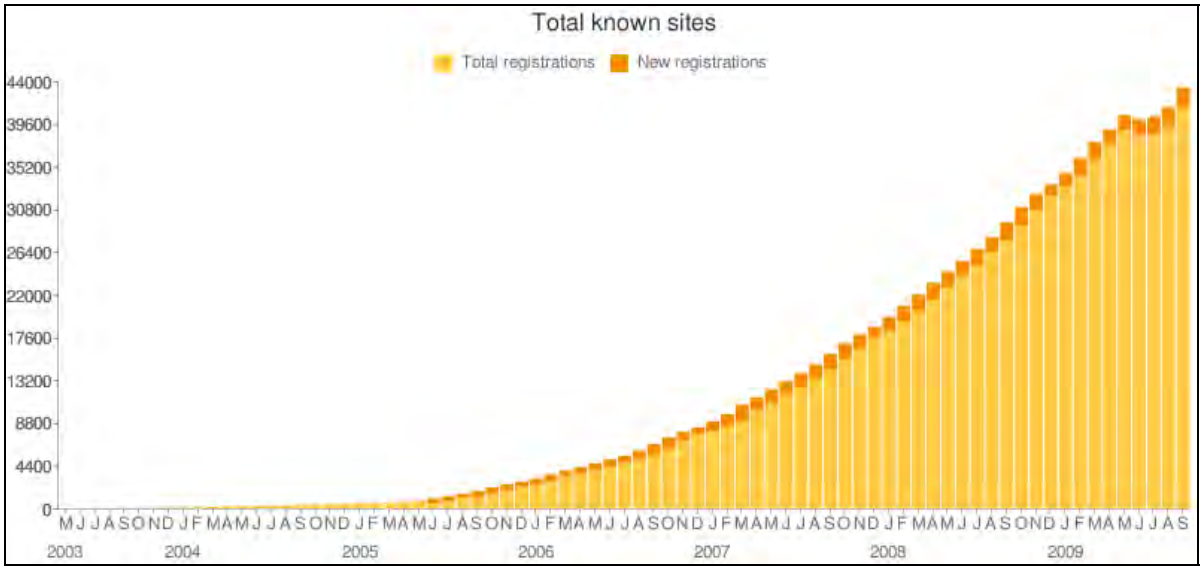

Figure1. Total known Moodle sites

The focus of the Moodle project is always on giving educators the best tools to manage and promote learning, but there are many ways to use Moodle. The program has features that allow it to scale to very large deployments and myriad of students, as well as it can be used for a primary school or an education hobbyist. Many institutions use it as their platform to conduct fully online courses, while some use it simply to augment face-to-face courses (known as blended learning). Moodle is designed to help educators create online courses with opportunities for rich interaction. Its open source license and modular design mean that people can develop additional functionality. Development is undertaken by a globally diffused network of commercial and non-commercial users, streamlined by the Moodle company based in Perth, Western Australia.

Moodle features

Moodle has many features expected from an e-learning platform, plus some original innovations. Moodle is modular in construction and can readily be extended by creating plugins for specific new functionality. Moodle's infrastructure supports many types of plugins:

- Activities (including word and math games)

- Question types
- Data field types (for the database activity)
- Graphical themes
- Authentication methods
- Enrollment methods

Many third-party Moodle plugins are freely available, enabling to use this infrastructure.

Origin of the name

The word Moodle is an acronym for Modular Object-Oriented Dynamic Learning Environment. Moodle can also be considered a verb, which describes the improvisational process of doing things as it occurs to you to do them, an enjoyable tinkering that often leads to insight and creativity. As such it applies both to the way Moodle was developed, and to the way a student or teacher might approach studying or teaching an online course. "Moodle" is a protected trademark. Only Moodle partners get the right to use the trademark to market their services like Moodle Hosting, Moodle Customization etc.

Supporting Organizations

1. Open University, UK - contributed to Roles, accessibility in 1.8, Quiz (ongoing) and many smaller things.
2. Istituto Superiore di Sanità (ISS), Italy (especially Daniele Cordella) - contributed to accessibility compliance to W3C guidelines and Italian law.
3. Microsoft, US - contributed to development of XMLDB.
4. Google, US (Summer of Code) - contributed to development of Admin interface, AJAX editing and Database activity presets
5. Open Polytechnic, NZ (esp Richard Wyles) - for contributions to Moodle Network, Stats, PostgreSQL support, and many other things

Deployment and development

Moodle has been evolving since 1999 (since 2001 with the current architecture). The current version is 1.9.5, which was released in May 2009. It has been translated into 61 different

languages. As there are no license fees or limits to growth, an institution can add as many Moodle servers as needed. The development of Moodle continues as a free software project supported by a team of programmers and an international user community, drawing upon contributions posted to the online Moodle Community website that encourages debate and invites criticism. There are some auto install packages to facilitate the installation including Bitnami, Fantastico, JumpBox and the Moodle package for Debian. Users are free to distribute and modify the software under the terms of the GNU General Public License.

Specification

Moodle can be installed on any computer that can run PHP, and can support an SQL type database (for example MySQL). It can be run on Windows and Mac operating systems and many flavors of Linux (for example Red Hat or Debian GNU). Moodle runs without modification on UNIX, Linux, FreeBSD, Windows, Mac OS X, NetWare and any other systems that support PHP and a database, including most web host providers. Data is stored in a single database: Moodle version 1.9 could use MySQL or PostgreSQL. Version 1.7, released November 2006, makes full use of database abstraction so that installers can choose from one of many types of database servers (Oracle and Microsoft SQL Server are two specific target DBMSes).

Requirements

Moodle is primarily developed in Linux using Apache, MySQL and PHP (also sometimes known as the LAMP platform). It is also regularly tested with Windows XP/2000/2003 (WAMP), Solaris 10 (Sparc and x64), Mac OS X and Netware 6 operating systems. Support for PostgreSQL, Oracle and Microsoft SQL Server is also available.

The Hardware requirements for Moodle are as follows:

1. Disk space: 160MB free (min). You will require more free space to store your teaching materials.
2. Memory: 256MB (min), 1GB (recommended). The general rule of thumb is that Moodle can support 50 concurrent users for every 1GB of RAM, but this will vary depending on your specific hardware and software combination. This includes

hosting limits of PHP or MySQL on a hosting service. The capacity can limit the number of users your Moodle site can handle.

There are two basic ways to install Moodle: Most Moodlers are used to the installer script but with Moodle 2.0 you may install it from the command line. By default Moodle includes the TCPDF library that allows the generation of PDF documents from pages. If you want to run Moodle on your own computer, please see Installing Apache, MySQL and PHP for step-by-step instructions for installation on most popular platforms.

Security

All web application software are highly complex, and every application has security issues that are found from time to time, usually involving some combination of input that the programmers did not anticipate. Moodle takes security seriously, and is continuously improving program to close such holes. Moodle is designed and audited to be secure for its purpose. A security issues/announcements site exists at http://security.moodle.org. Moodle's current system of roles includes administrators, teachers, and teachers without editing privileges (sometimes called teaching assistants), students and guests. Each has a clearly defined set of privileges and cannot act beyond those privileges.

Interoperability

To support content from different sources and multiple vendors' hardware/software solutions, the LMS should exchange data using open industry standards for Web deployments.

- For enrolment, Moodle supports the use of an LDAP server (e.g. Active Directory), and the IMS Enterprise standard (via a downloadable plugin).
- For content, there are a number of aspects:
    1. Moodle supports the import of Reusable Learning Objects packaged according to the SCORM/AICC/IMS Content Packaging standards
    2. Quiz questions can be exported in the international standard IMS QTI 2 and several other formats
    3. RSS newsfeeds can be integrated into a Moodle site or course

4. Forum discussions, glossary entries and database content can be accessed as RSS newsfeeds, and therefore integrated into other RSS-capable websites or systems.

- The use of XML for import/export is standard in Moodle. The "web services" method of exchanging data with other systems (e.g. via SOAP or XML-RPC) is not yet standard - but is in active development.
- Currently Moodle already sends an email as notification of a lot of different types of events, but it can be difficult to manage.

Translation credits

From the very beginning, Moodle was designed to be translated into many languages. Moodle currently exists in over 60 languages and dialects. New translation projects are starting all the time.

Users

In addition to the hardware and software requirements, you also need to think about the capacity of your Moodle installation in terms of the number of users it can handle. There are two possibilities:

1. Browsing users: the maximum number of users able to browse your Moodle site. This is the number of computers in your organization or on your course (whichever is greater).
2. Concurrent database users: the maximum number of concurrent database users (needed for Moodle activities such as quizzes). This is the number of users who will be using Moodle at the same time. In an educational institution, use your timetable/roster to obtain this figure.

Once you know the number of users and the Moodle installation supports the needed capacity, you can start to work. The exact number of users depends on your hardware/software/network combination. Usually the amount of memory installed (RAM) is the deciding factor but a faster overall processor speed will also help in reducing waiting times for pages to load.

Courses

The basic unit of organization is the course. Each course homepage generally contains blocks on the left and right with the centre column containing the course content. Blocks may be added, hidden, deleted and moved up, down and left/right when editing is turned on. "Latest News", "Blogs", "Upcoming Events", and "Recent Activity" are a few examples.

Teachers can choose from a wide range of over 16 different block types, and therefore provide additional information or functionalities to the learners. The standard blocks that come with Moodle are shown on the right. There are also many contributed developed by Moodlers that an administrator can add to this list.

A teacher with editing rights will also have a course administration block. This is an important tool for teachers. It has sub menus for course: backup, restore, assign roles, grades, activity logs/reports, files and the useful course settings.

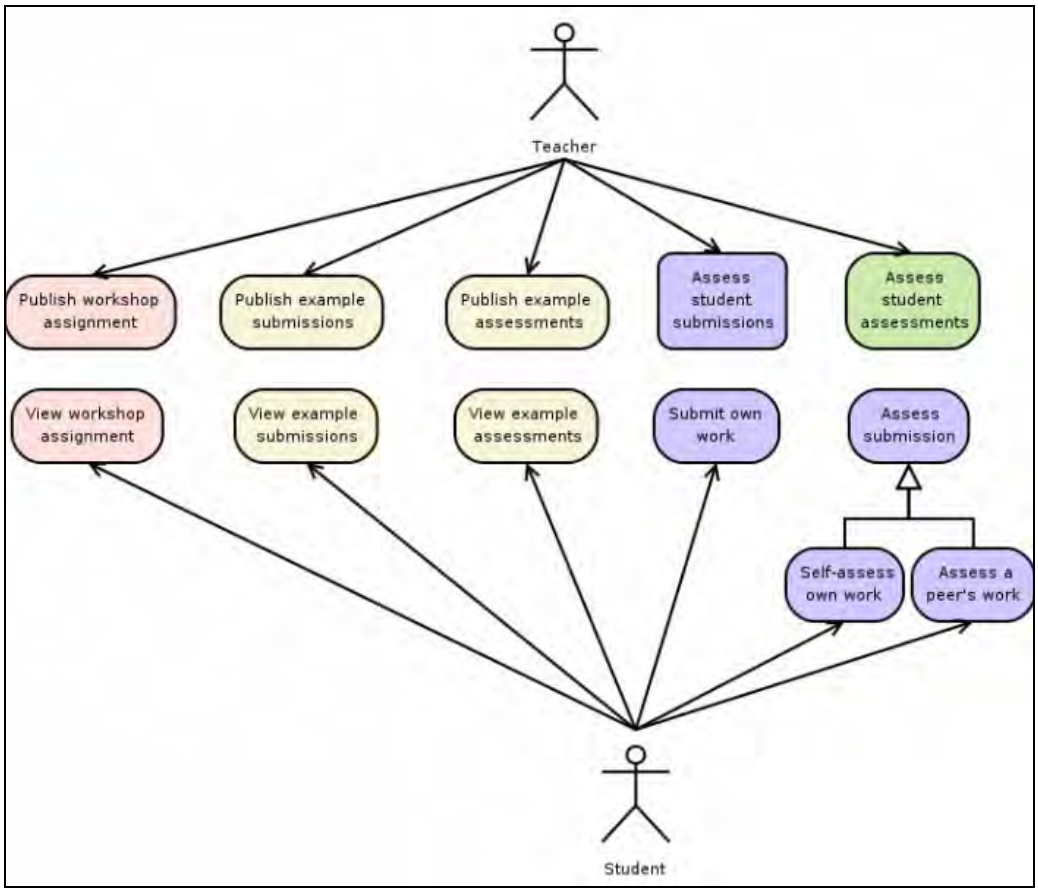

Figure 2. Teacher-student cooperation.

An administrator can assign any number of teachers (with or without rights to edit content) to a given course, which has its own file area as well as its own discussions forums and other activities. Teachers can decide whether content is visible or hidden to students.

Moodle courses automatically generate news forum which defaults to automatically subscribe all participants in a course. This is a useful feature and many use this forum in a Moodle course to announce exam dates, times or changes to exams, lectures or seminars, as well as important information about course work throughout a term or special announcements relating to events.

Work can be uploaded and submitted by students and scored by teachers using assignments or workshops. These modules have several assessment options, including instructor-assessment, self-assessment and even peer-assessment. Online Quizzes offer several options for automatic and manual scoring. You can even integrate Hot Potato quizzes by adding a Hotpot activity.

Lessons and SCORM activities deliver content and offer ways of individualizing your presentation based upon a student's choices. Glossaries of keywords can be set up by the instructor, and can be configured to allow students to edit, add or rate entries. Surveys and databases are also very powerful additions to any course.

Registration

Registration supports a range of authentication mechanisms through plug-in authentication modules, allowing easy integration with existing systems. Registration can be done via following ways:

- Standard manual method
- Standard email method: students can create their own login accounts. Email addresses are verified by confirmation.
- LDAP method: account logins can be checked against an LDAP server. Admin can specify which fields to use.
- IMAP, POP3, and NNTP: account logins are checked against a mail or news server. SSL, certificates and TLS are supported.

Students are encouraged to build an online profile including photos and description. Email addresses can be protected from display if required. Every user can specify their own time zone, and every date in Moodle is translated to that time zone (e.g. posting dates, assignment due dates etc). Every user can choose the language used for the Moodle interface (English, French, German, Spanish and Portuguese etc).

5. Moodle Distance Learning Course for Logistics Specialists

Finnish and Russian universities together with other partners combined knowhow via Lognet project. Lognet (Development of Logistics for Supplier Net Models) project started in March 2008 and it is terminating in November 2009; as the lead partner has acted Lappeenranta University of Technology, Kouvola Research Unit, Finland, while the other partners have been St. Petersburg State Transport University, Russia, North-Western Russia Logistics Development and Information Center, ILOT, Non Profit Research and Training Center of Adult Education, Protey and Innorail-organization from Kouvola, Finland. One of the project's objectives was to develop and implement a distance learning course for St. Petersburg area's logistics specialists. The main intention was to transfer academic knowledge to business people via interactive environment. Therefore, Moodle system was chosen as distance learning course's backbone. Course webpage was created to Internet under address www.lognet-project.ru (see Figure 3.)

Figure 3. Lognet distance learning course main page (Source: www.lognet-project.ru)

Lognet distance learning course webpage provided various kinds of data. Main concentration was on lectures, which operated as the main teaching method. Course topics covered various themes between basics of logistics to engrossed aggregates, for example over-sized cargo had an own lecture. All lectures were done by Finnish and Russian professors. Because course language was Russian, Finnish professors' lectures were re-done by Russian trainee. This ensured good language quality in all provided lectures. Lectures were recorded by using Camtasia program: voice was recorded while showing power point slides. This strengthened the studying experience. In addition to recorded lectures, webpages provided various data; students were able to read reports and notes, and see videos. Due to Moodle system's versatility, numerous functions were offered to students. For example, discussion section, news and e-mail possibility enabled close cooperation with organizers. This strengthened the learning experience.

Although course was done mainly interactively, in order to strengthen the cooperation between different actors in the field of logistics and provide recent information concerning logistics programs, two workshop days were organized. During the evening lectures Finnish and Russian professors shared the recent research knowledge and familiarized the participants with several programs. Additionally, during the workshop days test was kept and participants gave short company presentations. Overall both participants and organizers were really happy with the outcome: representatives from several companies (For example OOO Huolintakeskus and DHL Russia) participated in the course. According to gathered feedback, participants were satisfied with the course proceedings. Provided information was seen interesting and what is most important, vital for their daily duties. Therefore, Moodle has proven its functionality, and we can conclude the system is outstanding for such functions.

6. Conclusions

Moodle is open source software. Although people often think if something is for free, it is cheap and inoperative. However, this is not the case in Moodle system. Open source tends to be more secure, more stable and to develop faster than equivalent closed source software. Moodle's open source nature means that you own the system and have all rights allowing you to change and modify it, rather than renting the program "as it is", which is the case in many competing systems. These features combined with the huge community means that there are

an enormous number of third party plugins available so that functionalities can be added, for example to send text messages, pod casting, new types of quiz question and 3D molecule models. You can also commission a programmer to make any extra plugin or alteration you like, which may turn into a larger scale reform; once posted to moodle.org, other users may improve it further which strengthen the possibilities for development. Additionally, Lognet distance learning course proved Moodle is actually working in practice; it is an important tool in transferring knowledge to business people.

References

Dublin, L. (2003). If You Only Look Under the Street Lamps... Or Nine e-Learning Myths. The eLearning Developers' Journal, 1-7.

McMulli & Munroe (2004), VMoodle at DCU, http://odtl.dcu.ie/wp/2004/odtl-2004-01.html

Means, B.; Toyama, Y.; Murphy, R.; Bakia, M.; Jones, K. (2009), Evaluation of Evidence-Based Practices in Online Learning: A Meta-Analysis and Review of Online Learning Studies, http://www.ed.gov/rschstat/eval/tech/evidence-based-practices/finalreport.pdf, retrieved 20 August 2009

Moodle, http://www.Moodle.org - Original developer's site

Nichols, M. (2008). E-Learning in context. E-Primer Series.

Sclater, Neil (2008), A Large-scale Open Source eLearning Systems at the Open University, Educase, http://connect.educause.edu/Library/Abstract/LargeScaleOpenSourceELear/46878

Weller, M. (2006), VLE 2.0 and future directions in learning environments, Proceedings of the first LAMS Conference, Sydney

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Issues of Project “Common Information Area of Transport and Logistics Complex”

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Особенности проекта «Единое информационное пространство в транспортно-логистическом комплексе»

Андрей Симушков

Abstract
The Common Information area covers a considerable quantity of elements of transport and logistical process. It carries out innovations of all kinds of activities in transport and logistic complex of the Northwest Russian Federation, taking into account consolidating of information streams and strengthening of a role of responsibility. The model of the Common Information area is characterized by active involving of the user in process of development and perfection for achievement of understanding of the user requirements and appropriate allocating of functions between users and technologies. At its introduction interaction between all participants of transportation process essentially changes. Transportation becomes transparent at all stages. Creating the Common Information Area of transport and logistics complex will help implement the latest developments in the field of IT, which offer fundamentally new opportunities for the management of all areas of transport interaction.

Keywords: ACS, E-logistics, Common Information area**,** railway IT systems, RFID and bar-coding integrated IT-solutions

Аннотация
С помощью Единого информационного пространства решается задача представления всем участникам транспортного процесса гарантированной качественной информации по протоколам и стандартам, принятым в современных информационных системах. Для упрощения доступа пользователей и повышения качества представления информации в интегрированной информационной среде необходимо учесть все аспекты интерфейса системы. Понимание процессов функционирования единого информационного пространства поможет пользователям лучше взаимодействовать с информационной системой. Создание Единого информационного пространства поможет внедрить современные наработки в области информационных технологий, которые могут основательно улучшить работу управленческого персонала всех сфер транспорта и логистики.

Ключевые слова: электронная логистика, Единое информационное пространство**,** информационные ж.д. системы, Радио-частотные системы идентификации и системы штрих-кодирования, интегрированные в информационные системы

1. Introduction

The Common Information area of transport and logistic complex of Northwest region of the Russian Federation will allow to realize elaborations in the field of the newest information

technologies, which give fundamentally new opportunities in management of all spheres of transport interaction, and to solve next problems, namely:

- Giving to each participant of transport market a possibility to orientate himself easily in transport information area;
- Giving to authority of subjects of the Northwest region of the Russian Federation reliable information and prognoses of freight flows for making effective management decisions;
- As for international traffic, it is a realization of potentialities of integration with ICT systems of EU countries, especially with Finland;
- The use of public information as well as integration with existing information systems;
- Analysis and co-ordination of work of transport departments, forwarding companies, custom authorities, banks and other organizations in the sphere of transport and logistic;
- Control of all transportation stages and increase of goods delivery speed;
- Stock-taking and control of all stages of electronic documents circulation.

The main areas of functioning of the Common Information Area of transport and logistics complex are:

- Organization integrated escort of goods traffic;
- Information services for forwarding companies and operating companies (including stevedores and sea carriers);
- Organization of information interaction with border and customs control services;
- Informatization of integrated logistics services, including services for the storage and distribution of goods.

2. Technical Aspect

For its effective implementation, the Common Information Area will be able to involve the different technical possibilities existing in the operating information systems. They are:

- The using the equipment of satellite navigation systems (GPS NAVSTAR, ГЛОНАСС, Inmarsat, Globalstar) to find the location of the facility;

- The using bar-coding and RFID-coding to manage storage facilities and to control the goods in the terminal complexes;
- The using the database clusters and GRID technologies – the systems which work with parallel versions of databases and are used by ERP-systems, as well as transactional databases;
- The using the mechanism «TCO» for the selection of general software;
- Methods and devices to develop complex integrated ICT. CASE-technology and equipment;
- The implementation of wireless networks. WAP, Mobile WiMax-technology and their abilities to manage the business. The global mobile communication and Electronic Data Interchange.

3. Electronic Data Interchange (EDI)

The kernel of the system is based on the central database which allows to store and process the information. The basic directions of work of system:

- The Center of an information network and an open system, witch offers all transport companies interfaces of EDI systems.
- Realization "the Paperless technology".
- System for Electronic Customs Monitoring, designed to allow all participants to have a beam coupling with the Customs through the system.

Electronic Data Interchange (EDI) refers to the structured transmission of data between organizations by electronic means. It is used to transfer electronic documents from one computer system to another, i.e. from one trading partner to another trading partner. EDI documents generally contain the same information that would normally be found in a paper document used for the same organizational function. EDI can be transmitted using any methodology agreed to by the sender and recipient. This includes a variety of technologies, including modem (asynchronous, and bisynchronous), FTP, E-mail, HTTP, AS1, AS2, etc.

There are four major sets of EDI standards:

- The UN-recommended UN/EDIFACT is the only international standard and is predominant outside of North America.

- The US standard ANSI ASC X12 (X12) is predominant in North America.
- The TRADACOMS standard developed by the ANA (Article Numbering Association) is predominant in the UK retail industry.
- The ODETTE standard used within the European automotive industry

4. Information Technology and Timing of Information Transmission Technology EDI

Information interaction of the participants is in the nature of parallel action, the corresponding physical movement of goods and paper-based documents.

Table 1. Algorithm Implementation of information exchange

№	Operation	
Step 1	Preparing and sending messages on the goods transported by the company - exporter	Should be verified as follows: • message number is unique; • sending recorded date and time the message; Send the message will occur in the time prescribed by the rules. Prepared message is sent to the EDI server
Step 2	Acknowledgment	Operator exporter expects the arrival of a response to the sent message
Step 3	Receiving messages on the server EDI	When you receive the message automatically recorded the date and time the message was received, the code of the sender, message size, message number
Step 4	Formatted control message content	The operation is performed automatically on the application server. The server controls the syntax of the input message to the appropriate standards, EDIFACT (ISO 9735, the rules of the Message UNSM)
Step 5	Logical control message content	The operation is performed automatically on the application server. This step is controlled by the contents of fields in the message to the appropriate directories, codifier. Validates and compares the currency codes,

		countries, commodities, customs
Step 6	Convert the message into the internal format.	The operation is performed automatically on the server. The original message is converted into the internal format used by Russia in the system
Step 7	Sending messages to the border customs post	The goods are delivered by means of electronic mail MHS (GroupWise) automatically and demanding acknowledgment of fact delivery of the message
Step 8	Sending a reply message to the exporter	Upon successful completion of steps 4 - 8 of the application server automatically generates a reply message with a positive resolution on the transport of cargo
Step 9	Sending messages to the domestic customs post	After crossing the border control, border customs inspector's station shall perform the following operations on information support: • found in the database document that matches "paper" document; • written in the electronic and paper documents the necessary data in accordance with the technology of customs clearance; • send a file with an addition and a reaffirmation of the transition burden on the domestic customs border post
Step 10	Actions at the internal customs post	Receiving a message from the border customs post, the inspector of internal customs post must: • reflect the fact border crossing; • convey information to the AMS of the consignee or transport company.
Step 11	The response to the reply message	The exporter may obtain a response message from the server, the necessary data to monitor delivery of goods
Step 12	End	This cycle of action on information support the transport of goods is completed. All participants go into standby mode.

5. Information Interaction

Application with existing systems in the Common Information Area will provide an opportunity for the integration with other information systems (**ETRAN, DBS ASU, ASU PS, RAYU and RAISA**). For existing classical information systems of railroad communications and systems the interface of interaction of systems satisfy to following technical requirements:

1. Interaction will be performed under report HTTP of family of reports TCP/IP. Thus for maintenance of confidentiality of the transferred data between systems it is necessary to use the protected connection under report SSH.
2. Interaction of systems will be realized as a kit of the "Web-services" given by systems for accomplishing of necessary functions, namely: data acquisition NSI, reception of a specification. For unique commitments of data exchange it is enough to cause HTTP inquiry and to obtain the data in format XML.
3. Each interaction between systems is one complete transaction and in case of failure on any of domestic steps will be cancelled entirely. Successful end of a session of an exchange should be fixed in control magazine.
4. Interaction of systems will be carried out asynchronously under the claimed regulations.

For qualitative future development of Common Information Area it is necessary to consider a number of the specific moments inherent in an information technology:

1. Objects of an information exchange and its rule;
2. Ideology and architecture of integration program interaction (an integration infrastructure);
3. Criteria for creation of the unified intellectual interfaces;
4. It is necessary to develop the browser of control magazine for monitoring of processes of data exchange;
5. It is necessary to develop the special document describing services and parameters, in WSDL format (Language of Description Web of Services) in case of application SOAP, or a format returned document XML.

The problems of security and data protection are very important for scalable systems. The following methods can be provided to protect transmitted data:

- the authentication and access control (using MAC addresses);
- the using the keys SSID (Service Set Identifier) and the protected connection under report SSH.
- the encrypting of data.

WPA protocol can be installed in the most of existing devices (access points, network cards) to access control by the software updating.

6. Problems

Creation the principles and future models of the Common Information Area generates a number of the problems:

1. Creation of new ways of reconstituting of the information and improvement of process of transportation on the basis of optimum control of information streams;
2. Search of rational forms of interaction of the transport companies, Common Information Area and governing bodies;
3. Construction of various variants of models of functioning of the Common Information Area for satisfaction of demand of various target audiences;
4. Improvement of quality of the information product, allowing maintaining a competition on a foreign market.

