DEVELOPING OF TRANSPORTATION FLOWS IN 21ST CENTURY SUPPLY CHAINS

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INTRODUCTION

„In theory there is no difference between theory and practice,
but in practice there is”
J.L. van de Snapscheut

Supply chains are the natural work environment for logisticians who strive for their improvement through employing carefully selected methods, tools and concepts with overarching objective of logistics at their heart i.e. to assure product availability in line with predetermined rules. It seems that this environment is going to remain a tangible dimension in which logistics are immersed but also an area subject to optimisation both through theoretical concepts as well as practical endeavours. Assuring efficient flows of materials and information within supply chains poses multiple problems of organisational nature. Hence, transport issues have attained practical, ever-growing importance, but they also have become a conceptual challenge. Therefore, as the instigator behind publishing this body of work and as its Scientific Editor I have decided that these issues are worth of considerable attention that could – perhaps – start an interdisciplinary and international discussion on these matters. By writing “interdisciplinary” above all I refer to the fact that both economic and technical experts deal with transport issues. The shear diversity of approaches and emphases put on different aspects could have a strong, inspiring effect on the Reader, and it can be the first step towards combining in a creative manner both takes on the matter.

The concept of publishing a book delving into issues of supply chains and the role of transport in modern logistics processes has its roots both in discussions I had the chance to hold with representatives of science and practice from various countries and in desire to accumulate opinions of leading industry experts in one place. Hence, I addressed professors from Polish as well as Czech, Finnish and Russian scientific institutions with a proposal to prepare (for purposes of this occasion) papers expressing their scientific interests and

reflecting on their research and commercial works. This invitation was accepted by professors from numerous universities from the aforementioned countries. By acquainting with the research directions of senior academic fellows, the Reader will widen their horizons on tendencies and substantive scope of research conducted at presented research centres. Furthermore, the book will allow for exchanging experiences in research methodology, implementating academic projects and forming interdisciplinary research teams. Confrontation of economic and technical approach makes, in my opinion as a Scientific Editor, this publication attractive for the Reader.

Submitted papers were divided into three thematic groups. The first *Logistics / Supply chain management* features four papers written by representatives of Wroclaw University of Economics, Wroclaw School of Banking, and University of Economics in Katowice. The second – far broader group concerns transport issues related to logistics (*part II – Transport*). It features papers written by academics of Gdansk University, University of Economics in Katowice, Czestochowa University of Technology, Wroclaw University of Technology, Tomas Bata University in Zlin (Czech Republic), Lappeenranta University of Technology (Finland), and Petersburg State Transport University (Russia). The third group concerning urban logistics issues (part III – *City logistics*) features papers written by representatives of Poznan University of Economics and Opole University.

The following professors took the role of reviewers: Oleg Malikov from Petersburg State Transport University (Russia), Koichi Shintani from Oshima National College of Maritime Technology (Japan), and Jerzy Szkutnik from Czestochowa University of Technology (Poland). They represent both research perspectives (economic and technical ones). I believe their comments and observations have raised the level of the scientific publications featured.

Preparing and publishing this book would not have been possible without support from Dean of Faculty of Management at University of Economics in Katowice – professor Krystyna Jedralska, whom I would like to thank cordially. Much work and commitment was also contributed by Ph.D. Sebastian Twarog, who proved to be an excellent planner and organiser with patience to execute laborious procedures.

I sincerely hope the Reader will not only find this book a useful read, but will also become inspired to engage in broad-based collaboration between the worlds of economics and technical sciences, also in the international scale.

Jacek Szoltysek

Chapter One

LOGISTICS/SUPPLY CHAIN MANAGEMENT

Jarosław Witkowski
Bartłomiej Rodawski
Wroclaw University of Economics

THE ESSENCE AND SCOPE OF SUPPLY CHAIN STRATEGY

The article addresses the issue of strategic decisions undertaken while managing supply chains. Conclusions are drawn from economics, logistics, operations, marketing, supply chain and strategic management literature review.

Conducted research proves that three groups of supply chain strategic decisions could be distinguished: supply chain structure forming, relations crafting and supply and demand synchronization. The listed decisions reflect three levels of organization strategy: corporate (supply chain structure), business (relations) and functional (synchronization). Transaction costs and strategic positioning theories provide comprehensive basis for supply chain strategic decision analysis.

The idea of Supply Chains and Supply Chain Management

The idea of the integrated supply chain has been developed in management literature since early eighties of XX century. From the narrow logistics perspective supply chain is restricted to materials and information flows from suppliers, through manufactures and distribution centers to retail outlets and final customers. For example, M. Christopher defines supply chain as" a network of connected and independent organizations mutually and cooperatively working together to control, manage and improve the flow of materials and information from suppliers to end users"[1]. In broader sense "the supply chain is any combination of processes, functions, activities, relationships and pathways along which products, services, information and financial transactions move in and

[1] M. Christopher: *Logistics and Supply Chain Management. Creating Value – Adding Networks*. Prentice Hall 2005.

between enterprises"[2]. It means that every enterprise has its own internal supply chain which is a link in many external configurations. Furthermore, the logistics is only one part of supply chain process and it can not be considered as a synonimus for supply chain management concept. According to the Council of Supply Chain Management Professionals (non-profit organization which is better known under former name the Council of Logistics Management): "Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies"[3]. The demand management is relatively new component within supply chain management concept which helps the suppliers to understand the customer's buying processes as well as to build customer relationships. It is still less recognized element in logistically oriented supply chain designs[4]. Nevertheless based on the product – relationship matrix, Cooper and Slagmulder distinguished four key decisions and activities areas in the integrated supply chains management, such as[5]:

- configuration of product and network, which covers the decisions concerning the main rules of cooperation,
- formation of the production network, mainly the choice of production facility and warehousing locations as well as their capabilities,
- product design with involvement the research and development abilities of suppliers,,
- process optimization in order to reduce cycle times and inventory level in the cost-effective way.