7. Effectiveness

The effectiveness of the implementation of the Common Information Area will consist of:

1. Speeding up the processing of documents at customs points (a day of downtime costs transportation carriers on average 10$ per 20 tons).
2. Reducing the duration of the application/plan for transportation/loading from 10-15 to 3-5 days, that will lead to more flexible transportation process, to reducing downtime in the cargo loading cars at the terminals from 1.5 to 0.5 and to reducing the period of delivery of cargo by 15% (it will lead to the returning part of 1.5 billion rubles, which were lost because of denials at the 1st quarter of 2009)
3. Reducing the processing time of customs documents by 10-50% depending on their number (10 - 25 minutes for train) and the time for customs and other documents of the goods` arrival place from 1 - 3 days to 3 hours through the provisional transfer of documents and electronic declaration.

Efficiency from introduction of the Common Information Area will consist of following improvements:

- Acceleration of process of a handling of documents on customs points.
- Decrease in period of validity of the demand/plan for transportation/loading.
- Decrease in time of a handling of documents in a place of arrival of cargo.
- Improvements of already existing MANAGEMENT information systems and their user interfaces.

The model of the Common Information Area is characterized by active involving of the user in process of development and perfection for achievement of understanding of the user requirements and appropriate allocating of functions between users and technologies.

8. Conclusions

Using the new developments and technologies, combined with modern ERP-system, allows deploying IT solutions. These solutions provide the co-management of business and technological processes of the Common Information Area of transport and logistics complex. Basis, for an estimation of functioning of an information system, the mutual relation of expenses for system introduction to a positive effect realized by an innovation (improvement of quality of service, decrease in costs, and increase in delivery capacity or reception of additional financial benefit) is. Therefore the Common Information Area assumes carrying

out of an innovation of all key kinds of activity of a transport and logistic complex taking into account consolidating of information streams and strengthening of a role of responsibility.

Now in Russia certain steps on introduction of technologies which are considered as the tool of the organization and information support of all chain of participants on creation, manufacturing and production realization at all stages of life cycle are undertaken. These are systems of the coordination of approaches of rail cars and trains with cargoes to ports, to border stations, systems of electronic exchange between consignors and JSC "Russian Railways", and systems of the preliminary notification about the approach of cargoes to customs points. But effective application of such toolkit probably is only the basis of system of the integrated logistics which is "kernel" of the Common Information area. Application of various variants of reception of access to the Information field will help to create «single point to access» in which it will be possible to receive any information on a course of process of delivery of cargoes to consumers.

References

Framling, K. and Nyman, J. (2008) 'Information architecture for intelligent products in the internet of things', *Beyond Business Logistics proceedings of NOFOMA*, pp. 224-229.

Pfeiffer, D. (2006) 'How train operating companies optimize resource planning', *Railway Update*, No.1, pp.52-55.

Simushkov, A. and Korovyakovsky, E. (2008) 'Principles of formation Common Information area of transport and logistic complex', *Fourth International Railway Logistics Seminar: Cooperation among Transportation Modes in Northern Europe*, pp. 147-163.

Stefansoson, G. (2008) 'The essentials of smart transportation management', *Beyond Business Logistics proceedings of NOFOMA*, pp. 568-580.

Valinnskiy O.S. (2006) 'Logistics technology integration road and sea port', *Railroad transport*, No. 7, pp. 21-24.

Wide gates of Hamburg (2007) *Internet-journal (www.iks-media.ru) IKS-journal*.

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The Effect of Rear Terminal Container Processing Capacity on Seaport Throughput Capacity

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Влияние мощности тылового терминала на общую перерабатывающую способность морского порта

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Abstract
This article is about the interaction between the rear terminal and port which represents mutual transfer of material (transportations of container cargoes and empty container) and information streams (electronic, telephone, telefax, oral, in paper form). The influence of rear logistics terminal on capacity of seaport in course of delivery containers cargo is described. The devices, technology and working conditions, and also features of these terminals by definition of key parameters of port rear terminals are considered.

Keywords: Rear terminal, seaport, cargo transportation, seaport capacity, container, block-train

Аннотация:
Статья посвящена взаимодействию тылового терминала и порта, которое включает взаимную передачу материальных потоков (перемещение груженых и порожних контейнеров) и информационных потоков (электронных, телефонных, телетайпных, устных, на бумажных носителях). Описывается влияние тылового логистического терминала на перерабатывающую способность морского порта в процессе доставки контейнерных грузов. Рассматриваются устройства, технология, производственные условия и параметры этих терминалов, которые являются основными характеристиками тылового морского терминала.

Ключевые слова: Тыловой терминал, Грузовые перевозки, Перерабатывающая способность морского порта, Контейнер, Блок-трейн.

1. Introduction

The rear terminal is the technical object in transport net, located outside of port territory, on some distance from it, also it is intended for sea, automobile and railway transportation mode and serves for effective logistical flow cargo transformation by transfer of various kinds of cargoes from the sea on overland modes of transport and in the opposite. The rear container terminal is an overland terminal which allows expanding port possibilities about processing of container cargoes, increasing port container turnover.

It is necessary to consider the device, technology and working conditions, and also features of these terminals by definition of key parameters of port rear terminals. The great amount of

cargos arrives in TEU and 2 TEU, while 45 feet units are rarer. As one 40 foot container consists of two 20 footer, here exist English TEU or Russian DFE. It is accepted to name transportation of certain quantity of cargo like container stream and to designate its - the letter Qк with corresponding indexes.

Annual turnover of containers arriving in seaport and accordingly on the sea container terminal, we will designate as $Q_{мт.}$ Interaction between the rear terminal and port represents mutual transfer of material and information streams. Material streams are transportations of container cargoes and empty containers. Information streams are transfers of various messages (electronic, telephone, telefax, oral, in paper form). Main types of flows are the following between the sea terminal in port and the rear container terminal:

- Loaded containers (20-footer or 40-foot) of foreign shipping companies (are called – «linear containers») with import cargoes from port to the rear terminal;
- Empty linear containers of the foreign shipping companies that are empty from import cargoes in the sea port – from port on the rear terminal for time storage;
- Loaded containers with export cargoes – from the rear terminal to the seaport;
- Empty linear containers of the foreign shipping companies that are empty after unloading from them of import cargoes on the rear terminal – from this terminal in port for return abroad.

It allowed cargo operations, if the vessels with container cargo using sea transport to port arrive after passage of all customs procedures. It is necessary to examine all logistical chain for possibility of research of estimated capacity influence of rear container terminals on turnover capacity of seaport. In this case it will be a logistical chain of delivery of import foreign trade cargoes by sea transport. Construction of a logistical chain assumes consideration of system and its separate elements. Basic elements of a logistical chain as a system will be the following: moved cargoes (containers), transport (sea, railway, automobile and air), the open and closed warehouses, information streams, and also financial, legal, technical and scientifically-methodical maintenance.

It is presented the network model of logistical chain mixed (intermodal) transportations on Figure 1. Certain quantity of containers with the most various cargos arrives in a seaport within a year or navigation if a seaport is freezing. Moving of containers from a cargo ship is

carried out in the beginning on the container terminal of seaport (SPT), and then some part of containers from this terminal is transported to the rear container terminal (RCT).

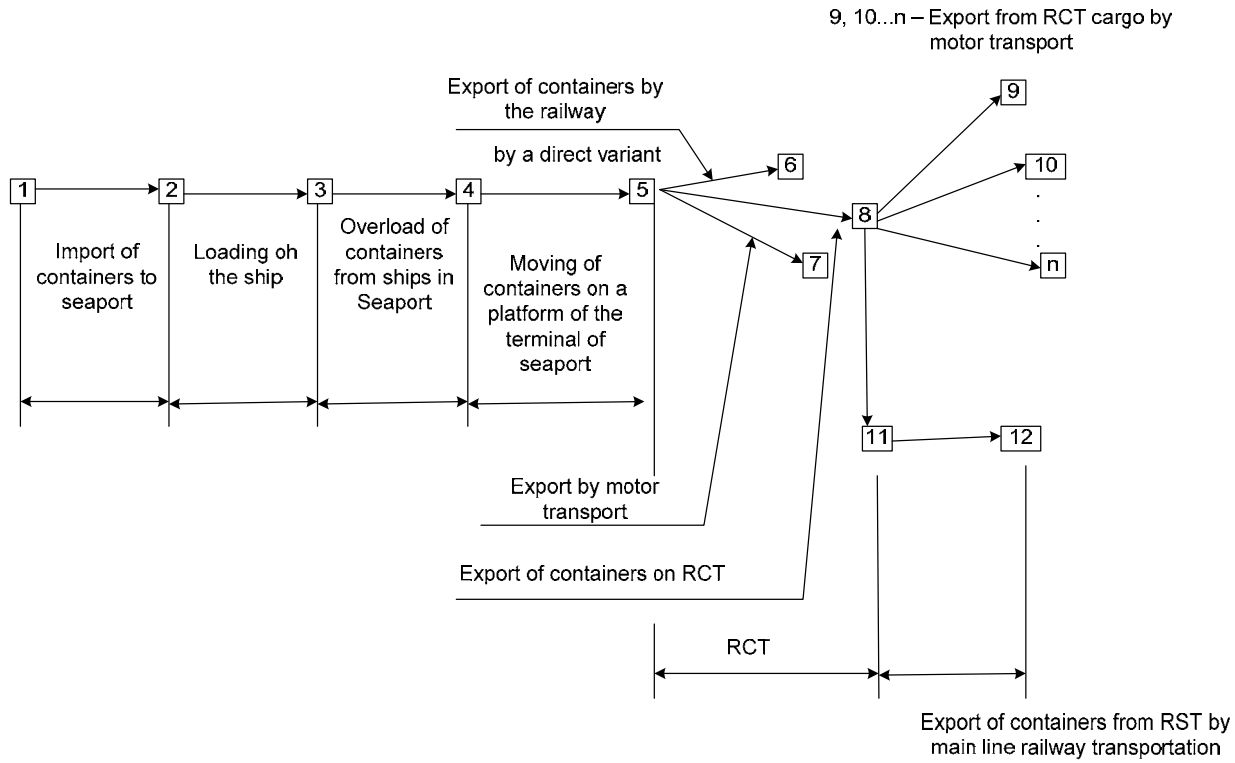

Figure 1. In network model mixed (intermodal) transportations it is necessary to establish the quantity of containers that flows on RCT.

The part of containers from the sea container terminal of port is cleared by automobile and by railway transport in corresponding directions to the different industrial centres, passing the rear container terminal. Quantity of the containers which are cleared from seaport by automobile and railway Q_{mr}, passing TKT will be:

$$Q_{mr}=Q_{spt}\alpha, \qquad (1)$$

where

α is the factor considering quantity of containers which can be cleared from the port terminal by railway and automobile transport, passing RCT, presumably, α = 0,4 – 0,6.

Therefore, quantity of the containers which have arrived on RCT QRCT, it is possible to express dependence

$$Q_{RCT}=Q_{SPT}-Q_{SPT}\,\alpha \quad \text{или} \quad Q_{RCT}=Q_{SPT}(1-\alpha)=Q_{SPT}\beta, \qquad (2)$$

where β – quantity of containers which can arrive to TKT from seaport, presumably, β = 0.4 – 0.6.

Containers can be imported railway and automobile transport on RCT.

It is possible to present following expression the quantity of containers which can be taken out with RCT railway and automobile transport at the same time,

$$Q_{RCT} = \delta Q_{RCT} + \gamma Q_{RCT}, \quad (3)$$

δ – coefficient considering export of containers with RCT by rail, not less, δ = 0,6;

γ – coefficient considering export of containers with RCT by rail, in limits, γ = 0,4.

It is possible to establish the following researching movement of container flow about logistical chain. The logistical chain represents process of transportation of container cargoes from one terminal (seaport) to another (RCT) taking into account loading of platforms on the sea container terminal and unloading of platforms on RCT with the subsequent warehousing of containers. Thus two components of this process will take place:

- transportation,
- cargo transfer and warehousing.

Transportation of containers from one terminal to another will be characterised by following parameters:

- Speed of a vehicle (train),*V*, km/h;
- Transportation Distance, *S*, km;
- Duration of transportation, τ , h or 24-hour period;
- Quantity of the transported cargo in containers $N_к$, st., Or cargo size in containers $Q_г$, t;
- Transportation Cost, C_n, rub.;
- Quantity of platforms m as a part of a pendular train – m - the block-train
- Quantity of haul cycle of the block- train.

The number fitting platforms *m* in structure of the block-train can be defined, proceeding from settlement daily goods traffic of containers on RCT under the formula:

$$m = \frac{Q_{ткт} \times k_н}{T_г \times N_i \times p} \quad \text{or} \qquad m = \frac{Q_{ткт} \times k_н}{365 \times 3 \times p}, \tag{4}$$

where

$Q_{ткт}$ – the plan one year container flow, TEU/y on RCT;

$k_н$ –coefficient of non-uniformity of a daily container flow (is accepted on the similar terminal in a limit 1 – 1,3 (At the regular circulation the block-train between port and the rear terminal under the schedule, we accept $k_н$ =1);

$T_г$ – Number of days in a year, $T_г$ =365days;

N_i – the number of 20-foot containers on fitting platform 60-foot platform, such containers on a platform can be three.

p –Number of dayly feed changes to the terminal.

The quantity of trips the block-trains for transportation of a daily container flow to RCT can be defined with the formula (4)

$$p = \frac{Q_{ткт} \times k_н}{T_г \times N_i \times m} \text{ или } p = \frac{Q_{ткт} \times k_н}{365 \times 3 \times m} \ . \tag{5}$$

The quantity of platforms in structure of block-train is expedient to accept as 41.The Operation «transferring cargo and warehousing» will characterise the following parameters:

- The Arrival time of containers by train on RCT – t_n;
- Time of departure of containers from RCT with other types of transport – t_y;
- Time Interval between arrival and departure of container cargoes - Δt, dayly;
- The Period of storage of container cargoes on RCT, T_{xp}, dayly;
- Capacity of warehouse of arriving container cargo about import E_T, thousand, st;
- Cost of processing and cargo storage in the outside and inside warehouse – C_{xp}, rub.

If we know the quantity of containers which arrives during a year, for example, in the seaport of St.-Petersburg, it is possible to construct the diagram of delivery of part of container flow on RCT. While analysing the container turnover in seaports from 2004 to 2008, research shows the greatest quantities of containers were handled in 2007. This year on indicators of port work comes to forward planning [4,5]. The following perspective indicators container

turnover of the rear container terminal since 2007 till 2010 which are received and presented in the form of the schedule on Fig. 2 Basing of data of turnover of goods on RCT of St.-Petersburg seaport and programming on the computer with application of means Microsoft Excel.

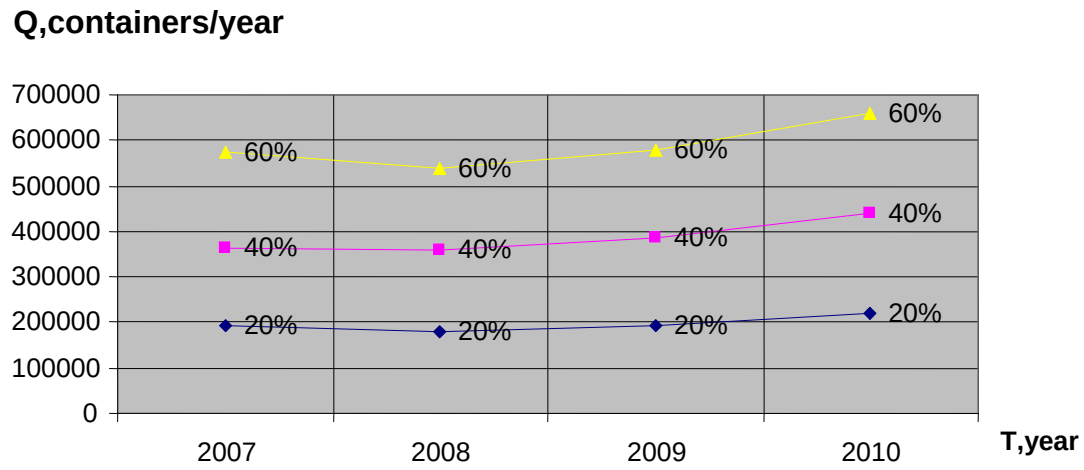

Figure 2. The graph of the perspective annual containers' turnover of RCT.

The volume of containers transportation on RCT can be realised within 20; 40; 60 percent of a goods turnover of seaport depending on possibility of the rear container terminal, quantity of block-train trips or the several block- train. Daily carrying capacity in case of transportation of containers only in one party can be defined the block-train under the formula:

$$Q_{mкm} = \frac{24}{T_{б-m}} m_i \times N_i \times f \text{ , TEU/dayly,} \qquad (6)$$

where 24 hours – duration of days, hour;

$T_{б\text{-}m}$ – duration of 1 full trip of the block-train, hour;

m_i – number of fitting platforms in structure the block- train;

N_i –Number of 20-foot containers transported on one fitting platform for full trip of the block-train:

N=3 using transportations only in one direction,

f – coefficient of filling the block-train with containers is 0,9 – 1,

During the year or navigation if the seaport is freezing, the quantity of containers which is necessary for taking out from the sea container terminal on RCT, is presented in the form of

model, the formula (2). It is expedient for carrying out railway transportation between seaport and the rear container terminal basically only by means of ring routeing trains, the block-trains. These trains can go under the firm schedule some times in day and have full structure from 41 fitting platforms or incomplete structure from 12 – 20 platforms (depending on the sizes of a container flows consisting from 20 or 40 foot containers and other local conditions). The quantity of block-train turns the depending on quantity of platforms in its structure (12, 20 or 41-s' platform) is presented on the graph fig. 4 received as a result of programming of the data on the computer with application of means Microsoft Excel.

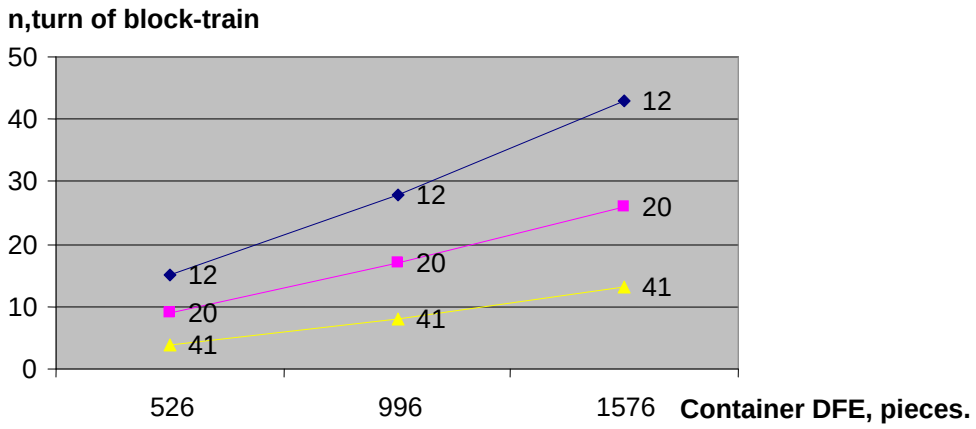

Figure 3. Quantity of the block-train flights per day for transportation containers DFE on the RCT: 12; 20; 41 – possible quantity of the fitting platforms on the block-train.

The graph on Figure 3 shows the following:

- It is expedient, that there were as much as possible platforms in structure the block-train;
- The number of daily block-train turns increases or it is required to increase quantity of block-trains with increase of quantity of carrying out containers from the sea container terminal on RCT;
- It will be probably required to increase quantities of receiving-and-departure tracks on RCT and transhipping areas.

Estimated capacity of RCT is an indicator of its productive capacity and it also reflects the possibility of terminal to unload railway train with container cargoes, to carry out their time warehousing and storage, to load containers on the main or local kinds transports for the

certain period of time at rational technology and the organisation of performance of the basic and auxiliary operations of reloading process.

Estimated capacity of RCT is measured in quantity of discharge or loaded containers and it is also depends on the following factors:

- Cargo handling area extents of means of transport on RCT;
- Productivity of materials fuel handling vehicle;
- Estimated capacity of container areas and warehouses, connecting railway tracks and auto ways;
- Tonnage and the characteristic of fittinng platform;
- Time of containers export from the sea container terminal.

It is possible to express processing ability of cargo fronts with the formula

$$N_{см}^{ф} = \sum_{1}^{n_i} N_{см}^{ф_i}, \qquad (7)$$

где $N_{см}^{ф_i}$ – estimated capacity of *i*-th cargo area;

n_i – quantity of cargo area.

It is possible to express estimated capacity of cargo area, cont./dayly (using of materials fuel handling vehicle) with the simplified formula which receives as a result of transformation of the formula of Poljacheka-Hinchena [2].

$$N_{см}^{ф} = \frac{\tau_{\omega} z_n (1 - T_{mex})}{2\left[2\tau_{\omega}\tau_{об} + \tau_{об}^2 (1 + c_{тоб}^2\right]}, \qquad (8)$$

где τ_{ω} – mathematical expectation of service duration of one container, dayly;

$\tau_{об}$ – mathematical expectation of duration idle trip materials fuel handling vehicle, сут.;

z_n – quantity of materials fuel handling vehicle;

$c_{тоб}$ – coefficient of time service variation (it is recommended to accept $c_{тоб}$ =0.52);

T_{mex} – duration of a technological break in work of materials fuel handling vehicle, Shares of days.

Expected daily container flow on the sea container terminal (SPT) is worked out (which is subject to carry out on the rear container terminal (RCT)):

$$Q_{сут}^{расч} = \frac{Q_{МТ}(1-\alpha)\kappa_{н}}{T}\ , \qquad (9)$$

where $\kappa_{н}$ – coefficient of dayly cargo carrying out inequality;

T– time of working in the period of navigation;

α – coefficient, that characterises export of containers from seaport, passing RCT;

Q_{MT} – annual container turnover of sea port.

Therefore, capacity of МКТ is

$$E_{м} = \frac{Q_{МТ}(1-\alpha)\kappa_{н}}{T} t_{хр}^{м}, \qquad (10)$$

where $t_{хр}^{М}$ – time of container storage on SPT,

$\kappa_{н}$ – coefficient of dayly cargo carrying out inequality on SPT.

It is possible to define the same way dayly container fow, that comes to RCT. Therefore the capacity of RCT is

$$E_{т} = \frac{\beta Q_{к}\kappa_{н}}{T} t_{хр}^{Т}, \qquad (11)$$

where $\beta Q_{к}$ – annual container flow, that carries out to RCT from sea port terminal;

where $t_{хр}^{Т}$ – time of container storage on ТКТ.

For full port release from containers, capacity of RCT should accumulate all taken out containers from МКТ, i.e.

$$E_{М} = E_{т} \text{ или } \quad \frac{Q_{МТ}(1-\alpha)\kappa_{н}}{T} t_{хр}^{М} = \frac{\beta Q_{Т}\kappa_{н}}{T} t_{хр}^{Т} \qquad (12)$$

After receive $(1-\alpha)t_{хр}^{М} = \beta t_{\text{хр}}^{Т}$, then

$$t_{хр}^{Т} = \frac{(1-\alpha)t_{хр}^{м}}{\beta} = t_{в}, \qquad (13)$$

Where $t_в$ – time of container carrying out from sea port terminal.

Under the conditions $\beta = (1-\alpha)$, receive:

$$t_{xp}^{м} = t_{xp}^{T} = t_в, \text{ daily.} \qquad (14)$$

Thus, it is possible to come to conclusion that influence of estimated capacity of rear container terminals on capacity of seaport at processing of container cargoes is connected with containers staying on the sea container terminal and time of containers staying on RCT.

The container seaport terminal is the important link of a logistical chain under the conditions transfer of goods traffics on railway transportation. Terminal capacity is defined by estimated capacity of reloading complexes and the rear container terminal. Container seaport terminal capacity depends on its processing capacity and it is defined by a logistical chain « SPT – warehouses – railway cargo front – a container train in structure of fitting platforms – RCT». It is necessary the presence of the high-efficiency reloading equipment and sufficient size of containers on the terminal for an exception of idle times of a train about containers export. It is presented the logistical scheme of containers movement from SPT to TKT and with an overload on railway and automobile transports for container cargoes export (fig. 1).

It is necessary to make certain capital investments under the construction of the rear container terminal. The quantity of containers will also essentially increase at the same time processed in common seaport and the rear container terminal (Figure. 4). It is possible to assume that in some years of co-joint operation of sea and rear container terminals, there will be a recoupment of capital investments in building of the rear container terminal.

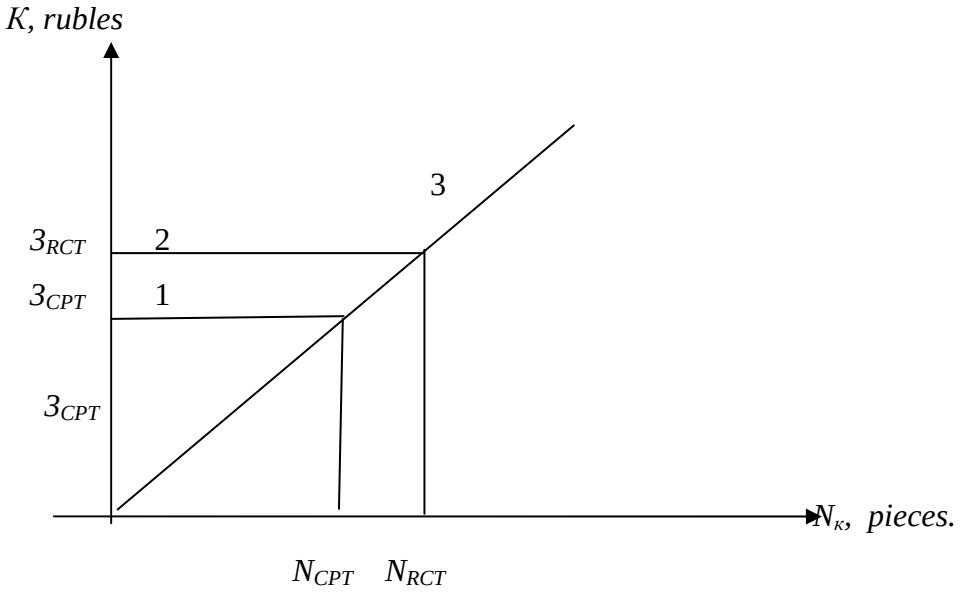

Figure 4. Dependence of expenses from quantity of the transported containers:
1. 3_{CPT} – Dependence of expenses from quantity of the transported containers through the seaport terminal;
2. 3_{RCT} – Dependence of expenses from quantity of the transported containers through RCT;
3 – Growth of quantity of the containers arriving to seaport.

Figure 4 shows that the expenses connected with building RCT, will become covered by growth of container transportations in sea port. The quantity of the containers arriving from seaport on RCT, will provide a gain of container transportations through seaport $\Delta N_к$

$$\Delta N_к = N_{мтп} - N_{мт} \longrightarrow max, \quad (14)$$

where $N_{мт}$ – existing container flow,

$N_{мтп}$ – perspective container flow.

From anithe side

$$\Delta N_K = p_i * m_i * N_i * T_г, \quad (15)$$

where p_i – quantity of trips of block-train dayly; m_i – quantity platforms in в block-train; N_i – quantity of container TEU on one platform;

$T_г$ – quantity of days in a year of container carry out from sea port to rea container terminal.

It is obviously possible to bring some correction in the formula offered for definition of estimated capacity of seaport as a result of making research and to present this formula in a following way:

$$П_{пк}=к_{п}П_{м}+(1-к_{э})П_{м}+П_{ткт}, \quad (16)$$

where $П_{пк}$ – estimated capacity of container terminal od seaport;

$П_{м}$ – estimated capacity of transhipping complex on maritime port;

$к_{п}$ – coefficient, that characterises correlation of depot capacity $П_{ск}$ and a reloading complex on a sea mooring; $к_{п}=\frac{П_{ск}}{П_{м}}\leq 1;$

$к_{э}$ - correlation of the used estimated time by unloading of the vessel using warehouse variant to к расчетному calculated monthly period.

$П_{ткт}=N_{см}^{ф_i}$ – estimated capacity of cargo area of RCT according to formula (8).

Thus, estimated capacity of seaport should be considered as set of throughput estimated capacity of a reloading complex on a sea port, throughput estimated capacity of the seaport container terminal, processing ability of cargo front RCT with the subsequent export of container cargoes from this terminal.

References

Frank S.O. and Kolik A.V. (2006) ‘To the problems decision of placing of container terminal complexes’, *Transport. A science, technics, management*, No. 9, pp. 9-11.

Kapitonov A.E. (2001) *The organization of container transportations on the basis of logistics principles*. The author's abstract PHd on competition of a scientific degree of PHd. St.-Petersburg.

Malikov O.B. (2005) *Warehouses and cargo terminals*. The directory. – SPb.: the publishing house of “Business press”.

Matvienko V.I. (2008) ‘Without complicating a transport situation’, *Container business*, No. 4, Issue 16, pp. 56-57.

Moroyov V.H. (2007) ‘Open Society "Russian Railway" and ports: development of interaction’, *Transport. Science, technics, management*, No.8, pp.15-18.

Vetrenko L.D. (2000) Management seaport work. – SPb: Joint-Stock Company "Stroka".

Yakunin, V.I. (2007) ‘New forms of railway and sea transport interaction in the conditions of globalisation of the international cargoes transportations’, *Transport. A science, technics, management*, No.8, pp. 4-9.

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Methods of Warehouse Stock Determination

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Методы определения складских запасов грузов

Олег Маликов

Abstract
The problem of stock at warehouses determination is very important for supply chains' projecting and management. Usually the problem is searched theoretically while considering some supply chains, which contain several warehouses with their stock. These researches mostly are concerned only supplying warehouses, although there are many other types of warehouses in supplying chains. Besides there are practical tasks, warehouse activity is connected with cargo handling and stocks' fluctuation. These procedures significantly influence on efficiency of work both – transport and warehouses and the whole supply chains. Their projecting sometimes is underestimated and considered as very simple procedure. Some methods of taking into account the warehouse stock changing in warehouses projecting are displayed in this article.

Keywords: Logistic chain, warehouse, stock, material flows, unevenness, cargo, capacity, probability, transport

Аннотация
Проблема определения запасов грузов на складах очень важна для цепей поставок. Она усложнена тем, что запасы грузов представляют собой случайную величину, меняющуюся под воздействием случайных грузопотоков приема и выдачи грузов со складов. Но ем-кость складов, которая является одним из основных их параметров, - должна быть вели-чиной постоянной при выбранном способе складирования. Для преодоления этого проти-воречия используют следующие методы определения расчетной величины запасов и ем-кости склада: с использованием среднего срока хранения грузов на складе; как математи-ческого ожидания случайной величины запасов; на основе доверительной вероятности; на основе сопоставления вероятностей величин суточного приема и выдачи грузов со скла-да; имитационным моделированием складских запасов на компьютере.

Ключевые слова: Логистическая Цепь, Склад, Запасы, Грузопотоки, Неравномерность, Груз, Перерабатывающая способность, вероятность, Транспорт

1. Introduction

Sometimes warehouse stock is considered as the most important problem in supply chains management. But before management of some system such as supply chain it is necessary to create this system, for example it should be firstly projected, organized or its facilities should be built and put into action. It is not enough for this to know some constant level of warehouse stock, because material flows coming into and out of warehouses can change from day to day. So the warehouse stock is changed also. Under these conditions it is very difficult to project warehouse and particularly to determine warehouse dimensions and capacity.

However, all main parameters of a warehouse and whole investments on its building and operation costs significantly depend on the level of the stock, keeping in it. And this stock level should be of some specific value.

2. Simplest Methods

Nowadays warehouse stock in projecting more often is calculated on base of regular terms of stock keeping at warehouse. These terms were established on foundation of real experience of warehouses operation in different industries. With this method the warehouse capacity is computed as follows:

$$E=\frac{Q}{365}*t\,, \qquad (1)$$

where Q – annual value of material flow (in tones, units or m^3); t - term of stock keeping at the warehouse.

Drawback of this method is constant value of capacity, which does not take into account real conditions of changing of the warehouse stock. In real condition of warehouse operation the quantity stock is a some function of time and parameters of material flow going in Q_1 and out of the warehouse Q_2 :

$$I = f\,(t, Q_1, Q_2\,). \qquad (2)$$

So as changing of material flows, connecting with warehouse, are some stochastic processes, warehouse stock is also an unknown stochastic process. But warehouse dimensions and capacity are constant valuables for every specific warehouse. This contradiction can be overcome with special methods of warehouse stock calculation.

As was displayed in the Warehouse System Theory, developed in scientific works and books of the author [1, 2, 3], a warehouse should be considered as a technical system, i.e. as a complex of interconnected elements, created for reaching of united objective. The purpose of warehouse is transformation of material flows, which are going through it, with the least spending of 6 main resources – space, time, materials, labor, energy and money. This transformation is fulfilled for provision the most efficient further transportation or using of cargo. Temporary keeping and management of the merchandise stock are some part of

technological operations, executed for this transformation of material flows. The warehouse system can be characterized with capacity E of its main storage area, additional capacity ΔE of its other areas (reception-dispatching areas, loading-unloading docks etc.) and real quantity of merchandise I, remaining at the moment at the warehouse.

Interaction of these valuables for supplying and transferring warehouses is shown in Figure 1. The difference between these warehouses is the purpose of their activity. The supplying warehouse should keep some insurance stock I_0 , that must provide supplying of consumers in case of interruption of cargo arrival to the warehouse.

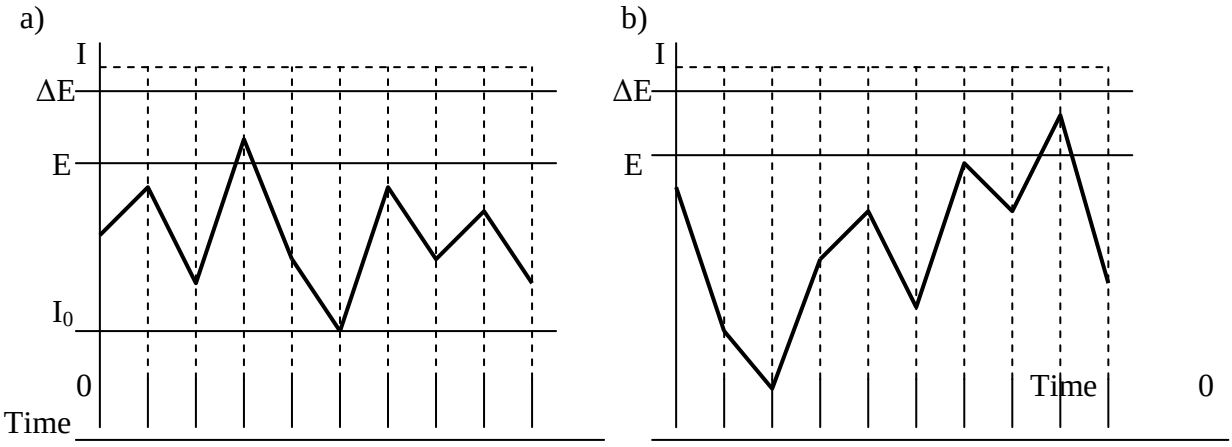

Figure 1. Interaction of stock fluctuation I and constant values capacity of storage area E and additional capacity ΔE of other areas for supplying warehouse (a) and transferring warehouses at long-distance transport (b).

For both these types of warehouses the stocks are fluctuating between two levels, but these levels are different for these ones. In supplying warehouse the stocks fluctuates from insurance stock I0 to the warehouse storage area capacity E (and sometimes up to additional capacity some other areas ΔE). In transferring warehouse the stocks fluctuates from 0 to the warehouse storage area capacity E (and sometimes up to additional capacity some other areas). Therefore, in The Theory of Scientific Stock Management several two-level methods of stock management were developed. The consideration of these methods goes over the limits of this article.

Function of warehouse stock, depending on time t I = f (t) for constant time steps (for example – days) can be represented in form of polygon as shown in Figure 2.

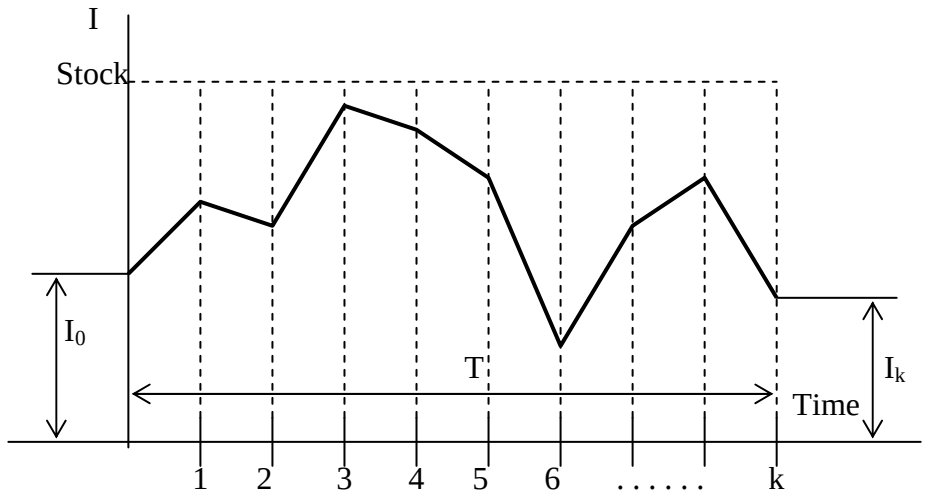

Figure 2. Polygon of warehouse stock function I = f (t) as depending on time.

While researching way of warehouse stock transformation, the warehouse is considered as some “black box”, which configuration is unknown and only its changing under influence of two flows – going in and out of the warehouse - are taking into account. This process can be described with function I = f (t). Having integrated this function by time it is possible to determine the whole quantity of cargo W, which was kept at the warehouse for some period T. However, type of this function is usually unknown. Therefore the value W can be calculated with assistance of polygon of function, shown in Figure 2. In this case in is convenient to us formulas of trapezium:

$$W = \frac{\Delta t}{2}(I_0 + 2 * \sum_{i=1}^{k} I_i + I_k), \qquad (3)$$

where Δt – value of time interval; I_0 and I_k –respectively initial and finish values of warehouse stock; k – number of time intervals (for example days or months).

Then average warehouse stock:

$$I = \frac{W}{T}, \qquad (4)$$

where T – the whole time of consideration.

Now the average time of cargo remaining at the warehouse:

$$\tau = \frac{W}{\sum_{i=1}^{k} Q_i} \quad \text{or} \quad \tau = \frac{W}{\lambda}, \qquad (5,6)$$

where λ - average intensiveness of cargo arrival to the warehouse.

3. Probability Methods

There are several methods of warehouse capacity determination, that taking into account casual processes of arrival and dispatching of material flows from warehouse. It is possible to calculate warehouse capacity as Mathematic Expectation M (I) of warehouse stock I:

$$E = M(I) = \sum_{i=1}^{n} I_i * P_i, \tag{7}$$

where I_i - i-value of warehouse stock during time of stock research;

P_i - conforming Probability of i-value appearance;

n - the whole number of considering values of warehouse stock.

For using this method probability distribution of the warehouse stock should be created firstly, that can be fulfilled on the statistic base:

$$I = \begin{Bmatrix} I_1 & I_2 & \dots & I_n \\ P_1 & P_2 & \dots & P_n \end{Bmatrix}, \tag{8}$$

where I_1 I_2 . . . I_n - statistic election of warehouse stock in a warehouse, similar to that under consideration;

P_1 P_2 . . . P_n - conforming probabilities of these stock values, that can be calculated with using of number of days in which the relative stock value has been observed:

$$P_1 = \frac{D_1}{365}, \quad P_2 = \frac{D_2}{365}, \quad \dots, \quad P_n = \frac{D_n}{365}. \tag{9}$$

Other method of warehouse stock and capacity determination is one with assistance of Creditable Probability. In this case the warehouse capacity is calculated not as one specific value, but as only possible value with creditable possibility, for example 0,95 or 0,97. Other cases of 0,05 or 0,03 probability are considered as very rare and therefore they can be neglected. For this method using also as in the previous case probability distribution of the warehouse stock should be produced, as mentioned above. For the warehouse stock determination it is necessary to know the law of distribution of the stock :

$$F(I) = \sum_{i=0}^{n} I_i, \tag{10}$$

In Figure 3 an example is shown of warehouse stock determination for creditable possibility P=0.95.

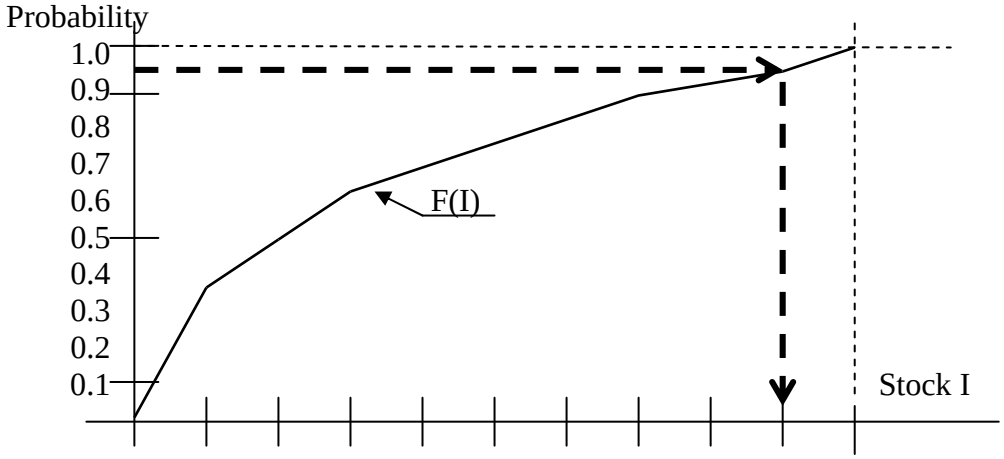

Figure 3. Graph of warehouse stock distribution cumulative function F(I) with an example of stock determination for creditable probability P=0.95.

4. New Method of the Warehouse Stock and Capacity Determination

This method of warehouse capacity was created at Petersburg University of Transport Engineering in the 80th and was used while projecting a lot of warehouses for various industries. It does not request to form graph of distribution F(I) and contains only mathematic calculations. So it is possible to fulfill this method on computer and optimize capacity of warehouse with taking into account casual fluctuations of going in and out material flows.

The following probability distributions should be designated as initial data:

of arriving flow: $$Q_a = \begin{Bmatrix} Q_{a1} & Q_{a2} & \dots & Q_{an} \\ P_{a1} & P_{a2} & \dots & P_{an} \end{Bmatrix};$$ (11)

of dispatching flow: $$Q_d = \begin{Bmatrix} Q_{d1} & Q_{d2} & \dots & Q_{dm} \\ P_{d1} & P_{d2} & \dots & P_{dm} \end{Bmatrix}.$$ (12)

The core of this method is calculation of warehouse capacity as casual i-event, which is represented combination of probable values of flows going in Q_a and out of the warehouse Q_d:

$$I_i = I_0 + Q_{ia} - Q_{id},$$ (13)

where I_0 - is some initial or insurance stock, that is set depending on type of warehouse and some other conditions.

Probability of i-stock at the warehouse is calculated with formula:

$$P(I = I_i) = P(Q_{ai}) * P(Q_{di}),\ i = \overline{1,nm}, \quad (14)$$

where $P(Q_{ai})$ and $P(Q_{di})$ - conforming probabilities, that Q_{ai} cargo would arrive to the warehouse and Q_{di} cargo would be dispatched from the warehouse;

n – number of values in the flow going into the warehouse;

m - number of values in the flow going out of the warehouse.

Block-chart of algorithm of calculation the warehouse capacity by this method for designated Creditable probability “p” is shown in Figure 4.

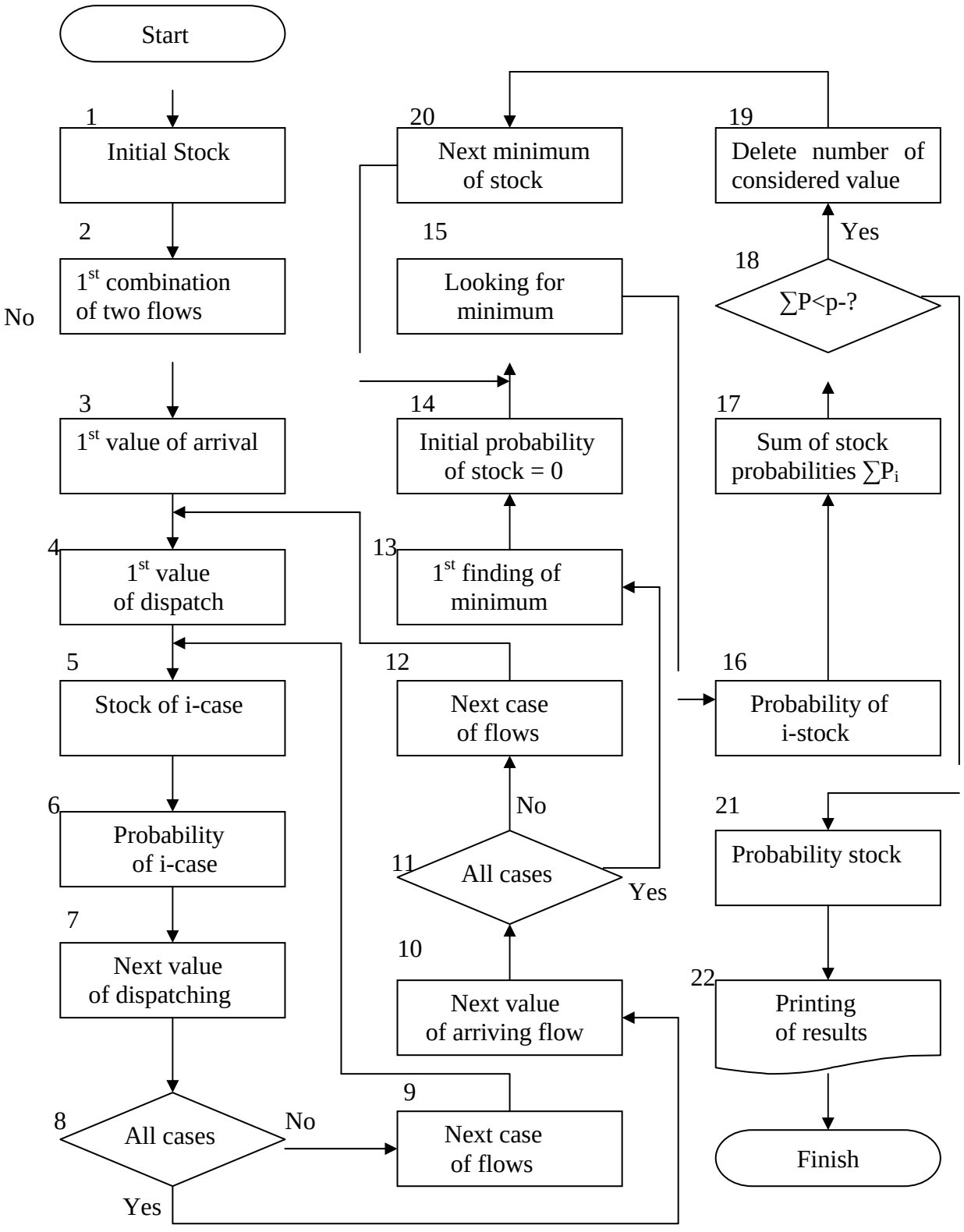

Figure 5. Algorithm of the method of stock calculation using material flows' probability combination.

Calculation of warehouse capacity with the mentioned method under simple conditions (when n and m are not more than 3-4) can be easily produced just on-hand, that is confirmed by the following example. Let accept that it is necessary to determine capacity for a warehouse, which experienced the following material flows:

arriving flow: $Q_a = \begin{Bmatrix} 120 & 150 & 200 \\ 0.20 & 0.60 & 0.20 \end{Bmatrix}$; (15)

dispatching flow: $Q_d = \begin{Bmatrix} 140 & 180 \\ 0.65 & 0.35 \end{Bmatrix}$, (16)

where 120, 150, 200 - number of transport batches (railway cars, trucks etc.), that arrive to the warehouse for some period of time;

0.20, 0.60, 0.20 – conforming probabilities of these arriving quantities;

140, 180 - number of transport batches, that dispatch from the warehouse from the same period of time;

0.65, 0.35 - conforming probabilities of these dispatching quantities.

Let us determine initial stock from the condition, that the warehouse was not empty at the beginning:

$$I_0 = 180 - 120 = 60 \text{ batches},$$

where 180 and 120 – minimal values relative arriving and dispatching flows into and out of the warehouse. Assign the creditable probability of the stock calculation p = 0,95.

Let us calculate all the possible unions of arriving and dispatching material flows (there may be only 6 such unions):

1st combination: Stock = 60+20-140=40; probability of the stock: P(I=40)=0.20*0.65=0.13;

2nd combination: Stock = 60+20-180= 0; probability of the stock: P(I=0)=0.20*0.35=0.07;

3rd combination: Stock = 60+150-140=70; probability of the stock: P(I=70)=0.60*0.65=0.39;

4th combination: Stock = 60+150-180=30; probability of the stock: P(I=30)=0.60*0.35=0.21;

5th combination: Stock = 60+200-140=120; probability of the stock: P(I=120)=0.20*0.65=0.13;

6th combination: Stock = 60+200-180=80; probability of the stock: P(I=180)=0.20*0.35=0.07.

It is necessary to verify that these cases form full group of events (in this case the sum of their probabilities must be equal 1.00):

$$\sum_{i=1}^{6} P_i = 0.13+0.07+0.39+0.21+0.13+ 0.07 = 1.00.$$

The standard condition is observed. Thus probability distribution of warehouse stock as cooperation of two fluctuating flows has been formed:

$$Q_a = \begin{Bmatrix} 0 & 30 & 40 & 70 & 80 & 120 \\ 0.07 & 0.21 & 0.13 & 0.39 & 0.07 & 0.13 \end{Bmatrix} .$$

Now the cumulative function of stock distribution (from less stock up to the bigger ones) can be produced:

I	0	30	40	70	80	120
F(I)	0.07	0.28	0.41	0.80	0.87	1.00.

From this function it can be seen that creditable probability having been assigned as p=0.95 is located between 0.87 (for stock 80 batches) and 1.00 (for stock 120 batches):

$$0.95 \in [0.87;1.00] .$$

So design value of warehouse capacity may be determined in interval of possible stock $E \in [80;120]$ with formula of linear interpolation:

$$E= 80 + \frac{0.95 - 0.87}{1.00 - 0.87} * (120 - 80) = 105 \text{ transport batches.}$$

5. Using the Queue Theory for Warehouse Capacity Determination

With using of the Queue Theory methods the warehouse capacity may be determinated without preliminary gathering statistics and formation of probability distributions. But the drawback of these methods is calculation with some average values. The author used the mathematic model of “destroying & multiplying” to produce a method of warehouse capacity determination with assistance of The Queue Theory.

In this case a warehouse is considered as many-channel mass-service system, with a place for keeping of cargo representing a canal of service of one transport batch (cargo from a truck or a railway car). “Refusal” is an event when the storage area is completely full and there is no room for reception next transport batch, which is considered as entry, which needs to be serviced, i.e. unloaded, received and put to the place of storage.

The process of entry service is considered as keeping merchandise in warehouse during some time τ, so that intensiveness of entry flow:

$$\mu = 1/\tau. \qquad (17)$$

The storage area can be in one of the following states W_i (see Figure 7):

W_0 – no place in the warehouse is occupied, i.e. the warehouse is empty;

W_1 – there is one transport batch in the warehouse;

W_2 - there are two transport batches in the warehouse;

W_3 – there are three transport batches in the warehouse;

. . . .

W_k - there are k transport batches in the warehouse (k places are occupied, other n-k places are empty);

W_n - there are n transport batches in the warehouse (all the n places are occupied, no places are empty);

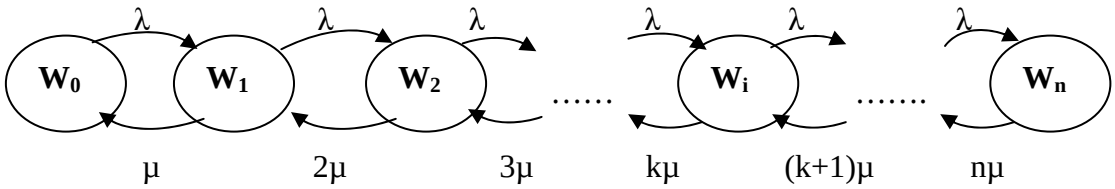

Figure 7. Marked graph of states and transitions of the warehouse system relative its storage area occupation.

From every states to another one in direction of increasing its stock (to the right) the warehouse system transfers with intensiveness of λ in the moment, when the next transport batch comes into its storage area. So the system occurs in the (i+1) state.

Transition the warehouse system in direction of decreasing its stock (i.e. to the left in the Figure 7, from the i-state to the (i-1)-state) is happened with intensiveness of $k\mu$ in the moment, when a new transport batch is dispatched from the warehouse.

In according to the Queue Theory probability of storage area to be empty may be calculated with formula:

$$P(W_0) = \left(1 + \frac{\lambda}{\mu} + \frac{\lambda^2}{2\mu^2} + \frac{\lambda^3}{2*3\mu^3} + ... + \frac{\lambda^k}{k!*\mu^k} + ... + \frac{\lambda^n}{n!*\mu^n}\right)^{-1} \quad (18)$$

or with taking into account expression (17):

$$P(W_0) = \left(1 + \lambda\tau + \frac{1}{2}\lambda^2\tau^2 + \frac{1}{2*3}\lambda^3\tau^3 + ... + \frac{1}{k!}\lambda^k\tau^k + ... + \frac{1}{n!}\lambda^n\tau^n\right)^{-1}, \quad (19)$$

where λ - intensiveness of the entering flow.