Despite that there is no consensus of the contemporary supply chains and supply chain management definitions, the essence of the concepts is focused on changing customer-suppliers relationships from traditional power and competition to trust and close collaboration in order to receive synergy effects in terms of value added and competitive advantage. It is always focused on efficient integration of its links and coordination of the main value-added business process from the supplier to the final customers.

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[2] J. Gattorna: *Living Supply Chains. How to Mobilize the Enterprise Around Delivering What Your Customers Want*. Prentice Hall, 2006, p. 2.

[3] CSCMP Supply Chain Management Definitions, www.cscmp.org.

[4] See: W.E. Hoover, E. Eloranta, J. Holmstrom, K. Huttunen: *Managing the Demand- Supply Chain. Value Innovations for Customer Satisfaction*. John Wiley and Sons, New York 2001.

[5] R. Cooper, R. Slagmulder: Supply Chain Development for the Lean Enterprise – Interorganizational Cost Management. Productivity Press, Portland 1999, p. 10.

Strategic decisions and their hierarchy

Strategic decisions are long term and their results are difficult to change. Moreover, they deal with high complexity, future, hence involve a lot of risk. Strategic decisions undertaken within a company could be divided into three groups, in accordance with management level and the level of detail:

1. Corporate strategy which embraces the following decisions: growth direction (eg. market development, product development, diversification), growth pace (stabilization, expansion, defense of position) as well as form of growth (internal, capital, contractual);
2. Competitive/business unit/sector strategy – includes decisions concerning company's relations with competitors, clients, suppliers within each sector the company plan to operate. In particular, competitive strategy should provide answers to the following questions:
   a. Where to compete/cooperate (whole market, chosen segment)?
   b. What to compete with (value delivered to the final customer – price, quality, innovativeness, time, others)?
   c. Whether to compete (direct competition, avoiding competition, cooperate)?
   d. What kind of relations are developed with suppliers and clients (transactions, partnership, acquisition, merger)?

From SCM point of view, vertical relations (supplier – client), are of the greatest significance. Nonetheless, concerning the broad understanding of supply chain, according to which it includes both vertical and horizontal constellations, relations with competitors (competition, strategic alliances, mergers, acquisitions) should be also taken into account.

3. Functional strategies – include details of mentioned above strategies. But to put it differently, they not only describe the mechanics of implementing corporate and competitive strategy across various functions, but simultaneously they indicate the possibilities as well as barriers of its full implementation. Furthmore, functional strategy can be understood as a means for supporting the firm's overall strategic good to achieve competetive adventage.

Supply chain management is based on process not function approach to company. Hence, identification of functional strategies might rise some concerns. To address this issue Lambert distinguishes process, instead of functional strategies for the sake of SCM[6].

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[6] See: K. Croxton, S. Garcia-Dastugue, D. Lambert, D. Rogers: *The Supply Chain Management Process.* „International Journal of Logistics Management" 2001, Vol. 12, No. 2, p. 13-36.

Strategic decisions within supply chain

Concerning described above levels of strategies, three types of strategic decisions regarding supply chain could be listed:

A. Forming supply chain structure;
B. Shaping relations with supply chain members;
C. Designing rules of synhronization between demand and supply streams.

It should be highlighted that although described separately, described decisions are linked closely, being undertaken simultaneously.

A. Supply chain structure formulation

Supply chain structure stands for constellation of companies forming supply chain, as well as roles these companies play, i.e. manage/perform activities/processes included in supply chain. Such understanding of supply chain structure is closely related to business model definition presented by Obłój (formulation of value chain allowing for efficient utilization and renovation of resources and competences[7]) as well as concept of business architecture defined by Trocki (the way of shaping group of companies, which collaborate at achieving business goals, along with mutual links among those companies[8]).

Strategic decisions regarding formulation of supply chain structure include:

1. Construction of value system and roles each supply chain member plays in the system – **logic of responsibilities/activities deployment;**
2. Number, location and capacity of nodes forming production-logistics net – **spatial deployment of activities**.

As far as value system construction is concerned, the starting point is definition of key competences in the context of value provision to the chosen market segments. The competences that provide competitive advantage to the company should be controlled internally, while the others, especially those performed by the other companies in the most efficient manner, should be outsourced[9].

It should be underlined that the above general recommendation is, to some extent, a simplification. First of all, decisions concerning integration/ disintegration of value chain (usually known as make or buy decision) are

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[7] K. Obłój: *Tworzywo skutecznych strategii*. PWE, Warszawa 2002, p. 98.

[8] M. Trocki: *Kształtowanie struktur działalności gospodarczej*. „Organizacja i Kierowanie" 2000, No. 4, p. 28.

[9] S. Cohen, J. Roussel: *Strategic Supply Chain Management*. McGraw Hill, New York 2005, p. 15.

sophisticated and next to obvious potential benefits (other company could perform a certain activity faster and at lower cost) pose a risk and certain costs (uncertainty concerning reliability or quality of external company, increase of transactional costs). Regarding the theory of transactional costs by Williamson, it should be flatly stated that decision concerning outsourcing of activity depends upon specialization of necessary resources, uncertainty (caused by opportunism) and eventually repetitiveness of transactions[10]. Moreover, next to transactional problems, the issue of great importance while configuring supply chain is the level of autonomy of activity/process in question. In case, the activity is closely related to other activities strategic alliances are better way of supply chain structure formulation than outsourcing[11]. Secondly, as Prahalad, Ramaswamy and Kay states, the core competence next to ability to manage/perform chosen activity/process, could be also the ability to coordinate activities undertaken at different stages of value system. According to Prahalad, Ramaswamy coordination means collaboration at value creation and generation of value at the points of interactions of collaborating companies[12]. Kay explains that the core competence is the ability to create and manage "relative contacts" – unwritten rules of collaboration among employees and other companies, members of value system[13].

On the basis of the above description, Obłój proposed three models of value system construction[14]:

- Operator: the company concentrates on chosen aspect of value creations (certain element of value system). In the past that operator model was characteristic for small and medium companies or business units of large enterprises, which specialize in managing a single activity/process within value system, fulfilling the roles defined by supply chain leader. Today the market trends such as outsourcing, lean management, virtualisation and IT development causes changes of role and behaviours of SMEs in supply chains. Analysis of statistical data and observations concerning quality changes proves that these changes consist in:
  - development of new competences and skills connected with requirement of informational transparency for increase of value added;
  - increase of activity and flexibility of SMEs in creation of supply networks utilisind resources of large companies;

[10] O.E. Williamson: *Ekonomiczne instytucje kapitalizmu*. PWN, Warszawa 1998.
[11] H.W. Chesbrough, D.J. Teece: *When Is Virtual Virtous.* „Harvard Business Review", Jan-Feb 1996.
[12] C.K. Prahalad, V. Ramaswamy: *Przyszłość konkurencji. Współtworzenie wyjątkowej wartości wraz z klientami*. PWE, Warszawa 2005, p. 8.
[13] Por. J. Kay: *Podstawy sukcesu firmy.* PWE, Warszawa 1996, p. 99.
[14] K. Obłój: *Tworzywo skutecznych strategii*..., op. cit., p. 135-154.

  - establishment and development of revelance of trransactional brokers as new intermediate links between participantes of supply chains;
  - increase of influence of retails on demand forecasting, as well as inventory and supply chain management in the other links of chains;
  - abandoning of logistics self-services for public logistics services centres;
  - decrease of number and independency of small truc companies in fulfilling transportation needs of supply chains[15].
- Integrator: the company takes control over whole or substantial part of value system. At the first glance, integrator is not a proper model for supply chain management. Nonetheless, as Obłój explains, control over value system does not only materialize through mergers/acquisitions of suppliers/clients but also by building long term relations with other supply chain members, where integrator dominates, imposing the rules of value creation (utilizing his bargaining power). The model is characteristic for large companies, usually international corporations. In such cases headquarters control not only its own subsidiaries, but also independent suppliers and clients. The examples of such practices could be find in automotive, beverages, electronics, IT as well as large retailers, e.g. like in Japanese distribution Keiretsu structures with dominant position of the central integrator. The integrator, usually the large and well known brand firm, is not only responsible for establishing and introducing the rules and standards of product, information and finance flowsamong supply chain partners, but it also initiates its suppliers' development and integration. The central coordinator also decides about risk and gains divisions among supply chain participants. The classic example is Toyota Kereitsu structure with just-in-time system fully desribed by Ychiro Monden[16].
- Conductor: the company focuses on chosen areas of value system (which are the core competences) spinning off/ forming strategic alliances for other areas. The very important competence of conductor is the ability of orchestrating activities and competences of supply chain members. A virtual company, which is able to reconfigure supply chain structure in a very fast manner is a vivid example of the conductor model. As Obój explains the size and value of tangible resources owned by conductor is not of primary importance. What really matters is the ability to create and implement supply chain vision and mutual competitive advantage. Conductor is a perfect model

[15] J. Witkowski: *The changing role of SMEs in European Supply Chains*. University of Autonome of Barcelona 2006, 3td EDP Workshop Proceedings, www://webs2002.uab.es/edp/workshop/cd/Proceedings/3EDPW_jWitkowski.pdf

[16] Y. Monden: *Toyota Production system. An Integrated Approach to Just-in-Time*. Institute of Industrial Engineers, Norcross-Georgia 1993.

for supply chain management since he leads supply chain or plays the role of partner in case of cooperation with company that has equally high bargaining power.

The type of model, chosen by a company, determines responsibilities of that company in the supply chain. Operator focuses on carrying out assigned (by the supply chain leader) activities – his role is rather passive. Integrator and conductor set supply chain goals, deploy value net activities among supply chain members, control and motivate them (active role)[17].

The basic feature of supply chains are physical (as well as accompanying information and monetary) flows. Activities undertaken by the cooperating companies are materialized mainly by the number, location and capacity of production/logistics network nodes: production sites, warehouses, logistic centres, sales depots etc. Therefore, the second group of strategic decisions concerning supply chain structure include number, location and capacity of production, sales sites, warehouses (centralization vs. decentralization, shortening vs. extending number of supply chain echelons) concerning efficiency and effectiveness of the whole net[18].

Is should be underlined that as far as value system issues are concerned, decisions are based on qualitative analysis. On the other hand physical construction of production/logistics net is mainly based on optimization techniques: linear/ integer programming and simulations.

B. Shaping relations with supply chain members

The second group of strategic decisions contain formulation of relations with other supply chain members. Building the right set of relations, the company considers the following list of criteria:

– Mechanism of relation: transaction, trust, capital;
– Symmetry of partners;
– Timespan of cooperation;
– Scope of collaboration.

According to Cohen and Roussel, relations within supply chain are formed usually with[19]:

– Customers;

[17] P.J. Batt, S. Purchase: *Managing collaboration within networks and relationships.* „Industrial Marketing Management" 2004, Vol. 22, p. 170.

[18] According to SCOR model basic supply chain parameters are: reliability, responsiveness, flexibility, costs and efficiency of assets utilization see: www.supply-chain.org.

[19] S. Cohen, J. Roussel: *Strategic Supply Chain*..., op. cit., p. 142.

– Physical goods suppliers;
– Services providers (mainly third party logisticians);
– Competitors.