Probability of only one transport batch at the warehouse (k=1):

$$P(W_1) = \frac{\lambda}{\mu} * P(W_0), \quad => \quad P(W_1) = \lambda\tau * P(W_0); \quad (20)$$

Probability of two transport batches at the warehouse (k=2):

$$P(W_2) = \frac{\lambda^2}{2\mu^2} * P(W_0), \quad => \quad P(W_2) = \frac{\lambda^2\tau^2}{2} * P(W_0), \quad (21)$$

Probability of k transport batches at the warehouse (k<n):

$$P(W_k) = \frac{\lambda^k}{k!\mu^k} * P(W_0), \quad => \quad P(W_k) = \frac{\lambda^k\tau^k}{k!} * P(W_0) \quad (22)$$

Probability of n transport batches at the warehouse, i.e. when the storage area of the warehouse will be completely occupied:

$$P(W_n) = \frac{\lambda^n}{n!\mu^n} * P(W_0), \quad => \quad P(W_n) = \frac{\lambda^n\tau^n}{n!} * P(W_0). \quad (23)$$

Now it is possible to determine probability of the storage area to be full not completely and next transport batch can be received into the warehouse:

$$P(k< n) = 1 - \frac{\lambda^k\tau^k}{k!} * P(W_0). \quad (24)$$

Having designated average stock of cargo at the warehouse $I = \lambda\tau$, it is possible the expression of probability of empty storage area rewrite in the following view:

$$P(W_0) = 1/\left(1+\sum_{k=1}^{n}\frac{I^k}{k!}\right) \quad . \tag{25}$$

Then probability that there will be some room for cargo at the warehouse (24):

$$P(k<n) = 1-\frac{I^k}{k!}*\frac{1}{1+\sum_{k=1}^{n}\frac{I^k}{k!}} \quad . \tag{26}$$

Changing the row, that is divider in this formula to e^I according to research of Macloren , receive probability of empty warehouse:

$$P(W_0) = \frac{1}{e^I} \quad => \quad P(W_0) = e^{-I} . \tag{27}$$

Now the formulas (22) and (24) may be written in the following view:

Probability of k transport batches at the warehouse (k<n):

$$P(W_k) = \frac{I^k}{k!}*e^{-I} \quad ; \tag{28}$$

Probability that the storage area is not full completely and there is room for the next transport batch to be received into the warehouse:

$$P(k<n) = 1-\frac{I^k}{k!}*e^{-I} \quad . \tag{29}$$

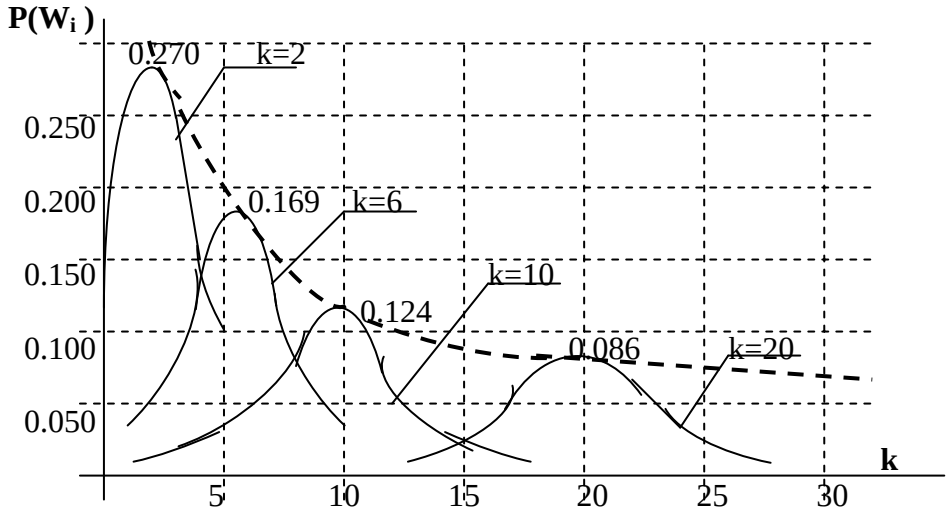

Figure 8. Character of probability of having room for cargo at a warehouse **P(W$_i$)** as depending on number of transport batches **k** at the warehouse at the moment.

Distributions of occupying storage area of the warehouse as calculating by the formula (29) are displayed in Figure 8. It can be seen from this picture that average stock at the warehouse

I = λτ conforms to the most probable stock and shows vertexes of the graph curves. However the stock may be exceeded and in this case capacity of the storage area would occur to be not enough. For practical use this new method of capacity warehouse determination, the graphs of cumulative functions of stock distribution were produced which are shown in Figure 9. The graphs were formed with the following formula:

$$F(W_k) = \sum_{k=1}^{n} \frac{I^k}{k!} * e^{-I} \quad . \tag{30}$$

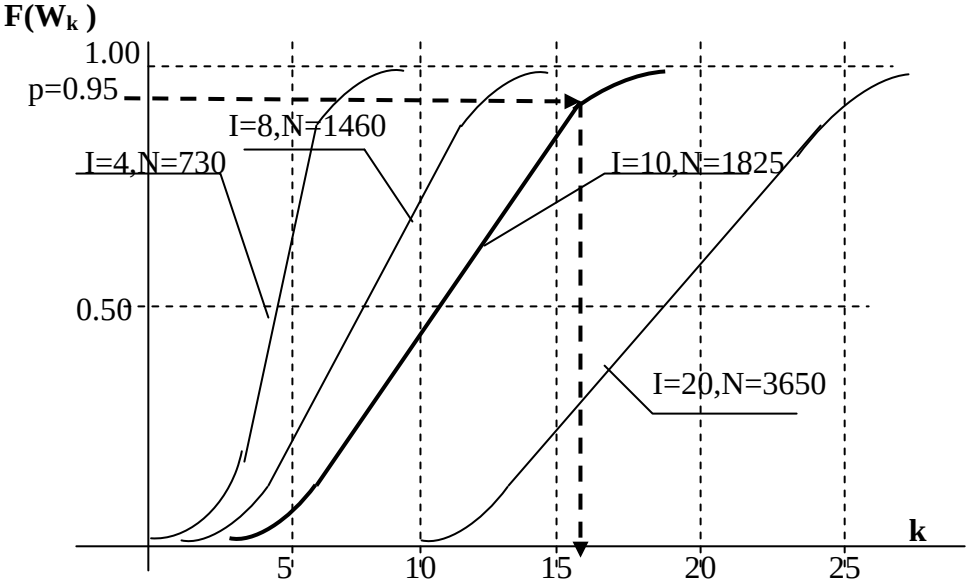

Figure 9. Graphs of Cumulative Function of warehouse capacity distribution **F(W$_k$)** as depending on transport batches number **k** for transferring warehouse with average term of cargo keeping 2 days (example is shown of warehouse capacity determination for capacity I=10 batches, annual flow N=1825 batches and creditable probability p=0.95)

6. Warehouse Capacity Determination Using Simulation

The task of determination of warehouse stock and capacity can be resolved by way of simulation on computer, but for this it is necessary to have special program, that is rather expensive (as a matter of act under Russian conditions). Simulation of warehouse stocks provides possibility to determine them rather precisely. Although for that it is also necessary to know the laws of material flows distributions – arriving to the warehouse and dispatching out of it. These laws are to be formed in the same manner as in methods of using probabilities.

The algorithm is based on the continuance equation:

$$Q_1 - Q_2 = \frac{\Delta I}{\Delta t}, \qquad (17)$$

where Q_1, Q_2 - arriving and dispatching quantities of cargo;

ΔI – changing of the warehouse stock;

Δt – period of time, for which the stock has changed by value of ΔI.

The initial data for simulation include laws of material flow going in and out of the warehouse and number of simulation experiences n. The flows can be assigned in view of tables, probability distribution or formula. While simulation is in process the warehouse stock the laws of casual quantities of arriving and dispatching cargo are formed with assistance of pseudo-casual numbers, evenly distributed in the interval [0,1] and on the foundation of assigned statistic distributions of material flows. The computer program, having created values of in-going quantity of cargo Q_1 and out-going quantity Q_2 in every i-cycle of simulation experience calculates the warehouse stock as follows:

$$I_i = I_{i-1} + Q_1 - Q_2 , \qquad (18)$$

where I_{i-1} - the warehouse stock in the previous, (i-1)-cycle of simulation experiences, that for the first cycle of simulation is taken equal to safe stock for a supplying warehouse and can be taken equal to 0 for a transferring warehouse at long-distance transport.

The number of experiences should be big enough (for example – 365 days, i.e. one year), so that the results received statistical steadiness and with determine probability could be acknowledged to be true. Such simulation model was worked out at the Freight & Logistics Department of Petersburg State University of Transport Engineering. In is displayed below:

```
  * GPSS - Inventory Management
*************************************************************************
*                                                                       *
*            Order Point Inventory System                               *
*                                                                       *
*************************************************************************
*  Initialize and define
          INITIAL    X$ACB,150         ;Arrival Cargo Batch.
          INITIAL    X$Point,300       ;Order point
          INITIAL    X$Stock,1000      ;Set initial stock = 1000
Inventory TABLE      X$Stock,300,50,7  ;Table of stock levels
Sales     TABLE      P$Demand,70,10,7  ;Table of dispatches per day
Var2      VARIABLE   RN1@24+40
*************************************************************************
          GENERATE   ,,,1
Again     TEST L     X$Stock,X$Point   ;Test of stock level
          ADVANCE    1                 ;Skip over time of 1 day
          SAVEVALUE  Stock+,X$ACB      ;Addition to Stock
          TRANSFER   ,Again            ;Repeat of stock replenishment
*************************************************************************
          GENERATE   1                 ;Create daily dispatch
          ASSIGN     Demand,V$Var2     ;Assign daily dispatch
          TABULATE   Inventory         ;Record inventory
          TEST GE    X$Stock,P$Demand  ;Make sure order can be executed
          SAVEVALUE  Stock-,P$Demand   ;Remove cargo from stock
          SAVEVALUE  Sold,P$Demand     ;X$Sold=Daily dispatched cargo
          TABULATE   Sales             ;Record daily dispatched cargo
          TERMINATE  1                 ;Daily timer
-------------------------------------------------------------------------
```

Figure 10. Order point inventory system.

The model consists of three main parts: the initial data declaration; simulation of cargo arrival process to warehouse; simulation of cargo dispatching process from the warehouse. Four columns of the model include: labels; blocks and commands; operands of the blocks and commands; commentaries. Additional information in the simulation model is marked with stars *, this information is ignored by the system translator.

The first block **INITIAL** declares parameters of transport batches, arriving to the warehouse. The next block **INITIAL** designates the “order point”, that shows moment of replenishment of the warehouse stock. The third block **INITIAL** designates the initial merchandise stock at the warehouse. The command **TABLE** (with label “Inventory”) forms a table for the changing stock. The second command **TABLE** is intended for offers for cargo to be delivered from the warehouse. The command **VARIABLE** interacts with generator of casual numbers, forms and gives them into the simulation model. The block **GENERATE** creates offers for dispatching cargo from the warehouse. The block **TEST L** testifies whether the stock occurs

less than the insurance stock. The block **ADVANCE** moves the model time. The block **SAVEVALUE** forms new warehouse stock. The block **TRANSFER** transfers the model entry to the next block in accordance with the simulation algorithm.

The further blocks simulate delivery cargo from the warehouse. The block **GENERATE** forms daily volume of dispatching cargo from the warehouse. The block **ASSIGN** forms demand for cargo. The block **TABULATE** writes in the TABLE with label «Inventory» data of stock. Block **TEST GE** testifies whether the stock in the warehouse is enough to make sure the order can be executed. The block **SAVEVALUE** decreases inventory at the warehouse by the volume of dispatched cargo in this day. The next block **SAVEVALUE** records the dispatched volume of cargo. The third block **TABULATE** puts in the TABLE with label “Sales” the volume of delivered cargo. The block **TERMINATE** counts number of fulfilled cycles and finishes simulation if the number occurs to be equal 0. GPSS system shows results of simulation automatically in standard view, that is rather full (contains some dozens of values).

Simulation system GPSS World gives away in the results also graphs with histograms of stock fluctuation (the table “Inventory”) and daily dispatching (table “Sales”). The research with using of the simulation model is not revealed here. They can be easy executed by any expert depending on characteristics specific warehouse, parameters of material flows and other conditions.

7. Conclusions

In the article several methods of merchandise stock and storage areas of warehouses determination are represented. This information may be useful for projecting and research by the engineers who are interested and eager for reception more specific knowledge on the warehouses in supply chains, where warehouses are of great importance. These methods take into account probable fluctuation of warehouse stock during their operation in the logistic networks.

References

Malikov, O. (1981) Automatic warehouses projecting. Saint Petersburg, Russia.
Malikov, O. (1986) Warehouses of Flexible Manufacturing Systems. Saint Petersburg, Russia.
Malikov, O. (2003) Business Logistics. Saint Petersburg, Russia.
Malikov, O. (2005) Warehouses and Freight Terminals, Saint Petersburg, Russia.
Malikov, O. (2009) 'The Theory of Warehouse Systems', *Network Logistics*, Research Report 211, pp.15-24.
Malikov, O. (2009) 'Business Logistics: New Specific Approach to Concept', *Network Logistics*, Research Report 200, pp.39-52.

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Warehouse Order Picking Process and Costs

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Процесс сбора заказов на складе и стоимость

Аурелия Буринскине

Abstract
Order picking process is the most laborious activity in warehouse. It consumes almost 50 % of all warehouse labour activities. The study pays special attention to order picking process in a wide-aisle warehouse with the aim to identify the opportunities resulting to reduction of order picker's costs. The order picking process optimisations are analysed using simulation model. The presented results show that the picker's travel distance can be reduced by 45%, and order picker's costs - by around 38% by using appropriate combination of optimisation methods.

Keywords: Order picking, simulation model, wide-aisle warehouse, batching, zoning, routing, order picker's costs

Аннотация
Процесс сбора заказов является наиболее трудозатратной операцией на складе. Он составляет примерно 50% всех операций в работе склада. Статья уделяет особое внимание процессу сбора заказов в широко-проходных складах с целью определения возможности сокращения затрат на сбор заказа. Оптимизация процесса сбора заказов анализируется, используя имитационное моделирование. Представленные результаты показывают, что расстояние, пройденное погрузчиком, может быть сокращено до 45% и стоимость сборки заказа – примерно на 38%, за счет использования определенного сочетания методов оптимизации.

Ключевые слова: сбор заказа; имитационная модель; широко-проходные склады; зонирование, маршрутизация, стоимость сборки заказа.

1. Introduction

Nowadays, a critical point in warehouse management practice is finding ways to answer a question "How to increase efficiency and how to reduce daily costs?" This research pays attention to a customer order picking process with the aim to reduce order picker's costs. The research focuses on manual picking process when the picker receives a pick list from a computer station, picks an empty picking cart at a pick-up point, travels to picking locations to pick products (Petersen et al., 1999), delivers them to a drop-off point and completes picking at computer station. In the research the meaning of the depot consists of the computer

station, the pick-up and the drop-off points. The simulation model created by author is used in the research.

2. Order Picking Process and Simulation Environment

Order picking process

Order picking is the retrieval of products from specified storage locations on basis of customer orders. In general, the order picking process is the most laborious activity in a warehouse. On average, order picking costs may amount to 50 % of warehouse operational costs, as measured by Tompkins et al. (2003). The common objective in the most of case studies is to minimise order picker's costs. Hodgson et al. (1982), Gray et al. (1992) study possibility to optimise warehouse operations and to minimise the costs mentioned above.

For studying manual order picking process, warehouses with single block are often chosen. There are some studies dealing with multi-block warehouses regarding 1) aisle configuration problems and 2) storage.

Aisle configuration problems
Bassan et al. (1980) and Rosenblatt et al. (1988) calculate picker's travel costs; Dukic et al. (2008) define that two block warehouses are more potential then single block ones.

Storage (random, class-based or volume-based) policy
According Petersen (2002), policies of random and volume-based storage affect the usage of labour; also order picking is significant in terms of its influence to company's customer service policy. This relation is determined by order picking efficiency and accuracy. Efficiency shows how fast an order may be retrieved, and how soon it is available for shipping to the customer; accuracy is a degree, which shows number of picking errors. In order to operate efficiently, the order picking process needs to be designed robustly. Any underperformance in the order picking can lead to unsatisfactory of service and to higher operational costs. (De Koster et al., 2006)

Most methods, which are used for the improvement of order picking efficiency, focuses on reducing picker's travel distance, and can be categorized into four groups according basic policies: routing, storage, batching (Roodbergen et al., 2006) and zoning (Gray et al., 1992). Routing methods determine the sequences in which the order picker is expected to move from one location to another and routes of travelling, trying to minimize total travel distance. The sequence of visiting locations in wide-aisle warehouse are studied by Merkuryev et al. (2009) and savings of 60 % are reported; the most famous routes of travelling are introduced by Roodbergen (2001), Dukic (2004), De Koster et al. (2006).

Storage methods, or assignments of items to storage locations based on some rules, can help to reduce travel distances compared to random assignment (Dukic et al., 2008). These assignments are compared by Hausman et al. (1976), Yang (1988), Roodbergen et al. (1999), Van den Berg et al. (2000), etc. Order batching methods, or the grouping of two or more customer orders in one picking tour, are also used to minimise total travel distance. The batch size (number of different customer orders picked per stop) is analysed by Gray et al. (1992), Gong et al. (2008), Gong (2009), etc. Order zoning methods analyse the order picking process when each picker is assigned to a single picking zone. The benefit of zone picking method is the minimisation of picker's travel distance per item picked through the maximisation of the number of picks along picking tour (Gray et al., 1992). Number of zones is studied by Gray et al. (1992), Le-Duc et al. (2005), etc. All above mentioned methods are used to improve order picking efficiency. However, the performance greatly depends on the batching and zoning, on size of the warehouse, characteristics of orders, on the picking cart capacity and on the technical process design.

This research focuses on two-block warehouse. The study pays special attention to the order picking process in the wide-aisle warehouse with aim to identify opportunities resulting minimisation of picker's travel distance and reduction of order picker's costs. The study focuses on order picker who retrieves products by customer orders. The customer order transferred into pick list is forwarded to the order picker via information technology-based tool, which tells the picker what to pick and from which picking locations. An order picker always starts a route at the depot. For changing the aisle, the picker moves in the direction of the closest cross-aisle. The routing algorithm chooses the shortest way for each aisle separately: the picker needs to return back to the front cross-aisle or to transfer the aisle through its entire length till the rear cross-aisle (Merkuryev et al., 2009). In a two storage

blocks warehouse, the middle cross-aisle operates as the rear cross-aisle for the first storage block and as the front cross-aisle for the second storage block. This route is called a composite route (combines S-shape and return routes, and is proposed by Petersen (1995), Le-Duc et al. (2004)) and displayed in Figure 1. With the composite route the aisles, which have the picks, are either entirely traversed or entered and left at the same end. The routing algorithm has a possibility to check one aisle ahead.

Other routing algorithms for multi-block warehouses are studied by Roodbergen et al. (2001, 1999). They adapted different routes with some modifications for such kind of warehouses (Le-Duc, 2004).

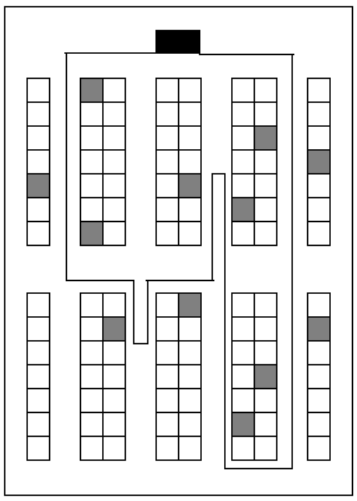

Figure 1. Composite route (grey- specified locations, black- depot).

For studying manual order picking process, warehouses with narrow aisles, which enable the picker to retrieve products from both sides of the aisle without changing position (De Koster et al., 2006), are often chosen. However, this case study, aiming to analyse a picker's travel distance, examines a warehouse with wide aisles. In order to retrieve products from both sides of aisle picker needs to travel in a wide-aisle warehouse additionally. In the case study the composite route is integrated with travelling inside the aisle to retrieve products from both sides of the aisle (Caron et al., 2000). The travelling inside wide-aisle is illustrated in Figure 2.

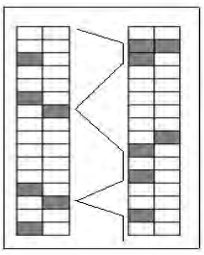

Figure 2. Travelling in the wide-aisle.

In the most of cases of minimisation of order picker's costs, authors analyse picker's travel distance. Two types of travel distances for order picking are used in literature: average travel distance per order and total travel distance (for a set of orders). The case study focuses on the last one. By minimising an average travel distance, the total travel distance is also minimised (De Koster et al., 2006).

In order to define the most efficient order picking method in the wide-aisle warehouse and to analyse possibilities to optimise the order picking process, a simulation model is created.

Simulation model

The structure of the Excel-based simulation model is based on:
Warehouse plan. A schematic picture of the wide-aisle warehouse is shown in Figure 3. The width of aisles is 5 metres. The items (each item with one picking location) are stored on shelves and are picked in cases from picking locations. The considered warehouse, called a reference warehouse, has eight parallel aisles, and each aisle contains one hundred picking locations (the width of each location is 0.8 and the length – 1.2 metres). The cross-aisle in the middle of the warehouse separates it into two storage blocks and makes three possibilities of switching between aisles: at the front, at the rear and in the middle. The width of middle cross-aisle is 4.8 metres and it is used in the reference warehouse to handle the traffic. In the reference warehouse the total width of corridor is 3.4 metres.

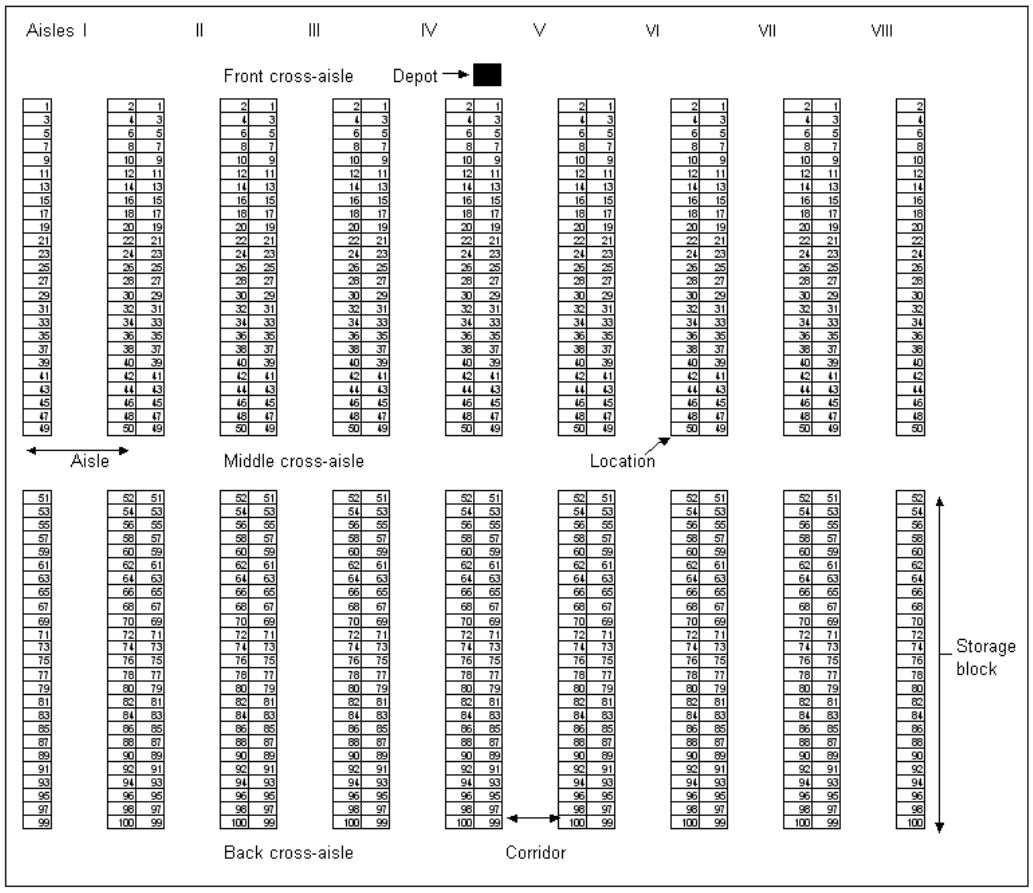

Figure 3. Wide-aisle warehouse plan.

Pick list database. Customer orders are entered into a pick list database, which contains the name of the customer, date, the items and the quantity ordered by the customer.

Simulation on warehouse plan. Simulation on warehouse plan uses the pick lists database, where sequences by locations shall be visited are defined; for picking in accordance with the next pick list, the picker returns to the depot. It is also considered that the order picker travels in warehouse at the same speed.

The movements such as order picker inside aisles, cross-aisles and picker returns to the depot are modelled by Visual Basic macro commands. Three macro command blocks are used for the algorithm:

The first two command blocks - for moving between even or odd locations. The picker is moving according to the schematic picture of the reference warehouse. Generally, during

simulation the picker is moving at the right side of the corridor and is stepping to the left side by a pick list request only.

The third command block - for returning to the depot.
If the picker moves between different aisles for any purposes (to pick items or to return to depot) the algorithm checks which cross-aisle is closer to the previous and next locations, and indicates the closest cross-aisle for the next picker's movement.

The simulation model also gives ability to check the customer order. The data may be seen on warehouse plan by choosing its appropriate customer order number (Figure 4).

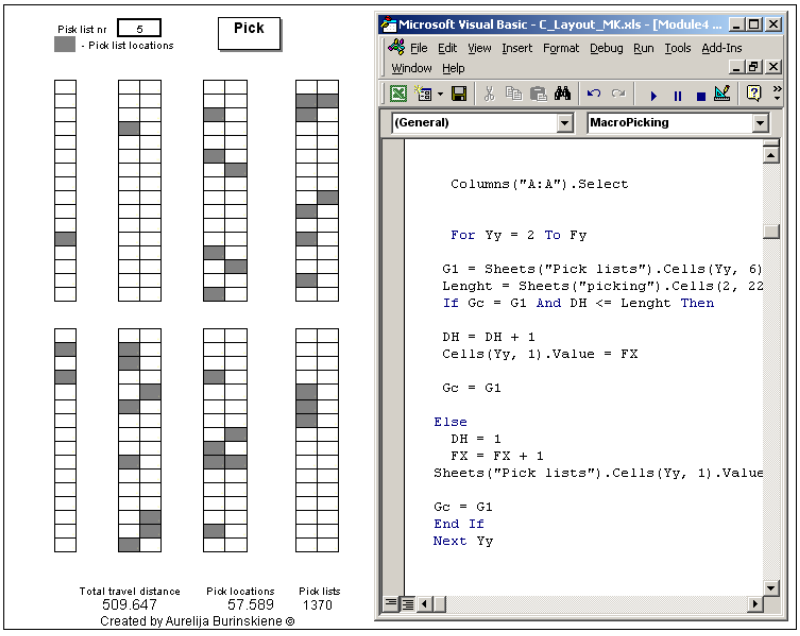

Figure 4. Simulation model: customer order on warehouse plan on the left side and routing algorithm on the right side.

The macro command is also used to calculate total travel distance. It is considered, that inside the corridor, the order picker is walking 0.3 metres away from the shelves. When the picker is retrieving a product, 0.3 metres till location and 0.3 metres back are added to the total travel distance. If the picker is stepping from the right side of the corridor to the left side or from the left to the right side, the distance of 2.8 metres for changing sides is added. The calculation of total travel distance is activated by pressing the Visual Basic macro command button (see Figure 4).

Customer order

A customer order is defined as an order placed by the customer on specified date. The customer order can be transferred into one pick list or into separate pick lists (De Koster et al., 2006). In this case study customer orders are split into pick lists based on the customer name, date and picking zone. When the customer order is large, it is split into separate pick lists according picking zones. However, the smaller pick lists are, the more often the picker is returning to the depot and his total travel distance additionally increases. Due to this, the number of picking zones needs to be carefully analysed.

Zoning methods

Zoning means, that entire warehouse is split in multiple parts, each with different order pickers. Zone picking requires that order picker only pick products stored within his picking zone. Possible advantages of zoning are defined by De Koster et al. (2006). De Koster et al. (2006) find that due to zoning order pickers need to traverse a smaller area and they become familiar with the products in the zone. Also that zoning reduced traffic congestions in warehouse (De Koster et al., 2006). Petersen (2002) examines the configuration of picking zones in order to minimise picker's travel distance. Petersen (2002) defines that both the size of the zone and the number of items on the pick list have a significant effect on picking zone configuration. Le Duc et al. (2005) find that in case of 'small' orders the order picking takes longer. However, if 'small' order is split into very small zones (or sub-zones) then order picking efficiency can be improved by 25 % (Le Duc et al., 2005).

De Koster et al. (2006) propose two approaches, how the zoning can be organised: Using the first approach one order picker starts to work on the customer order. When the first picker collects products from preferential picking zone, the picked products are handed to the next picker, who continues the assembly of the customer order. Hence the customer order is only finished after having visited all relevant picking zones. In practice, the usage of preferential zone depends on safety requirements or product characteristics, like size and weight.
Using the second approach several order pickers work on one customer order at the same time; order pickers work in different picking zones. The picked products are placed together and later (if needed) are merged by driver. In practice, zoning is partially based on the size of

picking cart and the number of picks in particular zone. Also zoning is used for separating detergents, tobacco, alcohol products and temperature-based products from other items.

In literature zoning methods are classified into (Le-Duc, 2005):
Sequential zoning – one order picker starts to work on the customer order. Hence, picking of customer order in one zone is finished, products are sequentially picked from all the other relevant zones;
Parallel zoning – all order pickers can work on the customer order at the same time. This synchronization of pickers intends to pick any customer order faster.

Regarding zoning, always even number of aisle has to be included into the picking zone: even aisles are left, most often, from the front (depot side).

Order picking

The order picking can be organised in several ways. The basic variants include picking by order or picking by article (batch picking) (Le-Duc, 2005). The customer order can be transferred into one pick list or into separate pick lists (De Koster et al., 2006). This way of picking is called ‘picking by order’ (De Koster et al., 2006). In the case of picking by article, the order picker retrieves product (the batch) from location according multiple customer orders.

Batching is the process of combining several customer orders into one or more pick lists. All customer orders which to be collected are joined together. This means that in one picking tour several parts of customer orders are picked. Later during the sorting process, the items are sorted into original customer orders. Many in-between variants exist, such as picking multiple orders followed by immediate sorting (Le-Duc, 2005) (separation to different picking carts) during picking, or the sorting takes place after in the special sorting area. The first way is called ‘sort-while-pick’, the second way - ‘pick-and-sort’.

Many studies focus on batch picking. Two types of order-batching algorithms are developed in order to find the most suitable orders to be batch together. First, for example, random orders are batched together or small orders are combined into a larger picking tour. Second, the orders are selected according different rules. At the beginning, for example, the order with

longest pick tour, or the order with large number of positions, or the order with most distantly located (i.e. furthest from the depot) items, or the order with the largest difference between depot aisle and the right-most and the left-most aisle are found. After that another order is selected, to be included in a batch. Usually, it is selected based on ‘travel distance’, for example, if there are additional aisles which to be visited when the new order is added; if there are additional locations to be visited the sum of travel distances between every location of an item in the new order and the closest location of item from the main order are calculated. Elsayed et al. (1989) propose algorithm, which combines small and large orders: at first they classify orders as ‘large’ or ‘small’ before assigning them to different batches, after calculation of smallest travel distances (De Koster et al., 2006). However, according the author of the research, warehouse management systems have no possibility to calculate picker’s travel distance - they are able to calculate some distances and to sum them only. That’s why the order-batching algorithms must be as simple as possible.

De Koster et al. (2006) treat, that when orders are fairly large, each customer order can be picked individually (i.e. one order per picking tour) (this way of picking is called as the single order picking method). Only, when orders are small, there is a possibility for reducing total travel time by picking a set of orders in a single picking tour (De Koster et al., 2006). However, this case study shows, that when orders are too small (consists only of ten products), there is a need to pick in a single picking tour.

If order picker is picking products according paper-based pick list, at first he receives a pick list at the computer station, then takes 4 picking carts on a lifter and moves to certain picking locations to retrieve products according to the pick list, at the end, delivers picking carts to the drop-off point and then moves to the computer station to confirm the completed order and quantities of delivered products (Petersen et al., 1999). For picking by article situation ‘pick-and-sort’ variant can be used only. The simplest way is to pick articles according single pick list. In such way, two or more customer orders are combined into one pick list. The products are retrieved by order picker in one picking tour and sorted by the picker after in the special sorting area. Over wise, the paper-based batch picking process is too complicated and order picker can make sort-while-pick errors. In general, even a good pick list, which have the information most needed, presented in the sequence needed and easy for the picker to handle, and can’t insure the order picker from making errors.

The usage of information technology-based tool in order picking process can be useful to help solving the above mentioned problem. Properly implemented technologies can help to reduce existing errors and can insure the order picker from having sort-while-pick errors, but none of them are able to eliminate all human errors.

The pick list is forwarded to the order picker via information technology-based tool, which tells the picker not only what to pick and where from, but also where to place. In such situation sorting during picking can be applied. Gademann et al. (2005) show that the batch picking can be applied in some case when order picker sorts several customers orders during picking.

The common objective for implementing information technology-based picking tool is to minimise labour cost. In literature picking with information technology-based tools is classified into picking with scanners, picking with voice and picking by light (Gong, 2009). By scanning location and picking cart, order picker identifies where from the product picked and where placed. In picking with voice situation pick list is converted into spoken commands. The order picker has a handset with a microphone and a small battery-powered portable computer with audio capability, wearied on belt. During the picking process, the order picker hears where to go, how much to pick and where to place. In batch picking situation, the order picker hears ‘pick five, distribute 2 to order A, 1 to order D, 2 to order F’. Practically, with using voice 2-6 orders can be batched at the same time (Flanders, 2002). For picking by light situation light-emitting diodes are used; they display picking location, the quantity to be picked, and the picking cart for placing the product. Also light-emitting diodes can have different colours for different order pickers (Gong, 2009). Instead of portable scanners and portable computers Tesco (2001) uses a computer on the trolley (picking cart) which tells the order picker what to pick and where from, and maps out the most efficient route. In such case the order picker communicates with warehouse management system electronically. Using such possibilities, for example, during a pick tour order pickers can be instructed through handheld terminals connected to the computer station, to pick items of new customers’ orders, which have been just received at warehouse (Gong, 2009).

According to Goetschalckx et al. (1989), the main target of above mentioned picking tools is to maximise both efficiency and accuracy in order picking process. The goal for accuracy is 1 error per 1000 picking lines, but in general during order picking process more errors appears.

For higher accuracy level, scanning or picking with voice (in high-volumes operations) can help (to validate the pickup). In practice, picking with voice helps to improve picking accuracy by 50-70%. For example, wholesale food distributor U.S. Foodservice reduced picking errors by 70% when voice picking solution was rolled out in 24 of its distribution centres (Lcefield, 2004). The company Save-A-Lot realized an 80% improvement in accuracy in its network of 16 warehouses after implementing specific voice picking solution (Save-A-Lot, 2005). While the Associated Wholesale Grocers' Kansas City warehouse improved its order accuracy rate from 99.52 % till 99.64% by voice picking solution. This means, that from 62 million cases a year 74.000 cases are picked additionally correctly (Langnau, 2004). So, more accurate picking can create a ripple effect from which benefits customer service policy of company.

Seeking to improve the order picking process efficiency, the case study analyses different possibilities to collect specified items by tools based on information technologies. In this research batch picking in two-block warehouse is studied. Herein, the first approach 'sort-while-pick' of batch picking is analysed and it is considered that pickers are closing picking tour with complete picking carts (there is assumption made that the pick cart has sufficient capacity to accommodate all picks (Gong, 2009)), which have to be placed at drop-off point based on original customer orders. From each of zone at least one full or almost full picking cart is delivered to single customer order collection area at the drop-off point. For higher accuracy level, the scanning of picking cart label and drop-off zone label can help to validate drop-off. It is considered that in each pick zone two orders are batched at the same time. In this case study the entire warehouse is split into two picking zones; four aisles represent each picking zone.

3. Experiments and Results

In the reference warehouse every item was passed by order picker many times during the day. Of course, such travelling took hours but not always added value. That's why optimisation of picker's travel distance was needed.

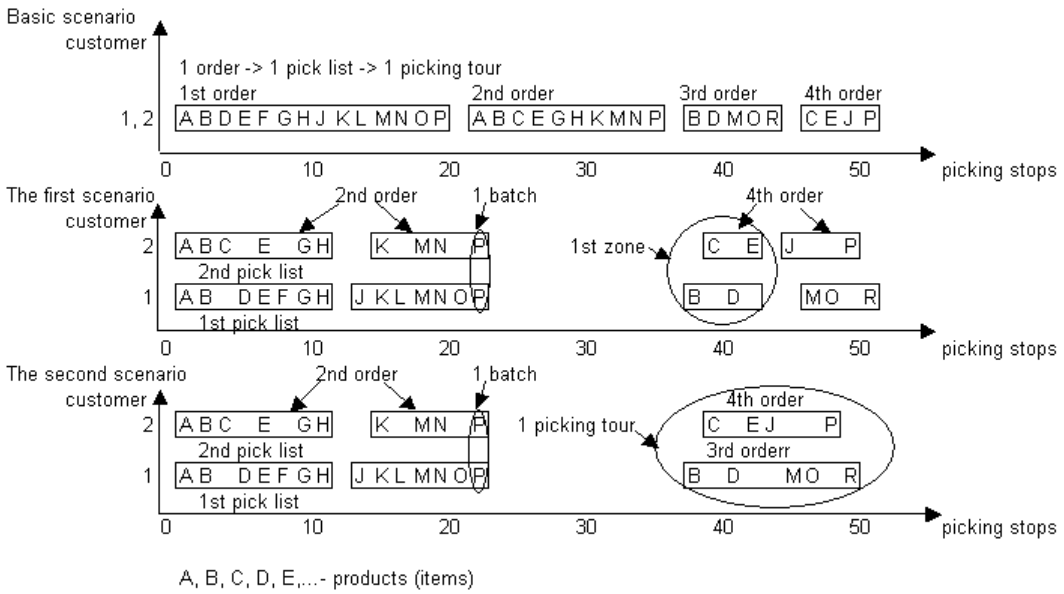

Figure 5. Different scenarios: zoning and batching algorithm

The objective of developed zoning and batching algorithm (which is presented in Figure 5) was to reduce picker's travel distance and to minimise the number of picking stops. Customer orders were classified into large and small ones. The orders, which had on maximum ten items, were called 'small', all others – 'large'. After that customer orders were assigned to different batches. For each batch were assigned two original customer orders only. Later all batches were separated into two picking zones. The scenario was tested, and results of the experiment and basic scenario were compared. Later the above mentioned algorithm was improved. Only the batches of large orders were split into different picking zones. The presented zoning and batching algorithm was used in pick lists generation stage.

In order to test different scenarios customer orders were entered into pick list database. The products and the number of products were selected for each customer order randomly. On average one customer order had 49 products. For basic scenario 3.532 pick lists and for first scenario 4.093 pick lists were generated.

The performed experiments showed positive results. Even in case when number of pick lists was increased the total travel distance was 34 % less (and were 1.854.427 metres). From the experiments was clear that it is not efficient to handle small pick lists. So, the experiment was repeated. This time the small customer orders (which had only ten items) were not linked to

picking zones. After recalculation, the total travel distance was 1.534.336 metres. The final results showed that the picker's travel distance was reduced by 45%.

4. Order Picker's Costs

The objective of this study is to minimise costs by optimising order picking operations. Gray et al. (1992) propose to analyse order picking operations in accordance with the components as follows:

- 'Travelling' associated with distance travelled by order picker,
- 'Stopping' associated with the number of different picking stops (i.e. number of picking cart stops or batches),
- 'Grabbing' associated with the total number of cartons picked at each stop,
- 'Closing' associated with operations at the computer station (to confirm completed order, quantities of delivered products, and receive new pick list).

Now we can study each above mentioned component:

- 'Travelling' component. Comparing results of basic and the second scenario, we can see that the picker's travel distance can be reduced by 45 %. The experiments show that this is the most labour activity during order picking;
- 'Stopping' component. Comparing the single picking and batch picking methods, we can see that number of picking stops can be reduced by 4 %. Gray et al. (1992) propose to calculate 0.29 minutes per stop. If on average the order picker stops 277 times, this means that during a day picker spends around 1.5 hours at picking locations;
- 'Grabbing' component. Comparing results of basic scenario and other scenarios, we can see that it is no matter when order picker grabs cartons on one or on several stops. Gray et al. (1992) propose to calculate 0.0383 minutes per carton. If on average the order picker picks 3 cartons per item, this means that during a day he spends half an hour to grab cartons;
- 'Closing' component. In basic scenario paper-based pick lists take some order picker's efforts to handle the job at the computer station. However, in other scenarios there isn't a need to have such operations. Gray et al. (1992) propose to calculate 2 minutes

per pick list. If on average the order picker picks 13 pick lists, this means that during a day he spends around half an hour at the computer station.

According Gray et al. (1992), which propose to calculate daily costs of order picker, during a day one order picker costs 40 Euro, then 27.5 Euro costs travelling, 7.5 Euro - stopping, 2.5 Euro - picking of cartons, 2.5 Euro - operations at the computer station. After comparison of the basic and the second scenario some results occurred that show benefits of usage of information technology-based tools as follows: 45 % (12.4 Euro) of travelling costs, 4 % of stopping costs (0.3 Euro) and all closing costs (2.5 Euro costs related to operations in the computer station) can be saved; totally can be saved 15.2 Euro, i.e. around 38 % of daily costs of order picker. The presented results show that order picker's costs can be reduced by around 38%.

5. Concluding Remarks

The described experiments demonstrate that in the reference warehouse the efficiency of the picking process can be improved up to 45 % by using batching and choosing the right zoning method (see Figure 5). The target of this case study is to have a possibility of evaluating different methods in a wide-aisle warehouse at the pick list creation moment in order to create the pick list according to the best one.

The concluding remarks for picker's travel distance are as follows:

- The total travel distance is lower when the number of aisles included in the picking zone is even,
- The combination of batching and zoning methods depends on the number of items ordered by the customer.

Results of the research show that even usage of simple order batching method lead to significant picker's travel distance improvement. Results also show that travelling takes hours in large warehouses but not always adds value. In order to provide value-added order picking process and shorten response time the information technology-based tool has to be used. The presented results show that the picker's travel distance can be reduced by 45%, and order picker's costs - by around 38% by using appropriate combination of optimisation methods.

References

Bassan, Y., Roll, Y. and Rosenblatt, M.J. (1980) 'Internal layout design of a warehouse', *AIIE Transactions*, Vol. 12, No. 4, pp. 317-322.

Caron, F., Marchet, G. and Perego, A. (2000) 'Layout design in manual picking systems: a simulation approach', *Integrated Manufacturing Systems*, MCB University Press, Vol. 11, No. 2, pp.94–100.

De Koster, R., Le-Duc, T. and Roodbergen, K.J. (2006) 'Design and control of warehouse order picking: a literature review', *ERIM Report Series Research in Management* (http://www.erim.eur.nl), pp.2–25.

Dukic, G. (2004) *Istrazivanje komisioniranja u regalnim skladistima*, PhD Thesis, Zagreb University, pp.1–55.

Dukic, G. and Opetuk, T. (2008) 'Analysis of order-picking in warehouses with fishbone layout', *Proceeding of International Conference on Industrial Logistics 2008*, Tel Aviv, Israel, pp. 197-205.

Elsayed, E.A. and Unal, O.I. (1989) 'Order batching algorithms and travel-time estimation for automated storage/retrieval systems' *International Journal of Production Research*, Vol. 27, pp.1097-1114.

Flanders, S. (2002) 'Voice directed picking- a technology that is ready for prime time!', *Newsletter* (http://www.2wmc.com), February 12.

Gademann, N. and Van de Velde, S. (2005) 'Batching to minimize total travel time in a parallel-aisle warehouse', *IIE Transactions*, Vol. 37, No. 1, pp.63-75.

Goetschalckx, M. and Ashayeri, J. (1989) 'Classification and design of order picking systems', *Logistics World*, June, pp. 99-106.

Gong, Y. and De Koster, R. (2008) 'A polling based dynamic order picking system for online retailers', *IIE Transactions*, Vol. 40, Issue 11, pp.1070-1082.

Gong, Y. (2009) *Stochastic modelling and analysis of warehouse operations*, PhD Thesis, Erasmus University Rotterdam, The Netherlands (https://ep.eur.nl), pp.58–69.

Gray, A.E., Karmarkar, U.S., Seidmann, A. (1992) 'Design and operation of an order-consolidation warehouse: models and application', *European Journal of Operational Research*, No. 58, pp.14-36.

Hausman, W.H., Schwarz, L.B. and Graves, S.C. (1976) 'Optimal storage assignment in automatic warehousing systems', *Management Science*, Vol. 22, No. 6, pp.629-638.

Hodgson, T.J., and Lowe, T.J. (1982) 'Production lot sizing with material handling cost considerations', *IIE Transactions, Vol.* 14, No. 1, pp.44-51.

Langnau, L. (2004) 'Speaking out for better productivity', *Material Handling Management* (http://www.MHMonline.com), March.

Lcefield, S. (2004) 'I can hear you now', *Warehouse&DC (*http://www.logisticsmgmt.com), October, p. 61.

Le-Duc, T. and De Koster, R. (2004) 'Travel distance estimation in a single-block ABC storage strategy warehouse', *Distribution Logistics: advanced solutions to Practical Problems*, Springer, pp.185-202.

Le-Duc, T. and De Koster, R. (2005) 'Determining the optimal number of zones in a pick-and-pack order picking system', *ERIM Report Series Research in Management*, RSM Erasmus University, the Netherlands.

Le-Duc, T. (2005) *Design and Control of Efficient Order Picking Process*, PhD Thesis, Erasmus University Rotterdam, The Netherlands (https://ep.eur.nl), pp.1–26.

Merkuryev, Y., Burinskiene, A. and Merkuryeva, G. (2009) 'Warehouse order picking process', *Simulation-Based studies in logistics: education and applied research*, Springer, pp.147-165.

Petersen, C.G. (1995) 'Routeing and storage policy interaction in order picking operations', *Decision Sciences Institute Proceedings*, Vol. 3, pp.1614-1616.

Petersen, C.G. and Schmenner, R.W. (1999) 'An evaluation of routing and volume – based storage policies in an order picking operation', *American Institute for Decision Sciences*, Vol. 30, No. 2, p.2.

Petersen, C.G. (2002) 'Considerations in order picking zone configuration', *International Journal of Operations & Production Management*, Vol. 27, No. 7, pp.793-805.

Roodbergen, K.J. and Petersen, C.G. (1999) 'How to improve order picking efficiency with routing and storage policies', *Progress in Material Handling Practice: 1999*, Material Handling Institute, Charlotte, North Carolina, pp.107–124.

Roodbergen, K.J. and De Koster R. (2001) 'Routing order pickers in a warehouse with a middle aisle', *European Journal of Operational Research*, Elsevier Science B.V. Vol. 133, pp.32-43.

Roodbergen, K.J. (2001) *Layout and Routing Methods for Warehouses*, PhD Thesis, Erasmus University Rotterdam, The Netherlands (https://ep.eur.nl), pp.1–109.

Roodbergen, K.J. and Vis IFA (2006) 'A model for warehouse layout', *IIE Transactions*, No. 38, pp.799–811.

Rosenblatt, M.J. and Roll, Y. (1988) 'Warehouse capacity in a stochastic environment', *International Journal of Production Research*, Vol. 26, No. 12, pp.1847-1851.

Save-A-Lot (2005) 'Leading Food store chain streamlines DC operations with Voxware solution', *Comments Voice Logistics*, February 14.

Tesco (2001) 'Tesco.com delivers a profit', *News* (http://www.tesco.com), September.

Tompkins, J.A., White, J.A., Bozer, Y.A., Frazelle, E.H., Tanchoco, J.M.A. and Trevino, J. (1996) *Facilities Planning*, John Wiley & Sons, New York.

Tompkins, J.A., White, J.A., Bozer, Y.A., Frazelle, E.H. and Tanchoco, J.M.A. (2003) *Facilities Planning*, John Wiley & Sons, New York.

Van den Berg, J.P. and Gademann, A.J.R.N. (2000) 'Simulation study of an automated storage/retrieval system', *International Journal of Production Research*, No. 38, pp.1339-1356.

Yang, M.H. (1988) 'Analysis of optimization of class-based dedicated storage systems', *Material Handling Research*, Georgia Institute of Technology, Atlanta, Georgia.

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Evaluating Automated Storage and Retrieval Systems Using Spreadsheet Simulation

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Оценка автоматизированных складов и систем поиска, используя моделирование в электронных таблицах

Лаури Латтила и Юха Саранен

Abstract
Warehousing plays an important role in the efficiency of todays international supply chains. Warehouse activities include the receipt of items and customer orders, storing items, order picking, shipping, customer service and reclamation, and control. Order picking constitutes 65 per cent of the total operating costs for a typical warehouse. Optimal configuration of warehouse activities depends on several design criteria. Basic alterative system designs are based either on manual labor or automated systems. While manual systems typically require smaller investments automated systems enable increased efficiency in space utilisation, advanced flexibility, as well as reduction in spoilage and administration cost.

Transportation and material handling systems tend to be too complex for analytical models to be modelled realistically. On the other hand, discrete event simulation offers a tool for evaluating automated material handling systems on a detailed level. However, discrete event simulation requires extensive model building time as well as special training. In this paper we conduct a feasibility analysis of two automated storage and retrieval system configurations by combining static spreadsheet modelling with Monte Carlo simulation. Using the spreadsheed simulation tool payback time of each investment alternative as well as main factors affecting the economic feasibility are identified. After this initial evaluation only configurations with most potential need to proceed to more detailed planning.

Keywords: AS/RS systems, warehousing, investment evaluation, Monte Carlo simulation

Аннотация
Транспортирование играет важную роль в эффективности современных международных цепей поставок. Складская деятельность включает получение грузов и заказов клиента, хранение грузов, перегрузку, обслуживание клиентов и претензии, а также управление. Сборка заказов занимает 65 процентов общих эксплуатационных расходов для типового склада. Оптимальная конфигурация складской деятельности зависит от нескольких критериев компоновочного решения. Обычно решение принимается либо вручную либо с помощью автоматизированных систем. В то время как «ручные» системы обычно требуют меньших инвестиций, автоматизированные системы позволяют получить большую эффективность в использовании складского пространства, большую подвижность, а также уменьшение производственных браков и стоимости обслуживания.

Транспортировка и системы перевалки грузов слишком сложны для аналитических моделей, чтобы результаты были адекватными. С другой стороны, дискретно-событийное моделирование предлагает инструмент для оценки систем автоматизированной обработки грузопотоков на достаточно детальном, достоверном уровне. Однако, дискретно-событийное моделирование требует продолжительного времени построения модели, а также специального обучения для работы с ней. В этой статье мы выполнили анализ двух автоматизированных участков хранения и системы получения заказа, комбинируя статическое моделирование в электронных таблицах с методом Монте Карло. Используя моделирование в электронных таблицах могут быть получены основные факторы, влияющие на экономические показатели работы склада, а также срок окупаемости инвестиций. После подобной предварительной оценки требуется лишь оценить конфигурацию размещения грузов внутри склада более детально.

Ключевые слова: системы AS/RS, складирование, оценка инвестиций, моделирование Монте Карло

1. Introduction

Warehousing plays an important role in the efficiency of todays international supply chains. Basic alterative system designs are based either on manual labor or automated systems. Optimal configuration of warehouse activities depends on several design criteria; while manual systems typically require smaller investments automated systems enable increased efficiency in space utilisation, advanced flexibility, as well as reduction in spoilage and administration cost.

As automated material handling systems incur large investments, need for detailed planning arises. Although discrete event simulation offers a tool for evaluating automated material handling systems on a detailed level it requires extensive model building time as well as special training. On the onher hand material handling systems tend to be too complex for analytical models to be modelled realistically.

This research stems from the practical need of an automated material handling systems provider. The objective is to construct an easy-to-use evaluation tool which calculates investment payback time as well as identifies main factors affecting the economic feasibility of a project.

This research report is structured as follows: In the following Section 2 we briefly review literature from warehousing and AS/RS-systems. Following Section 3 introduces spreadsheet simulation the research methodology used. Thereafter, in Section 4 we introduce two cases, where automated storage and retrieval systems are evaluated with spreadsheet simulation. In the final Sections 5 and 6 we discuss our findings and conclude our work.

2. Warehousing and AS/RS –Systems

According to Parikh and Meller (2009) warehouse activities include the receipt of items and customer orders, storing items, order picking, shipping, customer service and reclamation, and control. Order picking constitutes 65 per cent of the total operating costs for a typical warehouse (Coyle et al., 1996). Optimal configuration of warehouse activities depends on several design criteria (see e.g. Petersen et al., 2005). Basic alterative system designs are based either on manual labor or automated systems. While manual systems typically require

smaller investments automated systems enable increased efficiency in space utilisation, advanced flexibility, as well as reduction in spoilage and administration cost.

According to Material Handling Industry of America (2009) “An Automated Storage and Retrieval System (AS/RS) is a combination of equipment and controls that handle, store and retrieve materials as needed with precision, accuracy and speed under a defined degree of automation. Systems vary from relatively simple, manually controlled order-picking machines operating in small storage structures to extremely large, computer-controlled storage/retrieval systems totally integrated into a manufacturing and distribution process”. Roodbergen and Vis (2009) have summarized different classification methods for AS/RS systems. They can differ in the used cranes, handling of goods and used racks. In addition to the classification, the system design will also heavily impact the final system. These decisions include (Roodbergen & Vis, 2009) the system configuration, storage assignment, batching, sequencing, and dwell-points.