As far as supply chain relations are concerned, partnership is quoted as a most desirable form. However, this issue necessitates more detailed analysis. According to Lambert, partnership is always carefully crafted relation (non-standard) i.e. is based on specific solutions/undertakings/technologies fitted for individual needs and features of partners[20]. Hence, it is not a standard relation that could be offered to every supply chain member. As Hakansson explains, the less standard supply chain process the higher importance of learning and exchange of knowledge between potential partners[21]. Thus, mutual learning and transfer of knowledge constitutes the main feature of partnership.

Another important attributes of partnership is trust (basic precondition for exchange of business information and common undertakings), engagement of supply chain members (materialized by willingness to define mutual goals, undertake common projects, devote resources for the sake of partnership development) as well as perception of resources and competences of potential partners as a key factor of competitive advantage[22].

To recap, partnership has two dimensions. First, economic, including net benefits (and their distribution). Second, social, concerning trust and engagement.

A literature review proves that partnership is not homogenous[23]. On the contrary, various forms could be distinguished, subject to scope of collaboration (number of co-managed processes) and its strength (level of integration). However, two mains streams are visible in the analysed taxonomies. First, static – partnership type is determined by the specific features of companies (partners): strategic goals, organizational structure and culture, willingness to cooperate,

[20] D. Lambert, M. Margaret, A. Emmelhainz, J. Gardner: *Developing and Implementing Supply Chain Partnerships.* „The International Journal of Logistics Management" 1996, Vol. 7, No. 2.

[21] H. Hakkanson, V. Havila, A. Pedersen: *Learning in Networks.* „Industrial Marketing Management" 1999, Vol. 28, p. 444.

[22] S.L. Golicic, J.T. Mentzer: *An empirical examination of relationship magnitude.* „Journal of Business Logistics" 2006, Vol. 27, No. 1, p. 83-85; S. Cohen, J. Roussel: Op. cit., p. 139, T.M. Simatupang, R. Sridharan: *The collaborative supply chain.* „International Journal of Logistics Management" 2003, Vol. 13, No. 1, p. 15-30; P.E. Evans, B. Wolf: *Collaboration rules.* „Harvard Business Review" 2005 July-August, p. 99-101.

[23] See. S.L. Golicic, J.T. Mentzer: *An empirical examination of relationship magnitude...*, op. cit., p. 81-108; J.M. Whipple, D. Russell: *Building supply chain collaboration: a typology of collaborative approaches*. „The International Journal of Logistics Management" 2007, Vol. 18, No. 2, p. 174-196; H.S. Jagdev, K.D. Thoben: *Anatomy of enterprise collaboration.* „Production Planning & Control" 2001, Vol. 12, No. 5, p. 437-451; T. Skjoett-Larsen, Ch. Thernoe, C. Andersen: *Supply chain collaboration Theoretical perspectives and empirical evidence.* „International Journal of Physical Distribution &Logistics Management", Vol. 33, p. 531-549.

product/demand[24]. Second, dynamic – level of partnership development (scope and level of integration) increases as companies gain more experience in cooperation with a certain partner[25]. The first approach is represented by Lambert, who formulated comprehensive model of cooperation with three main types of partnership subject to length and scope of collaboration[26]. The second approach is advocated by Skjott-Larsen and Whipple[27]. The latter bases his model on concrete supply chain management concept CPFR (Collaborative Planning, Forecasting and Replenishment), accordingly at each level of partnership set of processes/activities is described in great details.

The common feature of partnership models is a negative coloration between level of integration, scope and strength of cooperation and number of partnership relations. As Lambert notices, the most sophisticated level of partnership (the highest integration level) does not exceed more than 2-5% of all inter-organizational relations in supply chain. Therefore the following question should be posed: what other relationship options are available for a company in case potential benefits from partnership are minor or it is not possible to develop partnership due to conflicting goals, asymmetry or other reasons. The answer could be find in governance spectrum described initially in marketing literature[28].

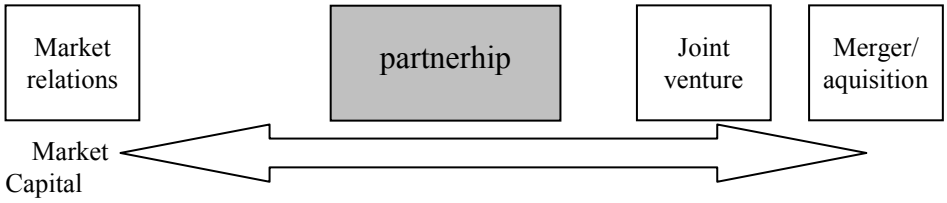

Fig. 1. Continuum of control and collaboration

Source: D.M. Lambert M.A. Emmelhainz, J.T. Gardner: *Developing and Implementing Supply Chain Partnerships.* „The International Journal of Logistics Management" 1996, Vol. 7, No. 2, p. 2.

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[24] See. L.-E. Gadce, H. Hakansson: *Supply Network Strategies.* Wiley 2001, p. 142.

[25] See. R. Brennan, P. Turnbull: *Adaptive Behavior in Buyer – Supplier Relationships.* „Industrial Marketing Management" 1999, Vol. 28, p. 481-495.

[26] D.M. Lambert, M.A. Emmelhainz, J.T. Gardner: *Developing and Implementing Suppy Chain Partnerships.* „The International Journal of Logistics Management" 1996, Vol. 7, No. 2.

[27] J.M. Whipple, D. Russell: Op. cit., p. 174-196; T. Skjoett-Larsena, Ch.T. Thernoe, C. Andersen: Op. cit., p. 531-549.