According to Baker and Halim (2007) there are many reasons why an automated system is chosen over a conventional system. The prime reasons are to accommodate growth, reduce operating costs and improving customer service. Other benefits include reduced staffing level, consolidated inventories, and improved accuracy. Possibility to grow and reduce costs can be more easily estimated than other benefits, but there has been a lot of work regarding consolidated inventories and some work on the impact of inaccurate data of supply chain performance (Sari, 2008). Caputo and Pelagagge (2006) created a decision-support system to use an automatic order picking system.

3. Spreadsheet Simulation

According to Banks et al. (2005) the purpose of simulations is to imitate a real system. There are many different kinds of simulations available. These include physical simulations (car in an air tunnel), interactive simulations (physically evacuating a building), computer simulations etc. Naylor et al. (1966) define simulation as the process of designing a mathematical or logical model of a real system and then conducting computer-based experiments with the model to describe, explain, and predict the behavior of the real system. Simulation analysis is a descriptive modeling technique. It does not provide explicit problem

formulation and solution steps like linear programming. In this paper only computer based simulations are studied.

According to Seila (2005), spreadsheet simulations contain three types of cells: input cells, intermediate computation cells, and output cells. In the input cells the users gives the specific parameters for the simulation model. They can be either inputted by the user or they can be sampled values from known distributions. The intermediate computation cells sue the input values and they define the transformations into outputs. The final output cells provide the actual simulation results.According to Seila (2005) there are two situations where spreadsheet simulations are used: when the model contains stochastic (random) elements or one wants to conduct proper sensitivity analyses.

Simulations have been used with AS/RS –systems to improve decision-making. In a recent literature review on AS/RS systems, Roodbergen and Vis (2009) found seven papers using simulation as a methodology to analyze these systems. However, there have been few studies using spreadsheet simulations (Wilson & Laney 2003). Most likely it is easier to simulate the system using a different simulation approach, like discrete-event simulations. Nevertheless, current simulation models have emphasized the actual performance of the AS/RS –system, not the high level configuration estimates.

4. Case Study – Estimating an AR/SR –System Configuration with Spreadsheet Simulation

In the case-studies the purpose was to build spreadsheet models which could give rough financial estimates for the AS/RS- and loading systems using a small amount of inputs. In order to make the financial estimates, it is required to make some physical performance estimates as well.

According to the supplier their AS/RS warehouse solution enhances space utilization by enabling additional pallet positions and higher input/output capacity within the system. The system offers integrated value added functions such as buffer inventory, order sorting, picking, staging and shipment consolidation, enables optimization of storage and handling processes.

The supplier provides solutions also for automated loadforming and loading of transportation vehicles. The system requires no modifications for transportation vehicles or the cargo space, while enabling minimized turnaround time and improvement cargo space utilisation.

The spreadsheet simulation models

Two spreadsheet simulation models are constructed, one for evaluating automated loading systems and one for AS/RS –systems.

The automated loading system spreadsheet model consists of three sheets: Instructions, information, and results. The instructions sheet simply states the general information for the simulation model, while the information sheet is used to gather inputs which are used the make the financial estimates. The final sheet, results, gives the actual financial savings achievable by using the automated system.

The main inputs of the model can be divided to three categories: operational information, transportation information, and investment requirements. All of the inputs are presented in Figure 1.

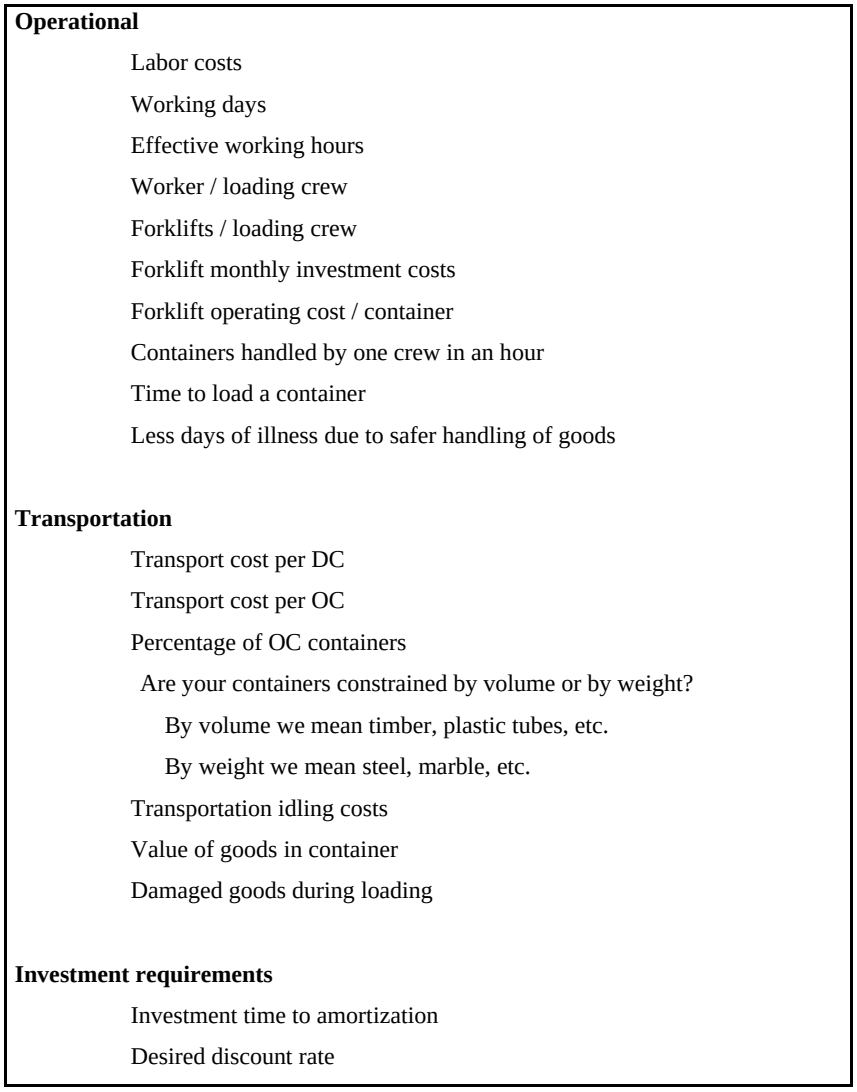

Figure 1. : Input window of the automated loading system spreadsheet model.

The results of the model are also divided to three categories: operational, transportation, and additional savings. The automated loading system can load 6 containers per hour with one forklift and two workers, which allows comparing the results with a traditional system. Transportation savings occur due to less use of open top containers. As the loading system pushes the material into the container, there is no need to use a crane and load the material from above. The additional savings include a shorter turnaround time (a truck needs to wait only for 5 minutes instead of 20 minutes), better space utilization (which requires less containers to transport the same amount of goods), less damages during loading and less days of illness. The spreadsheet model's results are presented and compared against the amount of containers to be loaded per hour.

Like the automated loading spreadsheet model, the AS/RS –system model contains three sheets: Instructions, information, and results. Again, the instruction sheet simply contains basic information about the spreadsheet program while the information sheet is used to gather inputs for the model. The results –sheet contains the actual output of the model.

The information is gathered under three categories: system data, operational costs and costs of ownership, and investment requirements. The system data contains basic information about the warehouse: size of the building, throughput rates and pallet sizes. Operational costs and costs of ownership contain basic operational costs like workers, wages, costs associated with forklifts, inventory costs, and facility costs. The last category is reserved for basic information about investments; cost of forklift trucks, facility investments, discount rate and other investments.

The spreadsheet contains many intermediate calculations, which use the system data to make an estimate of the potential automated system. The estimate includes actual physical information about the conveyors, lifts and amount of pallet positions. The system also estimates whether it is possible to have automated load forming where the automated loading system is integrated into the AS / RS –system. The average user does not need these values and they are not shown. The purpose of the simulation model is to provide an initial estimate for the cost of the system. However, the intermediate calculations have worked as a validation tool to see whether the spreadsheet gives accurate results (which it does).

In the results –sheet the final outputs are presented. In this sheet three different scenarios are presented. In the first one the financial results for a conventional system is presented. The second one contains the AS/RS –system while the third one also includes the automated load forming. The scenarios' results are divided to three categories: investments, operative costs, and additional benefits. The investments include the actual systems, possible facility and project management costs. The operative costs include everything which is needed to run the system (workers, forklifts, electricity, facility maintenance etc.). As an automated warehouse is able to save a lot of space and/or provide additional capacity for the warehouse, these needs to be taken into account in additional benefits. Also, as it was noticed in the literature review, there are many benefits available when an automated warehouse is used and it is difficult to convert the benefits into monetary values.

For the company there are two ways to use the simulation spreadsheet model. It can either use it internally to organize tmarketing efforts as new knowledge can be gained using simulations, or they can use it in their own selling process as the customers might not have exact information on all of the inputs. Nevertheless, both are done in a similar fashion by allowing some variable to vary according to certain distributions. We will first present a simulation model for the automated loading system and after that the model for the AS/RS –system.

As a default setting the simulation model contains a base scenario. This scenario is used in this paper as well. In the base scenario the customer uses three workers and two forklifts to load a container. The material is long and heavy (steel rods), which means that it is difficult to load using forklifts and includes a lot of safety issues. Sometimes the material is also loaded to an open top container which is even more hazardous. Some variables can be assumed to be well known, which does not require the use of stochastic variables. The rest require some sort of confidence limits. Using a spreadsheet simulation software (@Risk from Palisade), some values are allowed to vary. The fixed values are presented in Table 1 while the stochastic variables are in Table 2.

Table 1. Parameter values

Variable	Value
Labor cost	4000 € / month
Working days	22 / month
Effective working hours	7 hours / day
Worker / loading crew	3 workers
Forklifts / loading crew	2 forklifts
Forklift monthly investment costs	1500 € / month
Forklift operating cost / container	3 € / container
Containers handled by one crew in an hour	3 containers / crew
Time to load a container	20 minutes
Are your containers constrained by volume or by weight	Weight
Investment time to amortization	60 months
Desired discount rate	10%

Table 2. Distributions

Variable	Distribution
Less days of illness	Lognormal, μ = 2, δ = 2, Shift of 18 → Mean 20
Transport cost per DC	Normal, μ = 2000, δ = 200
Transport cost per OC	Normal, μ = 4000, δ = 400
Percentage of OC containers	Triangular, min = 5%, mode = 10%, max = 20%
Transportation idling cost	Normal, μ = 800, δ = 80
Value of goods in container	Normal, μ = 20000, δ = 2000
Damaged goods during loading	Triangular, min = 0,005%, mode = 0,01%, max = 0,02%

Simulation results

The results from the model are presented in Figure 2 and 3. Figure 2 shows the monthly savings by using the automated system compared to a traditional loading operation. There is a large amount of variation in the results. The savings range from 15000 Euros to 105000 Euros, mean value being 45000 Euros. As it is possible to notice from the figure, most of the monthly savings are between 27.6 thousand Euros and 68.4 thousand Euros. More information can be achieved by studying the regression coefficients of the independent variables (presented in Figure 3).

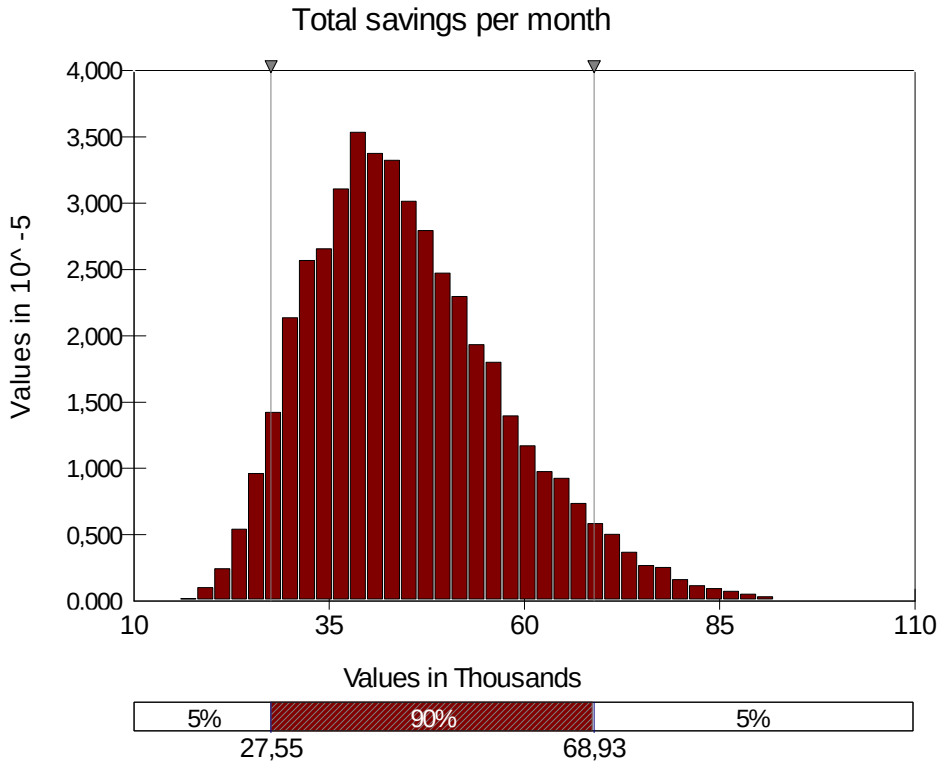

Figure 2. : Monthly savings in the first model.

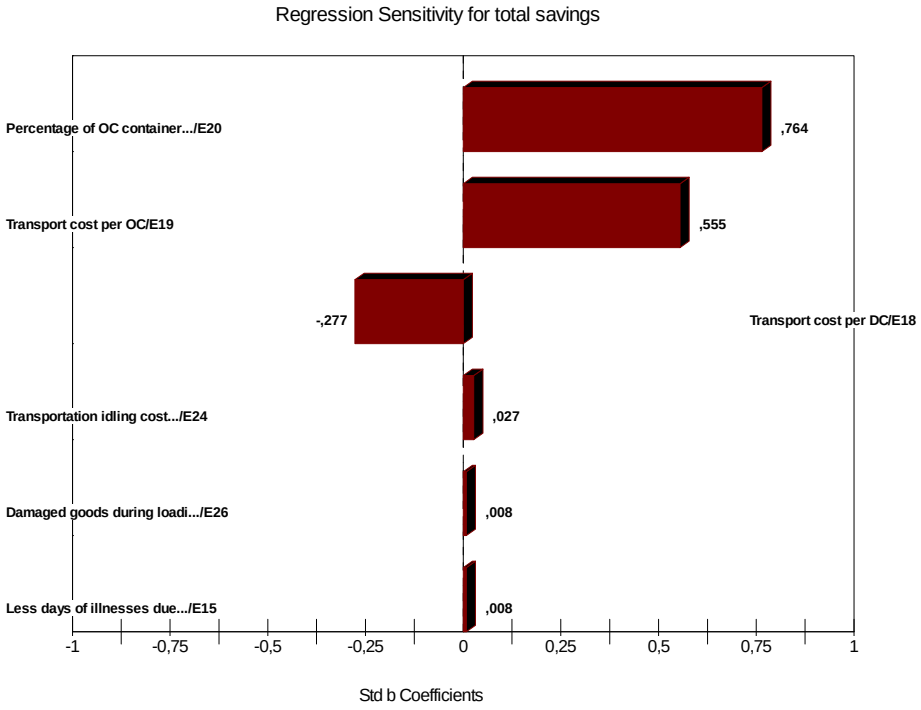

Figure 3. Regression coefficients in the first model.

Clearly the benefits are heavily dependent on the values of the transportation of containers. The ability to shift totally from open top containers to normal containers would drastically decrease the cost of transportation. Also, the cost of transportation will also impact the potential savings. If the transportation cost open top containers increases, the automated loading solution becomes more beneficiary while the opposite is true for normal containers. Other variables have very little effect in this scenario.

As the AS/RS –system spreadsheet contains a lot more variables, the individual values are not presented in this paper. Overall in the simulation model we are comparing a new automated facility to a new conventional facility. The physical warehouse is available, but the throughput is not known with certainty. Both the in- and outbound values are allowed to vary in the simulation model. The wages of the personnel are known, but the amount of personnel, as well as the amount of forklifts, is dependent on the simulated throughput. As price of electricity is expected to grow in the future, general facility costs are allowed to vary along with the price of electricity. Average price per pallet also contains uncertainty, as well as the amount of inventory costs in a traditional system annual cost savings are presented in Figure 4.

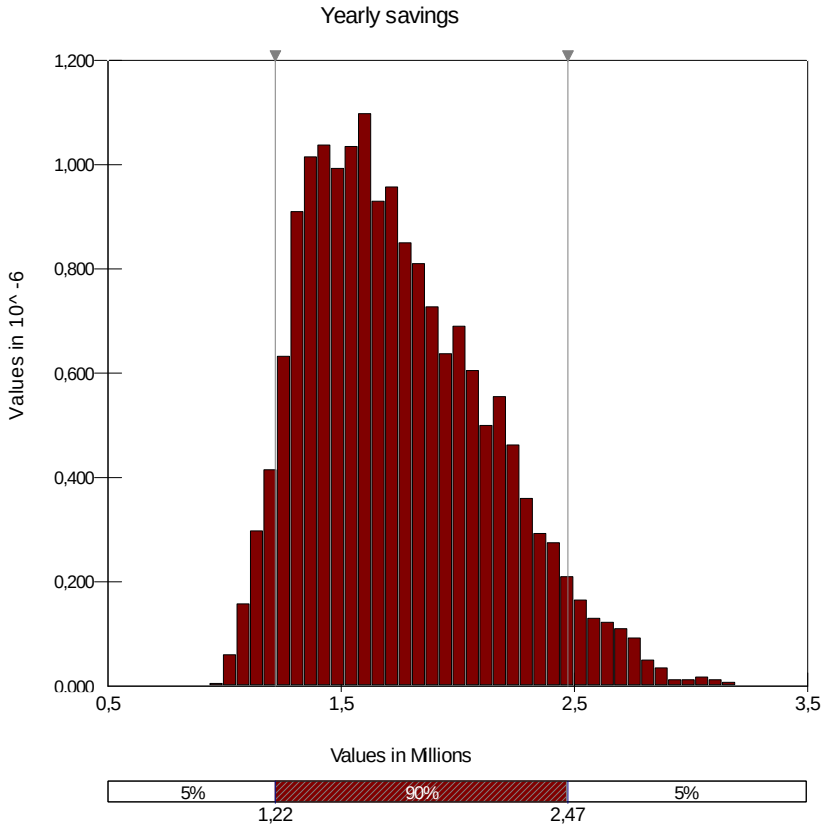

Figure 4. Annual savings in the second model.

Like in the automated loading system, there are large differences in the yearly savings. The maximum value is nearly double compared to the minimum value and the values are in millions. The decision-makers should gather more information to make sound decisions. Conducting a sensitivity analysis on the independent variables will yield additional insights to the results (presented in Figure 5).

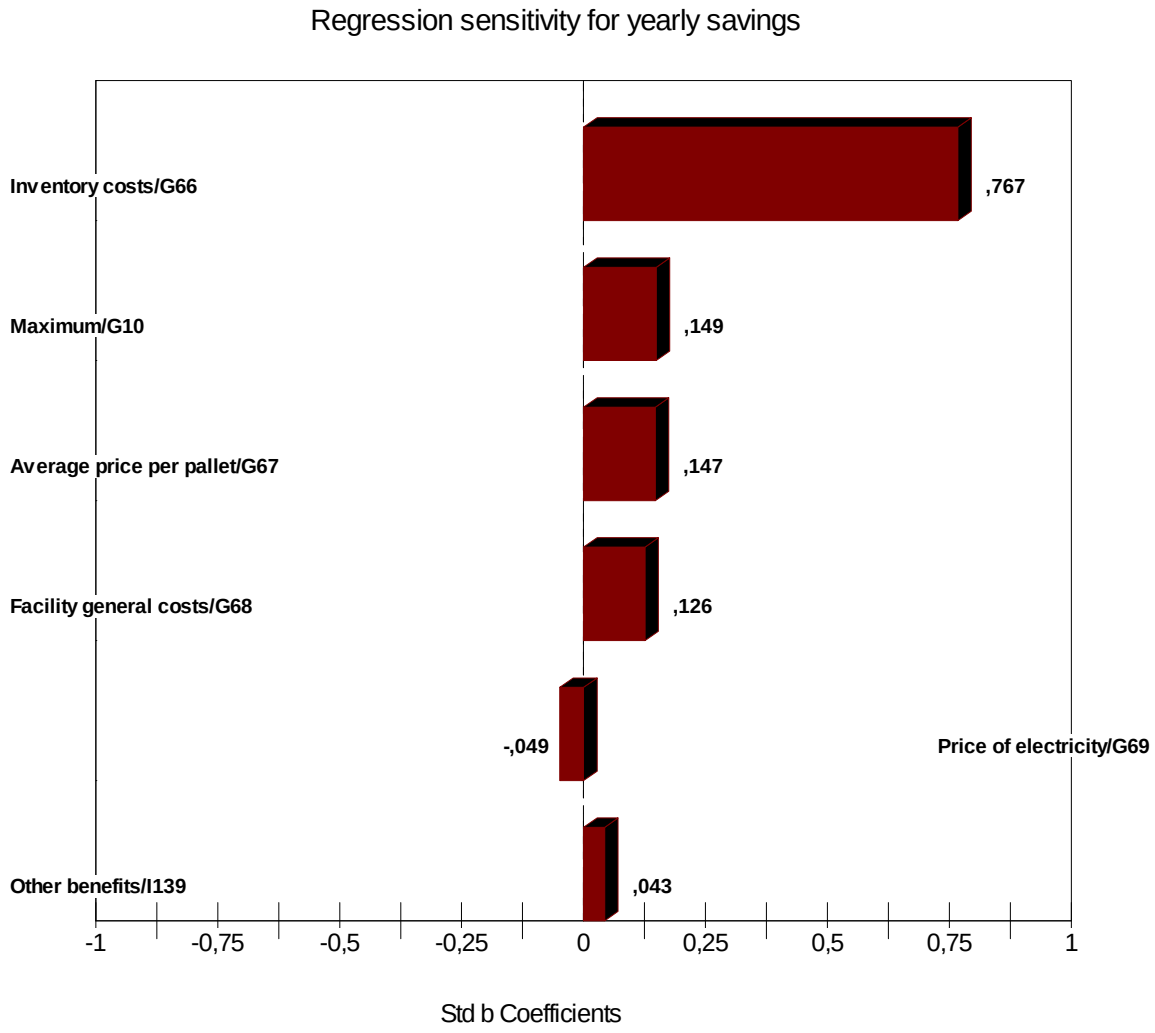

Figure 5. Regression coefficients in the second model.

The sensitivity analysis shows, that the actual throughput values are not that critical for the cost savings. The price per pallet and inventory costs impact very heavily the results, as the system is able to keep the goods in good condition. Also, the costs associated to the facility and system impact the results but in different ways. If the price of electricity increases and facility costs increase due to this, the automated storage is a lot smaller than a conventional system which minimizes these costs. On the other hand, the automated system requires electricity to function which will increase the system's costs.

5. Discussion

The simulation model offers additional insights to the AS/RS –systems. The automated loading system can be combined with other AS/RS –systems as well, which makes the

spreadsheet model a good marketing tool. The simulation of the spreadsheet model gives a confidence interval for the financial benefits which allows the potential customers to incorporate uncertainty in their decision-making. Also, the simulation model gives information on the sensitivity of the independent variables. The actual AS/RS system –model can be used in a similar fashion and simulation offers the exactly same benefits

According to the simulations it is clear that an automated loading system can offer large financial benefits to companies which need to load heavy and bulky cargo with cranes. By substituting open top containers with hard top containers it is possible to dramatically cut the transportation costs. The transportation costs had clearly the highest impact in the simulation model and the other variables impact was relatively small. It should be noted that other variables will become more important in different scenarios.

6. Conclusions

Warehousing plays an important role in the efficiency of todays international supply chains. Optimal configuration of warehouse activities depends on several design criteria. Basic alterative system designs are based either on manual labor or automated systems. While manual systems typically require smaller investments, automated systems enable increased efficiency in space utilisation, advanced flexibility, as well as reduction in spoilage and administration cost.

Transportation and material handling systems tend to be too complex for analytical models to be modelled realistically. However, detailed discrete event simulation models require extensive model building. In this paper we combined static spreadsheet modelling with Monte Carlo simulation for conducting financial feasibility analysis of two automated storage and retrieval system configurations. This initial evaluation tool enables us to select only configurations with most potential for more detailed planning.

In the cases studied the investments evaluated seemed economically feasible. As the system supplier conciders offering the tool directly for its potential customers on the web, the tool as a construct has passed the weak market test proposed by Kasanen et al. (1993).

References

Baker, P. & Halim, Z. (2007) 'An exploration of warehouse automation implementations: cost, service and flexibility issues', *Supply Chain Management: An international journal*, Vol. 12, No. 2, pp. 129-138.

Coyle, J.J., Bardi, E.J., and Langley, C.J. (1996) The management of business logistics. MN: West: St. Paul.

Kasanen, E., Lukka, K. and Siitonen, A. (1993) 'The constructive approach in management accounting research', *Journal of Management Accounting Research*, Vol.5, pp 243-264.

Naylor, T., Balintfy, J., Burdick, D. and Kong, C. (1966) *Computer Simulation Techniques*. John Wiley, U.S.A.

Parikh, P. J. and Meller, R.D. (2010) 'A travel-time model for a person-onboard order picking system', *European Journal of Operational Research*, Vol. 200, pp. 385-394.

Petersen, C.G., Siu C. and Heiser, D.R. (2005) 'Improving order picking performance utilizing slotting and golden zone storage', *International Journal of Operations &Production Management*, Vol. 25, No. 10, pp. 997 – 1012.

Roodbergen, K.J. and Vis, I.F.A. (2009) 'A survey of literature on automated storage and retrieval systems', *European Journal of Operational Research*, Vol. 194, No., 2, pp. 343-362.

Sari, K. (2008) 'Inventory inaccuracy and performance of collaborative supply chain practices', *Industrial Management & Data Systems*, Vol. 108, No. 4, pp. 495 – 509.

Sella, A.F. (2005) 'Spreadsheet simulation', In Kuhl, M.E., Steiger, N.M., Armstrong, F.B., & Joines, J.A. (Eds.) *Proceedings of the 2005 Winter Simulation Conference*, pp. 33 – 40

Wilson, D. & Laney, R. (2003) 'The use of simulation for clothing manufacturing executives; a case study', In Post, D.A. (Eds.) *MODSIM 2003: International Congress on Modelling and Simulation*, pp. 1847-1851.

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Comparison of Terminals in Finland and Russia

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Сравнение терминалов в Финляндии и России

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Abstract
Although Russian logistics sector has been studied greatly during last decade, comparison of terminals in Finland and Russia has been overshadowed. This research provides insights into the national peculiarities of the Russian terminal and warehouse market. As point of comparison, example from Finland is presented. Literature analysis combined with first hand data gathered by visiting terminals provides novel data. Research's main findings note the Russian terminal sector has been developing rapidly: WLAN, Enterprise Resource Planning system, wireless barcodes and Pareto principle are becoming standard in Russia. Although road transport is still the mainly utilized transport mode, terminal providers have plans to expand to railway transport.

Keywords: Finland, railway, road, Russia, terminal, warehouse

Аннотация
Несмотря на то, что российский сектор логистики был изучен достаточно серьезно в течение прошлого десятилетия, сравнение уровня развития складов Финляндии и России было недостаточно освещено. Это исследование позволяет понять особенности российского терминально-складского рынка. В качестве сравнения, представлен пример Финляндии. Обзор литературы, совмещенный с данными, полученными в ходе посещения терминалов, позволяет получить нам новый взгляд на проблему. Основные результаты исследования состоят в том, что российский терминальный сектор развивался быстро: WLAN, система ERP, беспроводные штрих-коды и правило Парето становятся общепризнанными в России. И несмотря на то, что автомобильный транспорт – основной вид транспорта, при перевозке грузов, провайдеры складских услуг имеют планы осуществлять перевозки и железнодорожным транспортом.

Ключевые слова: Финляндия, железная дорога, автомобильная дорога, Россия, терминал, склад

1. Introduction

Although supply chain management is often seen as an attractive field of research in logistics, also other parts of logistic chains are noted. One of these is warehousing, which has been scrutinized world widely in numerous studies (see for example Baker, 2007; Hilmola and Szekely, 2006; Min, 2009). Although logistical functions between Finland and Russia are widely studied, terminals have not been among the mostly investigated factors. Therefore, this research tries to fulfil the gap by presenting results, which are gathered via qualitative case study analysis. Main intention is to compare Finnish and Russian terminals and estimate

whether there are discrepancies. The transport modes utilized by the visited terminals are presented, and future prospects are clarified. Therefore, the main research question this article tries to tackle is "Are there discrepancies between Finnish and Russian terminals' functionality?" As minor research question, article tries to clarify which are the mainly utilized transport modes.

Many researchers have recently concluded studies concentrating on Russian logistics sector (see for example Filina, 2009; Hilmola et al., 2008; Lorentz et al., 2007). Interestingly, many studies have compared Finland and Russia (Inkinen and Tapaninen, 2009; Lorentz, 2008; Tuominen et al., 2009). Although Finnish–Russian logistics sector has grabbed researchers' interest for decades, studies have mainly scrutinized transport. However, due to increased amount of terminals, warehousing and technologies related to increased productivity have sharpened their portions.

Due to various reasons, many international companies prefer establishing warehouses to Finland. Warehouses operating in Finland are seen safe, reliable and liquid; however, short distance to Russia has assured quick re-transport to Russian markets. (Hilletofth et al., 2007) Additionally, Russia has faced shortages in warehouse space. According to Pekkarinen (2005), in 2005 deficit of high class warehouse space was 400 000 – 500 000 square meters in Moscow, while the figure for whole country was 2.5 – 3 million square meters. According to Tuominen et al. (2009), the main reason for problems in establishing warehouses are lack of suitable land and bureaucracy behind land development permit process. Although it is noted only 60 % of planned terminal space was concluded in 2004, the situation has changed. In 2004 as the main obstacle were mentioned legal and operational reasons; however, during the last years many new warehouses have been constructed to Russia, mainly Moscow and St. Petersburg (Inkinen et al., 2009; Pekkarinen, 2005). However, Finnish companies also establish own warehouses to Russia. According to Hilmola and Szekely (2006), Russia was seen as an interesting place for locating warehouses.

High-technology is gaining ground in terminals and warehouses. Radio Frequency Identification (RFID), Enterprise Resource Planning (ERP) and Wireless bar-codes are commonplace. RFID is widely used in the United States, for example in companies such as Wal-Mart and Tesco (Kwok and Wu, 2009; Vijayaraman and Osyk, 2006). Zeng et al. (2003) describe Enterprise Resource Planning (ERP) as a strategic tool which helps companies to

increase the competitive advantage, for example via integrating business opportunities and optimizing the available resources. Therefore, ERP has an important position in supporting most of the functions in companies (Elbertsen et al., 2006; Inkinen et al., 2009; Kakouris and Polychronopoulos, 2005).

The research is structured as follows: Section 2 presents shortly literature findings concerning warehousing in Finland and in Russia. In section 3 research methodology is described. Following section 4 presents the case companies and scrutinizes gathered information. In section 5 gathered data is discussed. Section 6 finalizes the paper by concluding the topic and giving suggestions for further research.

2. Research Methodology

Research utilized qualitative case study analysis. In order to gather genuine information, terminals in Russia and Finland were visited. Due to modest level of earlier first-hand data, by visiting terminals new insights were developed and genuine level information was gathered.

Russian logistics sector has confronted changes during the last decade. While country is rebuilding the main activities, logistics sector is increasing its foothold. According to Russian Freight Transport Report (2009), although the market is in deep crisis, logistics sector has an important role in Russian economics. Terminal operations and major warehouses are located in Moscow and St. Petersburg area, which enables business opportunities for international and Finnish companies.

In order to understand the discrepancies between western and eastern terminals, as case studies were chosen two Russian and one Finnish terminal. From Russia were visited one smaller scale and one larger scale terminal, which enabled us to evaluate whether terminal size affects on level of knowledge and utilized methods. Finnish terminal is expanding and updating its operations, wherefore it provides an interesting viewpoint for recent terminal functions in Finland. All visited terminals were new or expanded. Although sample is rather small, it provides an insight into terminal operations in countries in question. All terminal visits included two parts: in addition to conversation with managers or persons in such a position, terminals were visited in order to see the functions. This strengthened the level of

knowledge and confirmed the actions were understood correctly. The possibility for language misunderstandings was minimized by having Russians in the delegate.

3. Empirical Results

Section 4 scrutinizes the cases. Summary discussing the results is provided in the next section.

Terminal operator in the City of St. Petersburg

The operator is having main warehouse in St. Petersburg, in a warehouse complex area, where in total is available 170,000 m^2 of warehouse space. Their operations consists 15,000 m^2, from where 60-70 % is currently used for customer deliveries; in the warehouse is 40 000 pallet places and 41 loading docks. In total the warehouse has employees of a bit more than 100. Altogether this service operator is having more than 50 customers, but one retail chain operating in Russia is their main customer, other customers are mostly wholesalers. Interestingly, currently 40 % of their customer stocked items are originating from Russian manufacturers, while rest is coming from overseas, mostly from China (also Central Europe is important source of supply). Warehouse does not only serve customers in St. Petersburg or Leningrad Oblast region, but also long-distance destinations are being transported from this location (e.g. to north, into Murmansk, and some West Siberian locations, having up to 7-10 days of road transportation time). Most of the stocked items are non-frozen, and therefore this long-distance arrangement is possible. Logistics operator bases its transportation operations comprehensively on outsourced road transportation as shown in Figure 1. Operator could have desire to use more St. Petersburg harbour (and eventually sea vessel deliveries), but customers have influence on transportation mode being used, and e.g. some deliveries from Central Europe are being transported directly by trucks. On Russian outbound distribution side operator is solely using road transportation.

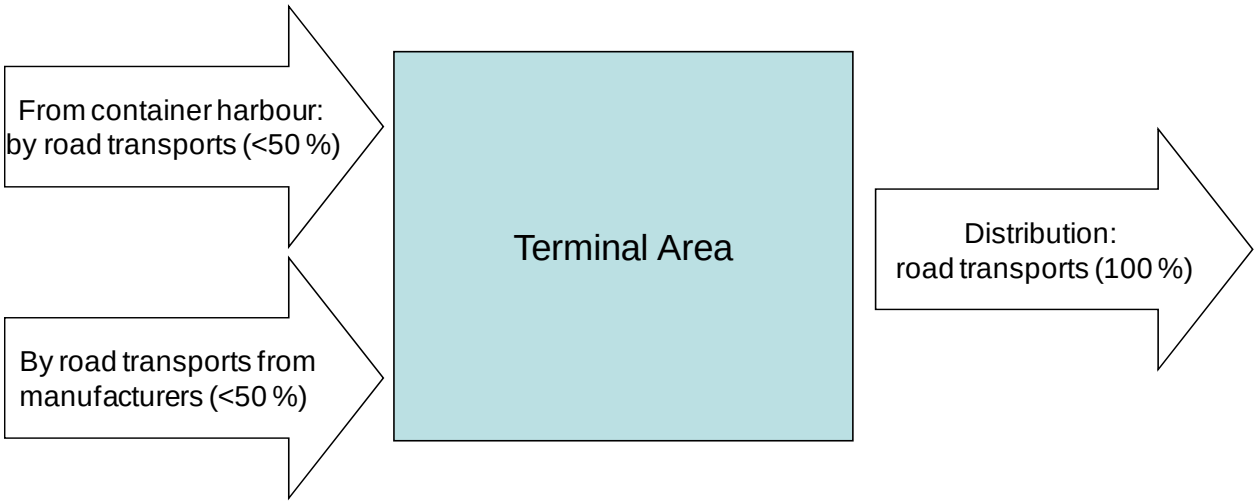

Figure 1. Transportation flows to and from operator's facilities in St. Petersburg.

The high-technology systems have a strong foothold in the terminal in question. For example, this operator has wireless WLAN based bar-code application, which is connected to Enterprise Resource Planning (ERP) system. ERP system is in most of the cases having connection on customers IT system – these all lead to situation, where information should be fresh and up to date as well as having least errors (as it is once typed in). Logistics operator is daily using also cross-docking (flow through approach) in some customer shipments, and in some cases customers are requiring dedicated services (for example warehousing section or transportation device). Based on company personnel, due to the global economic crisis more efficient practices have been started to be favoured among customers. For example, cross-docking has become increasingly popular. Logistics operator is also using rational management methods in its order picking, e.g. placing items in selves by using Pareto principle (ABC; where highest volume times are placed in the first closest section to order picking area). The warehouse turnover depends on customer: basically, the time varies between 1 week and 3 months.

Logistics operator was telling that some more distant cities, like Krasnojarsk, is currently growing fast (as the weight on retail and economic activity has been earlier on St. Petersburg and Moscow). Although, operator is nowadays able to manage these long-distance shipments, pressures to enlarge warehouse network is growing, and if economic conditions will improve in the future, customers will require warehouse space in these more distant locations too.

Currently operator is managing these long-distance shipments in a manner that particular day is order picking day of e.g. West-Siberian region, and another e.g. northern region.

Freight forwarder / Terminal operator in the City of St. Petersburg

The terminal was built in 2006 in order to take care of company's freight forwarding section's warehousing and distribution. The company in question is forwarding and transporting company, which has offices in Finland and Russia. Its main concentration is on transit traffic from Finland to Russia, but company operates in all areas of logistics. The terminal employs approximately 120 persons, including personnel in café and warehouse. At the moment company has around 300 customers, varying between large companies and small-scale businesses.

The terminal is located in St. Petersburg by the ring-road which circles around the city. Company's freight forwarding office will be located in the same location; today the office is in a different place. In the same building with terminal are located Customs, Bank, Café and Warehouse, providing all needed services to truck drivers who arrive to unload / load the cargoes.

The terminal's total size is over 3000 m2 and it's divided into bonded and normal distribution warehouse. Bonded warehouse occupies 1/3 of terminal's size and it has 4 loading docks. The loading docks' floor is adjustable, which enables smooth loading and unloading. All terminal operations are done both manually and electronically. Warehouse's shelves are in three layers, utilizing the smooth turnover time (rational management methods are used in order picking; items are placed in selves by using Pareto principle (highest volume goods are placed in the closest sections to ease the picking process)). Warehouse is equipped with 2 scales, one is able to scale goods till 3000 kg, and the other one is used for small and lighter goods. There is also an x-ray machine, which describes the content, temperature etc.

Normal, distribution warehouse occupies 2/3 of the warehouse and it has 6 doors. Few doors are meant for small vans, which easies the delivery of small lots. Warehouse is equipped with three-layer shelves, utilizing also Pareto principle. Wireless WLAN based bar-code application is used, which minimizes the human error possibility. Application has a connection on company's own Enterprise Resource Planning (ERP) system as well as

customers IT system. Both warehouses are equipped with heaters, which enables safe and reliable loading and unloading also during winter.

Group of companies also has an own distribution service, which provides local distribution within city limits using own cars. Additionally, company can arrange delivery by air, rail and truck to any destination in Russia. In future, terminal has a plan to expand its area and the services. Company owns an area of 24.5 hectares which enables the expansion in the future. The plan is to build new warehouses, including two which would have a railway connection.

In addition to warehouse and office building, terminal area consists of “Business Centre”, Inspection Zone, Custom control parking zone and functions which strengthen the warehouse functions in case of emergency times. Business Centre is an own complex which concentrates on Customs procedures. In the building are located offices of over 60 Customs Brokers’ companies. Inspection zone is a place to do a careful check for the trucks. At the same time 6 trucks can be examined. All needed IT systems are available enabling a full check. Custom control parking zone has space for 400 trucks. When entering the lot, trucks pass a gate which registers the trucks and gathers the needed information. IT systems enable careful checking: all the time for example amount of trucks and information about the Customs procedures can be examined. Parking lot is equipped with cameras and other needed security functions. Additional functions include boiler point, own transformation centre (enables own electricity in the case of power failure), diesel centre and clean water refill centre.

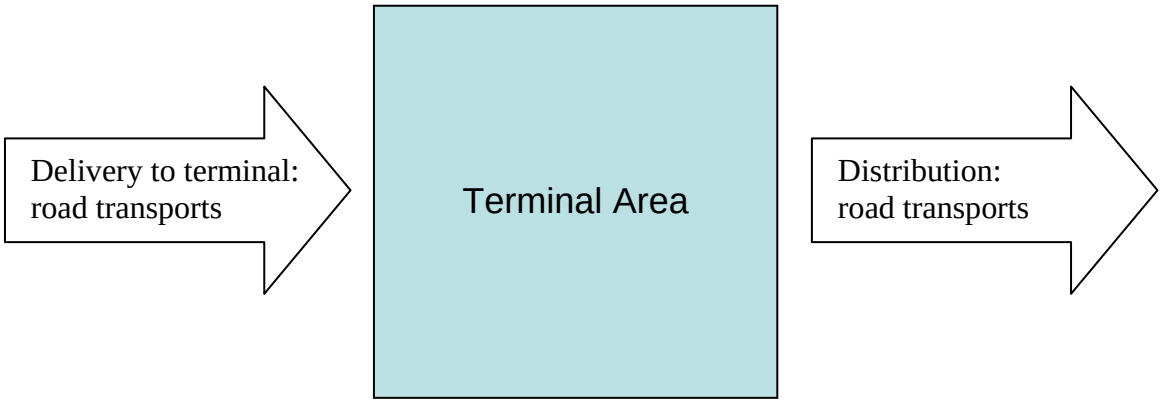

Figure 2. Cargo flows to and from the terminal

Figure 2 illustrates the cargo flows to and from the terminal. Today the cargo arrives to terminal 100 % via road transport. Distribution is done by the same transport method. Cargo arrives mainly by trucks from Finland (around 50 %); cargoes around the world are collected to Vantaa terminal, where it's distributed truck by truck basis to St. Petersburg terminal. Part of cargo is arriving from St. Petersburg port, which is located near-by. Airport is also only 30 minutes away, enabling smooth cargo flows in the case of air cargo. However, company representatives believe the situation will be different in the future: the new terminal area will have railway connection, and the intention is to change 40-50 % of transport to rails.

In the terminal the newest functions are used. In the entrance hall is customer display terminal, where customer can check truck-by-truck basis where the truck is located and what is the status of Customs procedures. Good service is also confirmed by providing all needed services under the same roof. For example electronic TIR Carnet control is used, which enables smooth information flow between the terminal and border stations. In the terminal is also located a bank section, where drivers pay for example terminal handling charge (THC) before continuing the journey.

Additionally, terminal is utilizing a truck control system, which gathers information concerning the trucks, drivers and the Customs control procedures. This strengthens terminal's competitiveness.

Terminal operator in the City of Kouvola

Company operates three warehouses in Kouvola area, covering total 38 000 m2. The largest warehouse is 15 000 m2; the office is located at the same premises. Loading and unloading operations are organized through 30 loading places and one bigger door which can be used with large machines; this enables trucks to enter the warehouse. Additionally, railway loading and unloading area is inside the premises, ensuring proper settings for temperature-controlled goods. Railway is asphalted, which enables trucks' side loading / unloading. Warehouse is free space warehouse, no shelving is utilized. The maximum height is 6 – 6.5 metres, which according to CEO is enough for this type of storage.

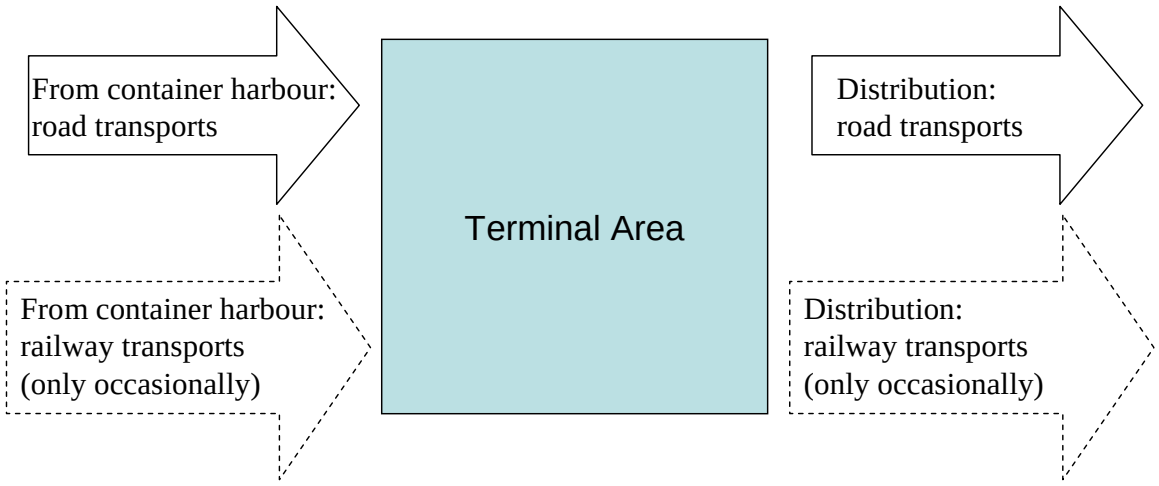

Figure 3. Incoming and outgoing cargo flow in terminal in Kouvola

All incoming containers arrive from harbours by utilizing road transport (see Figure 3). Containers are unloaded to warehouse and goods are stored various periods, depending on customers' requests. The distribution is done mainly by road transport. Occasionally, cargo arrives and departures by railway. The major part of goods is on transit to Russia: the main cargo types are electronics, various household goods and commodity products. Additionally, some cargos arriving from Russia, including paper rolls and other paper products, are stored before distributed to Finnish customers. Due to the nature of main product types, loading and unloading can be organized in not-temperature controlled sections.

Company owns one container handler, which according to the CEO is enough to handle all container movements. Additionally, several forklift trucks operate inside and ensure smooth cargo flows. Warehouse's turnover speed is good: on a normal day, 80 containers arrive and 120 trucks leave. However, during our visit the tempo was a bit quiet, due to change of lodger.

Although the economic downturn has decreased the market, company strongly believes in the future and is enlarging operations nearby the main warehouse. A new warehouse (4 000 m2) is built during summer 2009, and an option for another similar building is available. New warehouse specialises in construction industry's products, which do not endure moisture and therefore requires moisture expulsion system. Due to same reason, the railway track is built inside: company believes significant share of this product group will be transported by railway. Cargo handling will be done by cranes and 32 tonnes truck. At this location is also a

large container field, where companies can store empty or full containers, or trailers. Altogether the area is 6 hectares.

According to company's representatives, railway transport will capture market share from road. This strengthens Kouvola's position as a logistic centre. Once transit traffic to Russia is changed to tracks, Kouvola is a perfect location for container depots. Company's aim is to operate as a hinterland hub and provide both warehousing and depot services for diverse companies.

4. Discussion

Case studies in question provide interesting insights into the terminal operations in Finland and Russia. Development of Russian logistics sector has been rapid during the last years, which strengthen the level of operations. Actually, high level of utilized information technology systems, namely Enterprise Resource Planning (ERP) and wireless network and barcode system, surprises. Additionally, Pareto principle is in use, which enables terminals to function cost-effectively and strengthen the level of knowledge. Significant is to note although the visited terminals in Russia are different size (other occupies 15 000 m2 whereas other is 3000 m2), both are utilizing same high-technology systems. Due to the fact the backgrounds of visited Russian terminals are different (although other one is providing services also for smaller customers, it mainly concentrates on warehousing and distributing its forwarding company's shipments, while the other one's main customer is a retail chain), also provided services vary. Smaller terminal has multifunction services: at the same premises are located Customs, bank services and warehouse. Additionally, terminal has actual truck surveillance zone. The other terminal is part of a larger terminal complex. The Finnish terminal is facing new times as it is going through remarkable changes in clientele as well as terminal area. Operator has expanded its operations to windscreen transport, which needs special transport equipment. Therefore, it can be noted as an innovative company.

Additionally, ring road which circulates the city is strengthening transport market. Because ring road enables good connections to port, airport and roads to Moscow and Finland, numerous new terminals are located nearby. This concern also the two visited terminals in St. Petersburg, which both were located by the ring road. Same ideology is behind Finnish

terminal's location: it is located in Kouvola, which is often seen as hinterland for Kotka and Hamina ports.

Road transport is the mainly utilized transport mode in all terminals in question. However, some minor discrepancies are noted. In Finland basically all units arriving to terminal are unloaded from container feeder vessels to harbour, where after units are delivered to terminal. Although same method is utilized in Russia, in addition air and direct road transports are used. Interestingly, only terminal among analyzed cases utilizing railway transport is the terminal located in Finland. Although terminal has direct railway connection, only minor part of shipments is transported via railway. However, terminal operator's intention is to boost railway transport in near future. One Russian terminal operator referred to same aim: company has purchased land, and the intention is to increase the terminal areas' functionality by constructing new warehouses with railway connection.

5. Conclusions

Terminals' functionality in Finland and Russia are on the same level. During the last decade Russian counterparts have developed the operations rapidly: today terminals are equipped with latest high-technology equipments and systems. Although direct transportation to Russian ports has increased, due to national peculiarities many international customers still see transit route via Finland as more attracting route due to safety, accuracy and reliable liquidity. However, it must be noted the level of development has been outstanding, wherefore the future can only be roughly estimated.

For further research in this area, it would be interesting to evaluate a larger sample. Interviewing terminal operators nearby Finnish ports as well as Russian border would increase the level of knowledge and could adduce the divergences between terminals. Equally, by visiting larger number of Russian terminals, located nearby ports as well as in mainland could explicate the situation. Additionally, research concentrating on transport flows could evaluate the situation and provide new insights into the future expectations.

References

Baker, P. (2007) 'An Exploratory Framework of the Role of Inventory and Warehousing in International Supply Chains', *The International Journal of Logistics Management*, Vol. 18, No. 1, pp. 64-80.

Elbertsen, L., Benders, J. And Nijssen, E. (2006) 'ERP use: Exclusive or Complemented?', *Industrial Management and Data Systems*, Vol. 106, Issue 6, pp. 811-824.

Filina, V.N. (2009) 'Transport Logistics Services in Russia: Integration in the World Market, *Studies on Russian Economic Development*, Vol. 20, No. 3, pp. 259-267.

Hilletofth, P., Lorentz, H., Savolainen, V-V., Hilmola, O-P. and Ivanova, O. (2007) 'Using Eurasian Landbridge in Logistics Operations: Building knowledge through Case Studies', *World Review of Intermodal Transportation Research*, Vol. 1, No. 2, pp. 183-201.

Hilmola, O-P., Abraha, D. and Lorentz, H. (2008) 'Export Based Strategy or Manufacturing Establishment? Speculating with Russian Market', *International Journal of Logistics Systems and Management*, Vol. 4, No. 2, pp. 155-183.

Hilmola, O-P. and Szekely, B. (2006) *Logistics Development in Finnish and Swedish Companies with Respect of Russia and Four Asian Countries: Traffic Flow and Warehousing Analysis from Current Situation and Likely Development Trends*, Lappeenranta University of technology, Department of Industrial Engineering and Management. Research Report 175.

Inkinen, T. and Tapaninen, U. (2009) 'Finnish-Russian Transport and Business Expectations', *World Review of Intermodal Transportation Research*, Vol. 2, No. 4, pp. 279-295.

Inkinen, T., Tapaninen, U. and Pulli, H. (2009) 'Electronic Information Transfer in a Transport Chain', *Industrial Management and Data Systems*, Vol. 109, No. 6, pp. 809-824.

Inkinen, T., Ruutikainen, P. and Tapaninen, U. (2009) 'Development and Future Prospects of Finnish transit to Russia', in Hilmola, O-P. and Korovyakovsky, E. (Eds.) *North-European Logistics in the Era of Global Economic Turmoil*, Lappeenranta University of Technology, Department of Industrial Management, Research Report 213.

Kakouris, A.P. and Polychronopoulos, G. (2005) 'Enterprise Resource Planning (ERP) System: An Effective Tool for Production Management', *Management Research News*, Vol. 28, Issue 6, pp. 66-78.

Kwok, S.K. and Wu, K.K.W. (2009) 'RFID-based Intra-supply Chain in Textile Industry', *Industrial Management & Data Systems*, Vol. 109, No. 9, pp. 1166-1178.

Lorentz, H., Wong, C.Y. and Hilmola, O-P. (2007) 'Emerging Distribution Systems in Central and Eastern Europe: Implications from Two Case Studies', *International Journal of Physical Distribution & Logistics Management*, Vol. 37, Issue 8, pp. 670-697.

Lorentz, H. (2008) 'Collaboration in Finnish-Russian Supply Chains: Effects on Performance and the Role of Experience', Baltic Journal of Management, Vol. 3, Issue 3, pp. 246-265.

Min, H. (2009) 'Application of a Decision Support System to Strategic Warehousing Decisions', *International Journal of Physical Distribution & Logistics Management*, Vol. 39, No. 4, pp. 270-281.

Tuominen, T., Kitaygorodskaya, N. and Helo, P. (2009) 'Benchmarking Russian and Finnish food industry supply chains', *Benchmarking: An International Journal*, Vol. 16, Issue 3, pp. 415-431.

Pekkarinen, O. (2005) *Northwest Russian Transport Logistics Cluster: Finnish Perspective*, Lappeenranta University of Technology, Northern Dimension Research Centre, Publication 14.

Russian Freight Transport Report (2009). Available at http://www.companiesandmarkets.com/Summary-Market-Report/russia-freight-transport-report-q4-2009-162272.asp Retrieved November 2009

Vijayaraman, B.S. and Osyk, B.A. (2006) 'An Empirical Study of RFID Implementation in the Warehousing Industry', *the International Journal of Logistics Management*, Vol. 17, No. 1, pp. 6-20.