[28] Governance spectrum has been introduced in marketing literature by F.J. Contractor, P. Loranie: *Competition vs. Cooperation: A Benefits/Costs Framework for Chosing Between Fully-Owned Investment and Cooperative Relationships*. „Management International Review" 1988, Vol. 28, Special Issue, pp. 5-18; J. Heide: *International Governance in Marketing Channels*. „Journal of Marketing" 1988, Vol. 58, No. 1. pp. 71-85; F. Webster Jr.: *The Changing Role of Marketing in the Corporation*. „Journal of Marketing" 1992, Vol. 56, No. 4, pp. 1-17.

Market relations are probably the most common form of collaboration between suppliers and buyers. In that case no mutual initiatives improving flows of goods and information are undertaken. Obviously, market relations could be long term. However, trust is replaced here by formal agreements, which describe desirable behavior of both sides of relation. Moreover, market relations are proper for standard products/services, offered by many suppliers. In such cases potential benefits stemming from partnerships are insignificant. Hence it is more effective to choose from the pool of offers to get the best solution in a short term. The advantage of market relations is ability change the contractor when needed, due to market or supply chain changes. Accordingly, market relations remind rather competition but not cooperation. As Harison and Van Hoyek states, only several out of 200 suppliers of Japanese car manufacturers could consider their relations with manufacturer as partnership. The others have to compete for orders on everyday basis[29].

Hierarchical relations are placed on the other side of governance spectrum. They are usually implemented between asymmetric partners, i.e. companies with significantly different sizes, competitive positions, access to unique business information. Although, as figure 1 pictures, capital is a basic mean of control here, supply chain offers more popular ways of control – bargaining power of stronger node. Classic examples could be found among supermarkets and their suppliers. The former exert pressure on price erosion (less money for suppliers), postponing payments of assets reliable (money later available for suppliers)[30]. Another vivid example are car producers that cut lead times for raw materials and semi products (by the means of just in time approach), which usually cause higher inventories at supplier side.

Important feature of hierarchical relations is presence of a strong leader in the supply chain (also known as central coordinator) that sets the vision and goals in supply chain, initiates many activities and control their execution. Usually the role of coordinator is served by a large international or global company – a market leader. However, pending on the sector features, its location in value system and scope of influence over other supply chain member that role vary[31]. According to Peck, the leader has the biggest share in value creation, the best access to the market, the most specialized knowledge and competences[32].

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[29] A. Harrison, R. van Hoek: *Logistics Management and Strategy.* Prentice Hall, New York 2002, p. 219.

[30] See: D.R. Towill: *A perspective on UK Supermarket Pressures on the Supply Chain*. „European Management Journal" 2005, Vol. 23, No. 4, pp. 426-438.

[31] Por. H.Ch. Pohl, S. Mayer: *Trendy i strategie w logistyce europejskiej.* „Logistyka" 1999, No. 6, pp. 6-7.

[32] H. Peck, U. Juttner: *Strategy and Relationships:Defining the Interface in Supply Chain Context*. „International Journal of Logistics Management" 2000, Vol. 11, No. 2, p. 36.

More often, the role of coordinator is taken by fourth party logistics, called also supply chain integrators (4th PLs), who in the name of their client, manage whole supply chain.

It should be stressed that alike in partnership relations, hierarchical constellations are also diversificated:

1. Traditional control – the company utilizes its bargaining power or influence over other supply chain nodes based on legal issues; the leader imposes specific behavior of the other supply chain members or implement penalties (in case of undesirable behavior or effects unsatisfactory results). Control could be utilized under the umbrella of mentioned above CPFR or other supply chain concepts, like VMI (vendor managed inventory). Obviously, basic features of partnership are less important is such cases. First – engagement is replaced here by warrant – e.g. membership in leader's supply chain is conditioned by strictly defined rules of collaboration. Second, trust is replaced by control imposed by the leader. Third – deployment of net benefits – usually the lion share goes to the leader (he optimizes supply chain flows from his own perspective, which usually is not a best/ most profitable solution for other members).
2. Co-control – more similar to partnership. The leader influences the other supply chain members through its reputation, expert knowledge, experience, trying to motivate others to act in a certain way. If in case of traditional control, the most important elements are warrants, described in great details procedures, the focus in co-control is shifted towards social integration (materialized by intense communication, meetings loyalty). Co – control is beneficial for both sides. The leader by setting goals and supply chain standards based on reputation and expert knowledge, increase probability of long-run collaboration with chosen companies (Keiretsu structures[33]). On the other hand the latter, due to cooperation with the strong leader, gain competences or even resources (e.g. access to the sophisticated IT solution)[34].

Based on the above review, modified continuum of supply chain relations (governance spectrum) is presented (fig. 2). It contains three basic forms of relations, available for supply chain members: competence (market transactions), partnership (symmetric relations) and control (hierarchical relations) and their derivatives.

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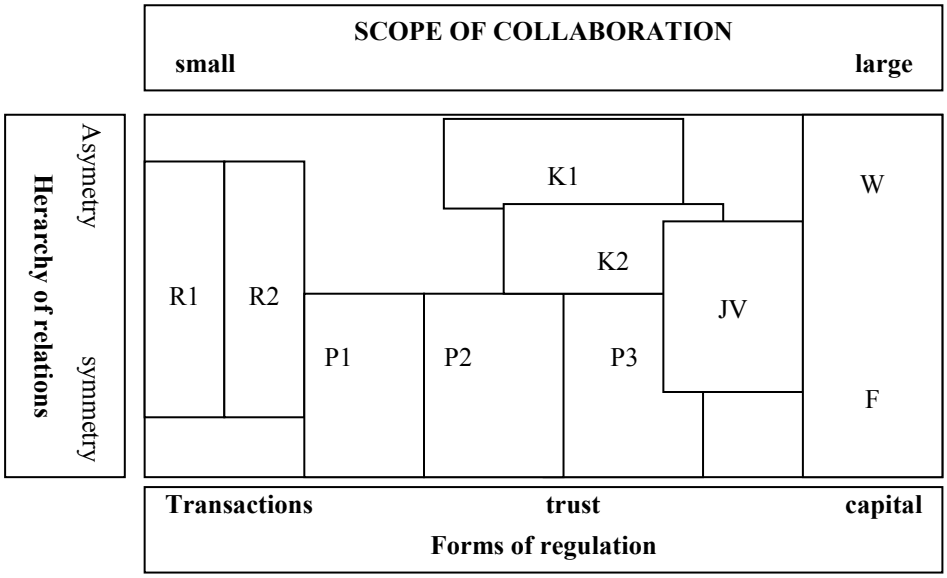
[33] See: J. Witkowski: *Logistyka firm japońskich*. Wydawnictwo Akademii Ekonomicznej we Wrocławiu, Wrocław 1998.