Zeng, Y., Chiang, R.H.L. and Yen, D.C. (2003) 'Enterprise Integration with Advanced Information Technologies: ERP and data warehousing', *Information Management and Computer Security*, Vol. 11, No. 3, pp. 115-122.

Types of Merchandise Storage at Warehouses

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Способы складирования грузов

Олег Маликов

Abstract
One of the important problems in Supply Chain Management (SCM) is inventory cost decreasing at the warehouses which are significant components of the supply chains. Before inventory control can be produced, it is necessary to create the warehouses and determine their technology of operation and equipment so as to select the best solutions. Some of these questions are considered in the article.

Keywords: Supply Chains, warehouses, storage Inventory, stock keep unit (SKU), rack, operation cost

Аннотация
Прежде чем управлять запасами грузов в цепи поставок, нужно создать склады с эффективными способами складирования, которые обеспечат минимальную себестоимость переработки грузов на складах. Понятие «способ складирования» включает видхранения (штабельный, стеллажный, конвейерный) тип и параметры грузовых складских единиц, стеллажного и штабелирующего оборудования. Приведены классификация способов складирования и характеристика хранения грузов в штабелях, в рядных и блочных стеллажах, конструкции стеллажей разных типов (каркасных фронтальных, бесполочных, глубинных, консольных, передвижных, гравитационных).

Ключевые слова: Цепь Поставки, Склады, Складские запасы, Стеллаж, Грузовая складская единица, Эксплуатационные расходы

1. Introduction

In the SCM the problem of Inventory Control is considered as very important for the total supply chain optimization. The purpose of the inventory control is to provide the least cost for keeping stocks at warehouses, which always include in any supply chain. These warehouses are of different types, but all of them fulfill likely function – to transform parameters of material flow so as any following partner in the supply chain can receive merchandise with the characteristics that are needed for them. That regulation is in accordance with the main principle of the Business Logistics – right load, in right quantity, in right time, in right place, of right quality, in right condition and at the competitive price (LQTPQC-P). However, it is very difficult and sometimes impossible to fulfill this principle if the warehouse was built and equipped improperly or unprofessionally. In this case it is also impossible to provide the least

operational cost of the warehouse nevertheless we would introduce the most efficient methods of inventory control or no.

One of the first stages in the supply chain projecting is creating warehouses in it with the best parameters, capacity, layout, type of storage and other characteristics. Specifically, the most significant problem in this respect is professional selection of the method of merchandise storage and the type of racking equipment in the storage area of the warehouse under consideration. Right solutions on these points would provide the best technical characteristics and economical indexes of the warehouse having been created.

2. Methods of Merchandise Storage

The storage area in the warehouse facilities of different types amounts to about 70-80% of the total square and cost of the warehouse. Therefore, it is very important to project and operate this area professionally and efficiently. The first and most important stage in this direction is to select proper way of storage at the warehouse. There is great variety of the methods of merchandise storage. This name itself includes the following points:

- Type of storage (stack, racking or conveyor);
- Types and parameters of Stock Keep Unit (SKU);
- Types and parameters of racking structures;
- Types and parameters of handling (stacker) equipment.

As analyses show there may be a number of hundreds of storage methods as combinations of these factors. Basic alternative stocking methods include stack, racking and conveyor storages. For example racking storages can further be devided into systems with or without pallets. In every type of storage the main purpose consists of reception maximum utilization of the warehouse space with cargo and provisions over this the biggest capacity of the warehouse. The simplest storage of cargo in stacks, at which SKU are established one on the other without any rack, can be produced with cargo on flat pallets, on pallets with uprights or in box pallets. This method is characterized with the following parameters:

- Number of tiers in height;
- Number of pallets in depth of the stack;

- Number of pallets in every vertical bay (these should keep the same items of cargo);
- Volume of transport shipment should consist of one or several full pallets.

Advances of the stack storage are as follows:

- Small initial cost of storage;
- There is no stationary equipment;
- Ability of operational maneuverability of the stack disposition.

Drawbacks of the stack storage:

- Little height of storage;
- Poor utilization of the warehouse volume;
- Possibility of the lower cargoes or their packing damage;
- Impossibility to take and dispatch any SRU from depth of the stack;
- Difficulty of addressing of the cargo location in the storage area (because of changing their places in the free way).

As a consequence of these specialties the stack storage is recommended to apply at rather small warehouses when number of different cargo items is not very big (for example not more than 30-40). Capacity factor that is number of loaded pallet per 1 m^2 of the total square of the warehouse is about 1 pallet per 1 m^2 when flat pallets are used (stack of 2 tiers high) and something like 2-2.2 pallets per 1 m^2 when pallets with uprights or box pallets are used (.stack of 4-5 tiers high). Racks have the following advantages as in comparison with the stack storage:

- More full utilization of the warehouse volume (that is the most significant characteristic of the way of storage);
- Great height of storage that provide possibility to save very expensive lot of land;
- Strict setting of the cargo location in the storage area, that make easy addressing of the cargo;
- Better preservation of merchandise in high bay racks;
- Possibility of automation of the storage area.

The racking equipment may be classified as follows:

- By the way of load supporting and kind of corresponding construction of the rack (cell, frame, shelves or absence of them, cantilevers);
- By the load condition in the racking (stationary or moving);
- By the drive: having or not;
- By the number of pallets in a rack cell: mono-pallet, double-pallets, many-pallets cells (compartments);
- By accessing to any load unit: with direct access to any pallet, with direct access only to the first pallets of the transport shipments (by the operational aisle);
- By the sort of loads to be stored: for loads on pallets, for separate loads without pallets, long cargoes, small parts;
- By the height of racks: low racks (up to 4 m high), middle height racks (5-8 m high), high bay racks (higher 8-9 m).

Total number of racking equipment can count to several thousands. Cost of racks in Russia fluctuates from $30 up to $70-80 per one stored pallet with load depending mostly on types of the racks. The concept of “row-storage” and “block-storage” are explained with assistance of Figure 1.

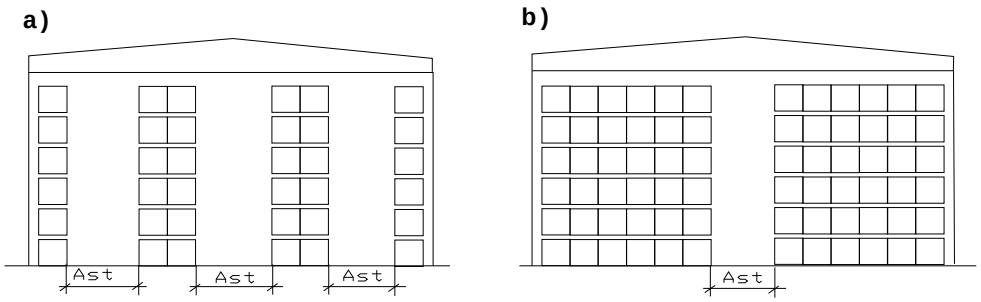

Figure 1. Sketch of main types of racking storage: row-storage (a) and block-storage (b)

While row-storage is applied the racks are established with separate rows and there is operational corridor Ast (aisle) after every row of racks. While block- storage is applied there is only one operational corridor Ast (aisle) between two blocks of the racks. Advantage of the row-storage type is possibility to reach to every pallet (and consequently to any item of load

in the racking) from the aisle along which stacking machine is moving. Little coefficient of the warehouse volume utilization is the drawback of this method of storage. It is occurred because of many aisles between the racks.

Coefficient of the storage area volume utilization is calculated with the formula:

$$k_v = \frac{a * b * c * R}{B * L * H},$$

where **a** and **b –** are dimensions of the used pallets;

c – is the height of SKU;

R – number of the SKU's, which are contained in the storage area of the warehouse;

B and **L -** relatively width and length of the storage area;

H – useful height of the building in the storage area (vertical distance between the floor level and bottom level of the girder of the warehouse building).

For the row-storage method the coefficient k_v is usually so little as only 0.12-0.20. There are some technical ways for the coefficient k_v increasing (appliance of narrow-aisles stacking machines, double-deep cells in the racks, setting pallets into the rack with their long dimension across the cell rack, creation of high-bay warehouses etc).

Taking into account the mentioned specialties of the row-storage method, it is applied mostly for the warehouses that keep great number of stored items – 2-3 thousands of items and more. These are logistic and distribution centers and big freight terminals. Possibility of access to every pallet and every item of stored merchandise for replenishing and picking is the obligatory requirement for these facilities.

The block-storage method, displayed at Figure 1b, features of having only one (or two – in the very wide building) work aisle for the stacking machine. That allows using maximally the warehouse volume and providing the greatest warehouse capacity and throughput. So the coefficient of warehouse volume utilization in this case is as big as 0.60-0.70. That is the main advantage of the block-storage method. The drawback of the block-storage is impossibility to pick loads from the depth of block rack and therefore some loaded pallets may stay in the racks for long time. However taking into account these specialties of the block-storage method, it is applied mostly for the warehouses that store cargoes of little

number of items – not more than 30-40 or big shipments of the same merchandise or designated for the determined consignees. These are transferring warehouses and intermodal terminals at transport corridors in the points of different modes of transport interaction. There is no need of reaching to every pallet and every item of stored merchandise at these warehouses and it would be enough to provide possibility to reach the pallets nearest to the aisle, where stacking machines operate. Cargoes at these warehouses are replenished and picked with big transport batches of several full packages (pallets) from the same many-pallets cells.

2. Types of Racking Structures

The most wide-spread type of racks is cell frame racks (see Figure 2), which in Russia are called “frontal racks”. This rack is applied along with the method of row-storage.

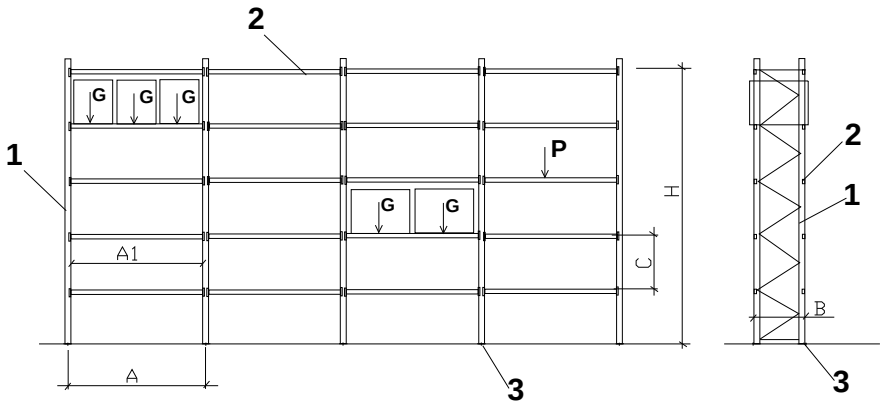

Figure 2. Performance and main parameters of the cell frame rack:
1 – Upright columns; 2 – Longitudinal load beams; 3 – Anchor bolts

Main parameters of the frame rack that should be determined while the way of storage is projecting are as follows: A – length of a cell; A1 – span clearance between upright columns; Y – number of cells along the rack (number of bays); y – number of pallets along a cell (bay); C – height of tiers; z –number of tiers; H – total height of the rack (height of upper tier); P – weight of load in a cell (there may be 2 or 3 loaded pallets in a cell of G weight every, as shown on the Figure 2); L – total length of the rack, as equal L = Y*A and some others.

Weight of the steel, which is spent for this rack structure, is about 50-60 kg per 1 stored pallet and cost of these racks in Russia is something like $30-35 per 1 stored pallet. Their disadvantages are load beams, which takes some height and decreases at near 5-8% useful tier height and make impossible to protrude shuttle grab under the pallet to take it. Advance of the rack is big distance between the upright columns, that provides lessen spending of metal for the rack and decreases cost of mounting works. The dimension of columns span of about 2700-2800 mm is considered to be optimal.

Cell frame racks usually are applied in conjunction with forklift trucks or bridge stacker-cranes. The cell racks without shelves consist only of upright columns (Figure 3), which have short cantilever supports for pallets. Absence of any shelves under the load provide room for shuttle grab of the stacker crane when it is necessary to put or take away loaded pallet in or out of the rack.

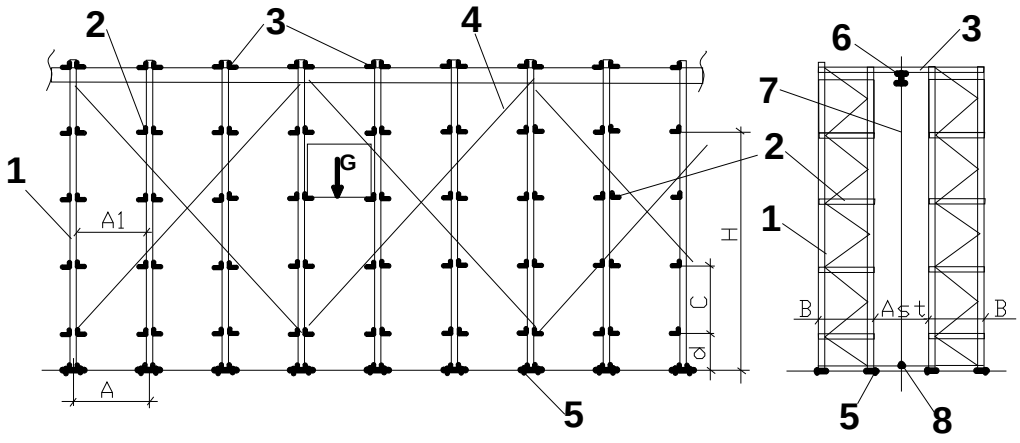

Figure 3. Performance and main parameters of the cell shelf less rack:
1 – Upright columns; 2 –Load support angles; 3 – Horizontal truss bracing; 4 – Vertical back bracing; 5 - Anchor bolts; 6 – Upper directing rail; 7 – Axis of the automatic stacker crane (storage robot); 8 – Low rail of the stacker crane

Expenditure of metal for this rack as calculated per 1 pallet and its cost are about the same as for the frame rack, but at the height more 12m these indexes increase dramatically. Advantage of these racks is possibility of great height of warehouse (up to 20-30m and more), that may be rather important especially when land lot is very expensive. Other advantages are high utilization of storage area (because of small width of the aisle for the stacker crane - only by 200mm more the dimension of pallet) and completely automated storage-retrieval operations with assistance of storage robots. This system is called AS/RS – Automated Storage/Retrieval

System. They are applied at big Logistic Centres and Distributional Terminals in Supply Chains of consumer merchandise.

Parameters of the shelf less racks, that should be selected and calculated while warehouse is projected, are almost the same as ones of the frame racks. When warehouse height exceeds 12m in the most cases it is efficient solution to use rack-supported building, because the racking structure is itself very power erection and it can bear additional loads of snow, wind, roof and siding of the building while being strengthened only by 5-7%. So in these cases the racking structure replaces the frame of the warehouse building and total investments for the warehouse facility are decreased dramatically (in some cases down by 20-30%). In the 80th of the last century 5 such warehouses (although only of 13m high) were built in Russia. Drawback of rack-supported solution is that it is impossible later to reconstruct the facility if the merchandise nomenclature or its designation would change.

Drive-in/drive-through racks, related to block-storage type, are called in Russia “deep racks”. They consist of separate many-places bays, separated with vertical trusses (Figure 4). This kind of racks provide high utilization of warehouse volume and big warehouse capacity on the same square, but in this case important rule of “First-in-First-out” can not be accomplished. Therefore these racks are usually applied when the merchandise is stored and handled by big transport shipments of 20-30 pallets, without unpacking packages and little batches picking.

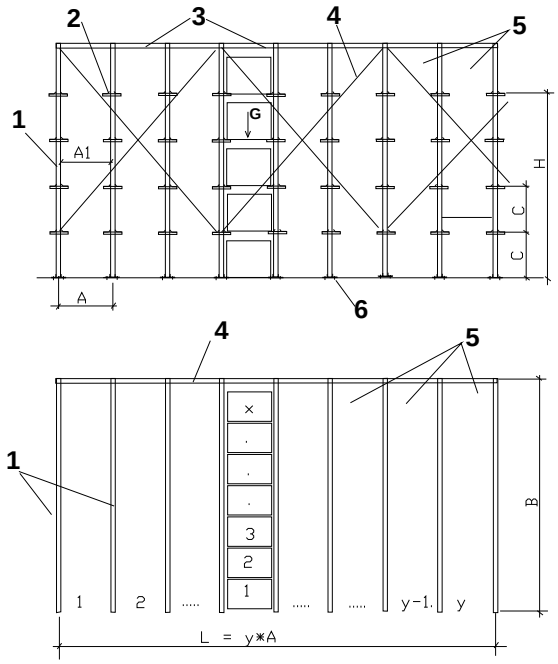

Figure 4. Performance and main parameters of deep-lane racks:
1 – Vertical side trusses; 2 –Load support rails; 3 – Horizontal truss bracing; 4 – Vertical back truss bracing; 5 – Load bays; 6 - Anchor bolts

Main parameters of the deep-racks, which may be seen in Figure 4, are as follows: A – length of a load bay; A1 – span clearance between upright frame columns; y – number of load bays along the rack; x – number of pallets in the depth of the load bay; C – height of tiers; z – number of tiers; H – total height of the rack (height of upper tier); P – weight of loads in a bay (there may be from 2 up to 10-12 loaded pallets in every tier and every one is of G weight , as is shown on the Figure 4); L – total length of the rack, as equal L = Y*A and some others.

The deep racks provide average load up to 2-3 pallets per m^2 of the total warehouse square, but they are more expensive as comparing with cell frame racks – near $40-50 per 1 stored pallet. Cantilever rack consists of central vertical columns and cantilever supports for loads, fixed to them (Figure 5). The racks features of absence of partitions between separate cells and as a matter of fact there are no cells at this rack at all. Therefore very long cargoes may be stored in this rack – up to 6m length and more and they may be of different length. This is the main advantage of the rack. Drawback of the cantilever racks is great stress on the central columns, because they are single ones along the rack and not double as in the racks of other

types. Other drawback is impossibility to use for storage all the height of the tier elevation because cantilever height occupies some part of this height.

Having in mind these features of the cantilever racks they are applied for the long steel bars, tubes, metal extrusions and other long and sheet materials. Handling of these loads is fulfilled by special side-loader lift trucks with side-reach fork grab or stacker cranes. The cantilever racks provide opportunity of access to any load in the rack from the operation aisle and so the rule of “First-in-First-out” can be provided in this case.

While steel rods are stored on the cantilever racks it is necessary to provide very reinforced foundation, because stress under rack columns can amount to 10-12 t per m^2 and more. One of options of the cantilever racks are cantilever-shelf rack, that has shelves over or between cantilever arms and so provide opportunity to store not only long loads, but also small and short ones. Therefore these racks may be applied for storage more various nomenclature of cargo.

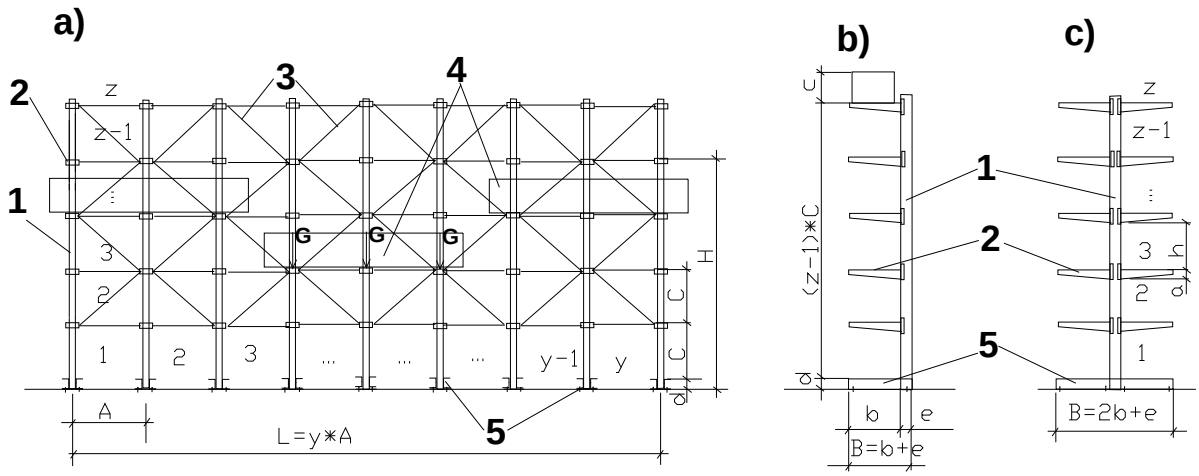

Figure 5. Performance and main parameters of cantilever racks - front view (a), side views of one-side rack (b) and double-sides rack (c):
1 – Upright columns; 2 –Load support cantilevers; 3 – Vertical truss bracing;
4 – Long cargoes; 5 – Bottom base with anchor bolts

Main parameters of the cantilever racks are shown in Figure 5. They are: A – span between columns; y – number of bays along the length of the rack; L – total length of the rack; z - number of tiers; d – height of the base; C – height of tiers; h – clearance between cantilevers in vertical direction; B – width of the racks; b – length of cantilever arms; G –load on a cantilever etc.

Moving racks (Figure 6) provide the full utilization of the warehouse volume, its capacity and throughput. They represent usual frame racks having been established on driving wheels. The moving racks are used in conjunction with the stationary ones, as in Figure 6 is displayed: two stationary frame racks are located on the margins of the section and several double-racks on driving wheels – between them. Operational aisle is provided only one in this case. Access to every pallet in the section is provided by way of moving of part of the racks. This type of storage can be considered as an intermediate type between row-storage and block-storage, because loads are stored in big blocks, but when it is necessary there is opportunity to have access to any pallet – just as with row-storage type. With appliance of moving racks it is possible to provide capacity about 2-2.5 pallet per m^2 of total square of warehouse facility. However, these racks are the most expensive at Russian market – in range of $70-80 per 1 stored pallet.

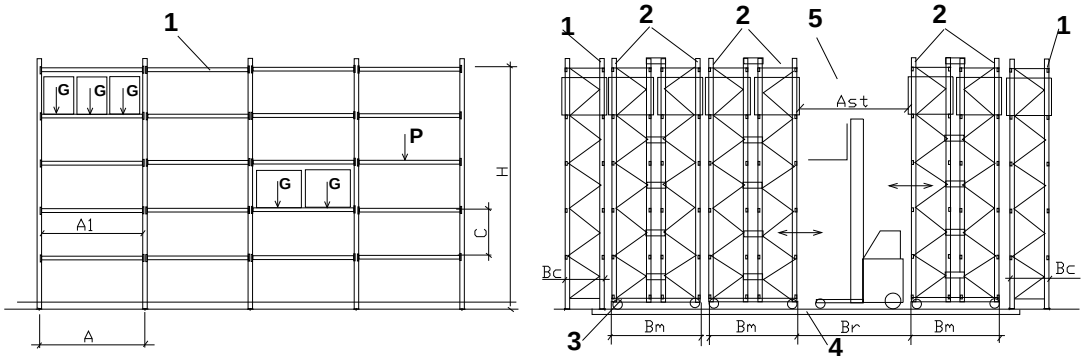

Figure 6. Performance and main parameters of a warehouse section with moving racks: 1 – Stationary frame racks; 2 – Moving frame racks; 3 – Wheels with drives; 4 - Rails for the moving racks; 5 – Operational aisle for stacking machine

The roller conveyor rack (Figure 7) is related to the flow types of storage. It represents welded steel structure with inserted slope lanes of roller conveyors.

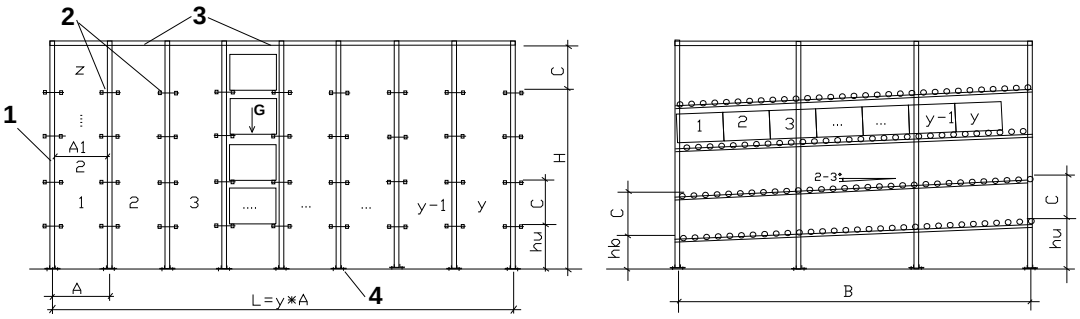

Figure 7. Performance and main parameters of gravity roller conveyor racks:
1 – Vertical side trusses; 2 –Load support rails with rollers; 3 – Horizontal truss bracing; 4 - Anchor bolts

Angle of slope of roller lanes usually does not exceed 2-3º - such angle is enough to prevail resistance of the rollers rotation. All the same height of loading high side may be higher on 300-500 mm of the height of low unloading side of the roller lanes. It is considered to be one of the drawbacks of these racks. The other drawbacks are big cost, possibility of jamming of pallets in roller lanes, incomplete using these lanes, too fast running of pallets in the roller lanes (it is necessary to insert braking devices) and requirement of more high quality of pallets. Advantages of roller lane racks are high warehouse space utilization, directed motion of material flow from receiving area to the shipping area of the warehouse and strictly accomplished throughput rule “First-in-First-out”. Loading and unloading of gravity racks is fulfilled usually by lift trucks or stacker cranes.

Main parameters of the gravity roller racks are shown in Figure 7. These racks are applied when term of merchandise keeping is rather little and number of load items is not too great. These conditions occur usually at warehouses of finished products at factories. The gravity racks also may be used as equipment for separate picking area at big logistic centres. There is no room to consider the storage types in more details and conveyor storage options in limits of this article. This information may be found in special warehouse literature.

3. Conclusions

There are many options of modern warehouse furnishing and it is rather difficult to select optimal one without profound knowledge of Theory of Warehouse Systems (TWS). As a matter of fact there are dozens and hundreds of options related to methods of merchandise storage and types of racking constructions in every case of warehouse creation. Cost investment and operational cost of warehouses in logistic chains influence dramatically on the total supply chain efficiency. Therefore, before the supply chains management it is necessary to project, build and equip properly the components of this chain, such as warehouses and freight terminals, with optimal solutions.

References

Malikov, O. (1981) *Projecting of Automatic Warehouses*, St. Petersburg, Russia.
Malikov, O. (1986) *Warehouses of Flexible Manufacturing Systems*, St. Petersburg, Russia.
Malikov, O. and Malchovich, A. (1989) *Warehouses in Industry*, St. Petersburg, Russia.
Malikov, O. (2003*) Business Logistics*, St. Petersburg, Russia.
Malikov, O. (2005) *Warehouses and Freight Terminals*, St. Petersburg, Russia.
Malikov, O. (2008) *Business Logistics: New Specific Approach to Concept*, Lappeenrata University of Technology, Finland.
Malikov, O. (2009*) The Theory of Warehouse Systems*, Lappeenrata University of Technology, Finland.
Tompkins, J. and Smith, J. (1988) *The Warehouse Management Book*, New-York, London, Paris.

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