[34] Interesting framework of company development resulted in net intersection is net model of internationalization. see: J. Johnson, L.G. Mattson: *Internationalization in Industrial Systems – A Network Approach*. In: N. Hood, J.E. Vahlne: *Strategies in Global Competition.* Groom Helm, London 1996, pp. 278-314.



R1 – market relations, short term, R2 – market relations – long term, P1-3 partnership , K1 – traditional control, K2 – co-control, JV – joint venture, W – acquisition, F – merger

Fig. 2. Modified governance spectrum

Obviously, shaping supply chain relations is a sophisticated task. First, large amount of possible solutions is available. Secondly, choosing from the pool of available options, it is necessary to consider interweaving econocmic, social and technical issues. What is more:

1. Each supply chain is a set of various relations that overlap[35];
2. Supply chain relations are not static and can be changed[36];
3. Change of relations type in one area of supply chain affects the others, hence holistic view is indispensable[37].

[35] See: M. Ciesielski, S. Zimniewicz: *Partnerstwo i dominacja*. „Gospodarka Materiałowa i Logistyka" 2005, No. 4, p. 4; B. Rodawski: *Supply Chain Relationship. Case of Automotive Company*. „Logistyka 2006, No. 5, p. 22 (Introlog 2006, 1st International Conference of Logistics 23-26 September 2006 Proceedings CD).

[36] H.S. Jagdev, K.D. Thoben: *Anatomy of enterprise collaboration. „*Production Planning & Control" 2001, Vol. 12, No. 5, P. 439.

[37] D. Ford, R. McDowell: *Managing Business Relationships by Analyzing the Effects and Value of Different Actions*. „Industrial Marketing Management" 1999, No. 28, p. 431-433.

C. Balancing supply and demand stream

First of all, Considering supply and demand balance, it is necessary, as the term is not unequivocal[38]. According to the Websters Encyclopedia synchronizing means "to occur at the same time or to proceed in the same rate"[39]. For the sake of the article, the understanding of issue in question is understand broader, i.e. as reconciliation between two streams in time and space[40].

Second, the subject of synchronization should be precisely defined. In this case, subject perception of supply chain is helpful, according to which, the synchronization includes spectrum starting from material flows, ending at balancing flows of materials, information, people, knowledge, technology and money. It is regarded here, that primary importance should be prescribed to adjusting demand (flowing through the chain as information – mainly orders and sales/production plans) and supply of goods and services (flows of material and business information). Both flows should be accompanied by the third – money which allows for better deployment of risk and costs and benefits among supply chain members.

In literature, next to presented above scope of synchronization, the following points of view are advocated:[41]:

1. Limited to synchronization of material flow between consecutive elements of production/logistics network (purchasing, production, distribution, retail) – this narrow understanding could be identified with traditional perception of supply chain as a mean of cost reduction;
2. Extended by the issues of designing and commercialization of new products, including, next to material, information and money, also exchange of knowledge and technology;

[38] See: T.M. Simatupang, R. Sridharan: *A benchmarking scheme for supply chain collaboration.* „Benchmarking: An International Journal" 2004, Vol. 11, No. 1, p. 23.

[39] *The New Lexicon Webster's Encyclopedic Dictionary of the English Language*. Lexicon Pulications, New York 1988, p. 1003.

[40] See: *Encyklopedia organizacji i zarządzania*. PWE, Warszawa 1981, p. 506.

[41] See: J. Godsell, A. Harrison, C. Emberson, J. Storey: *Customer responsive supply chain strategy: An unnatural act?* „International Journal of Logistics: Research and Applications" 2006, Vol. 9, No. 1, p. 52.

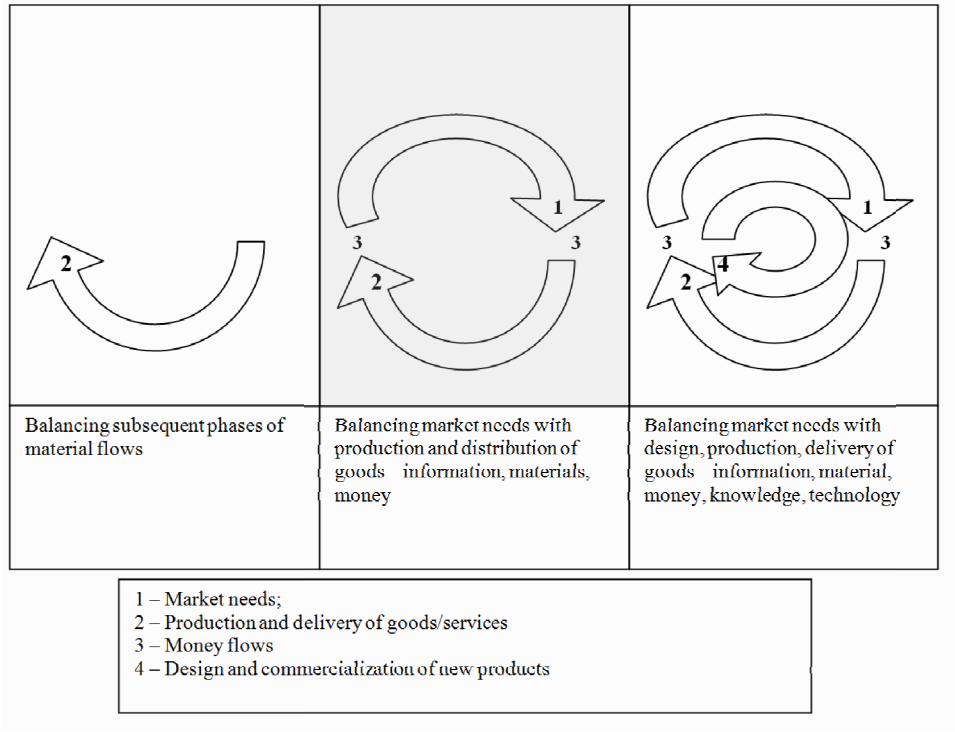


Fig. 3. Supply chain synchronization – applicable approaches

Literature concerning supply and demand synchronization is numerous, but in general based on. On assumption that the mechanism of synchronization is determined by the specific features of demand or more general (as Porter positioning theory states) market specifics. The significant importance here should be assigned to Fisher, who on the basis of demand character, introduced division of products into two broad categories: innovative (uncertain demand – make to order strategies suitable) and functional (certain demand – production and distribution based on demand forecast). Each of the groups should be served by different supply chains[42]. Fisher's model has been further developed by various authors. Christopher and Towill, as dominant criteria of demand

[42] M. Fisher: *What is the right Supply Chain for Your Product?* „Harvard Business Review", March-April 1997, pp. 95-105; M. Fisher: *Making Supply Meet Demand in an uncertain world.* „Harvard Business Review", May-June 1994, p. 83-93.

and supply synchronization, next to demand uncertainty, introduced lead time[43]. Based on combination of these two elements, they segmented possible ways of synchronization. (fig. 4)[44].

Lead time	Long	Lean supply chain Plan and execute	Leagile suppy chain postoponement
	Short	Continous replenishment	Agile supply chain Fas adjustment to demand changes
		High	Low
		Demand certainty	

Fig. 4. Demand and supply synchronization

Source: M. Christopher, H. Peck, D. Towill: *A taxonomy for selecting global supply chain strategies.* „International Journal of Logistics Management" 2006, Vol. 17, No. 2, p. 283.

Next to two basic supply chain models (called by Christopher lean and agile), intermediary solutions has been introduced, which, according to the cited authors, are more pragmatic[45]. The first model is called continuous replenishment. Here certain portion of inventories is located at each echelon of supply stream. The replenishment of inventory is based on real demand (inventories are controlled by real demand not demand forecast). The second intermediary solution, called postponement and or decoupling point[46], gained more attention not, only in logistics/ supply chain but also marketing literature. According to the model, material flows within supply chain are controlled by two different mechanism. Material flows in the lower part of supply chain are controlled by real demand (the main goal here is speed and flexibility), while material flows in the upper part of supply chain are regulated by demand forecast (basic issue are costs). Usually between two parts of supply chain, safety inventory

[43] See: M. Christopher, D. Towill: *Developing Market Specific Supply Chain Strategies.* „International Journal of Logistics Management" 2002, Vol. 13, No. 1, pp. 1-14; M. Christopher, H. Peck, D. Towill: *A taxonomy for selecting global supply chain strategies.* „International Journal of Logistics Management" 2006, Vol. 17, No. 2, pp. 277-278.

[44] Very similar brake down war introduced by Lee, who next to demand uncertainty implemented supply uncertainty as a synchronization segmentation criteria. H. Lee: *Aligning Supply Chain Strategies with Product Uncertainties*. California „Management Review" 2002, Spring, Vol. 44, No. 3, pp. 105-119.

[45] M. Christopher, D. Towill: *Don't lean to far – evidence from the first decade.* „International Journal of Agile Systems and Management" 2007, Vol. 2, No. 4, p. 406.

[46] R. Mason-Jones, D. Towill: *Using the Information Decoupling Point to Improve Supply Chain Performance.* „International Journal of Logistics Management" 1999, Vol. 10, No. 2, pp. 13-35.

is held (called material decoupling point). It should be underlined that two modes of postponement concept are identified. First, postponement of product form (stage of production which execution is delayed until real demand data is gathered). Second, suspension of distribution from central warehouse to next distribution nodes or even client[47]. Postponement of production activities has been additionally broken down by Zinn and Bowersox, who identified for stages of product manufacturing that could be delayed: labeling, packaging, assembly and production of semi products[48]. Production systems within which postponement is implemented are called configure to order.

Obviously the critical issue, in case of postponement, is choice of right location of material decoupling point[49]. Pagh and Cooper propose set of qualitative and quantitative criteria including product/market features, specifics of production and logistics processes which allow for right location of decoupling point[50]. On the other hand Zinn and Bowersox advocate cost model that underpins postponement decision.

As already mentioned, synchronization of supply chain is not limited to the choice of the right material decoupling point location. Cited above Fischer, as an issue of basic importance regards postponement of forecasting[51]. What is more, one of three basic synchronization approach within Supply Chain Operation Reference is engineer to order strategy, according to which not only material flows but also design activities are initiated by real demand[52]. As Reeve explains engineer to order is indispensable in case of prototypes, job-shop production which serve single customer needs[53].

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[47] W. Zinn, D. Bowersox: *Planning Physical distribution with the principle of postponement.* „Journal of Business Logistics" 1988, Vol. 9, p. 118; J.D. Pagh, M.C. Cooper: *Supply chain postponement and speculation strategies: how to choose the right strategy.* „Journal of Business Logistics" 1998, Vol. 19, No. 2, pp. 16-19.

[48] W. Zinn, D. Bowersox: Op. cit., pp. 123-125.

[49] The issue concerning location of decoupling point is explained by J. Nayol, M. Naim, D. Berry: *Leagility:Integrating the lean and agile manufacturing paradigms in the total supply chain.* „International Journal of Production Economics" 1999, No. 62, pp. 107-118; R. Mason-Jones, D. Towill: *Using the Information Decoupling Point to Improve Supply Chain Performance.* „International Journal of Logistics Management" 1999, Vol. 10, No. 2, pp. 13-35; M. Johnson, E. Anderson: *Postponoment Strategies for Channel Derivatives.* „International Journal of Logistics Management" 2000, Vol. 11, No. 1, pp. 19-35; H. Lee, C. Billington, B. Carter: *Helwet Packard Gains Control of Inventory and Service through Design for Localization.* „Interfaces", July-August 1993, pp. 1-11.

[50] J.D. Pagh, M.C. Cooper: Op. cit., pp. 24-25.

[51] M. Fisher: *Making Supply Meet Demand in an uncertain world.* „Harvard Business Review", May-June 1994, pp. 88-89.

[52] SCOR – Supply Chain Operations Reference, www.supply-chain.org

[53] M. Reeve, M. Srinivasan: *Which Supply Chain Design Is Right for You?* „Supply Chain Management Review", May-June 2005, p. 52.

Conclusion

Three main types of supply chain strategic decisions have been described: value system decomposition along with number capacity and location of supply chain nodes, crafting relations with other supply chain members as well as synchronizing demand and supply stream. The above decision could be broken down into each level of strategic decisions. Value system construction includes development form of the company, hence it reflects decisions undertaken at corporate strategy level. Building right set of vertical and horizontal relations mirror decisions within competitive strategy, while location and capacity of logistics/production functional strategies. Synchronization is a specific form of strategic decision, as it interlinks functional strategies (production, logistics, marketing and sometimes research and development).

Strategic supply chain management necessitates changes in strategic thinking. While traditionally the own resources of the company were the subject of strategic analysis and planning, supply chain approach is based on analysis of competences and resources of supply chain members, as they form the value system. Moreover, decisions regarding relations and synchronization must be accepted (more or less) by independent companies (other supply chain members) that they affect. In that context, mutual vision and goals is critical.

Concerning inter-organizational angle of supply chain strategy, two economic theories are of significant importance. First transaction cost theory by Williamson[54], second strategic positioning, the core of competition theory of Porter authorship[55]. As Nicerson, Hamilton and Wada a notice, in both theories, the basic unit of analysis is vertical chain of companies (supply chain members)[56].

Transaction cost theory is focused on relations between organizations that handle subsequent elements of production process and behave according to limited rationality and opportunism[57]. It could stand for a proper framework to explain why company decides to shift from market/hierarchical relations to

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[54] O. Williamson: *Strategizing, economizing and economic organization*. „Strategic Management Journal" 1991, No. 12, pp. 75-93.

[55] M. Porter: *Competetive Advantage. Creating and Sustaining Superior Performance*. Free Press, New York 1985; M. Porter: *What is Strategy?* „Harvard Business Review" 1996, No. 6, pp. 61-78.

[56] J.A. Nickerson, B.H. Hamilton, T. Wada: *Market position, resource profile, and governance: linking Porter and Williamson in the context of international courier and small package services in Japan*. „Strategic Management Journal", Vol. 22, 3, pp. 251-273.

[57] See: O. Williamson: *Ekonomiczne instytucje kapitalizmu. Firmy, rynki, relacje kontraktowe*. Wydawnictwo Naukowe PWN, Warszawa 1998, pp. 58, 60.

partnership. Lack of trust (main precondition for partnership) needs to be compensated by formal agreements, regulations, sanctions execution, which may lead to negative economic results – higher transaction costs. If the latter are regarded to high, the best solution to eradicate them is development of trust, hence partnership.

Porter's theory regards proper strategic choices through building intra- and inter-organizational value systems. These systems should be based on the right understanding of customer needs (demand features, expected lead time) and reflect the latter, which means that Porter's theory provide universal basis for demand – supply synchronization models.

Mentioned theories should be regarded as complementary. The basic assumption of transaction cost theory – limited rationality is accompanied by the lack of axiom concerning companies attitudes in Porters theory, which does not answer the question what types of behavioral patterns allow for competitive advantage gain. On the other hand, tenet of Porter's theory, concerning diversity of clients and as a result, necessity of adjustments to changing demand is not tackled by Williamson's model.

Strategies of companies are formulated as a result of strive to gain certain market (competitive) position, utilization of resources that allow for minimization of production and transactional costs as well as the management system of resources. Hence, the choice of the right supply chain strategy can be boiled down to the combination of market position, resources and management system that allows for increase of value added[58].

Thus, both theories allow a unique view of strategic management within supply chain – the strategy should be formulated as a result of interactions between current and future market position, management systems, resource pool within value system subject to savings within transaction and production costs. Combination of the listed elements determines goals and means of supply chain strategy is presented on fig. number 5.

[58] M. Ghosh, G. John: *Governance Value Analysis and Marketing Strategy*. „Journal of Marketing" 1999, No. 63, pp. 131-145; J.A. Nickerson, B.H. Hamilton, T. Wada: *Market Position, Resource Profile, and Governance: Linking Porter and Williamson in the Context of International Courier and Small Package Services in Japan*. „Strategic Management Journal" 2001, No. 22, pp. 251-273.

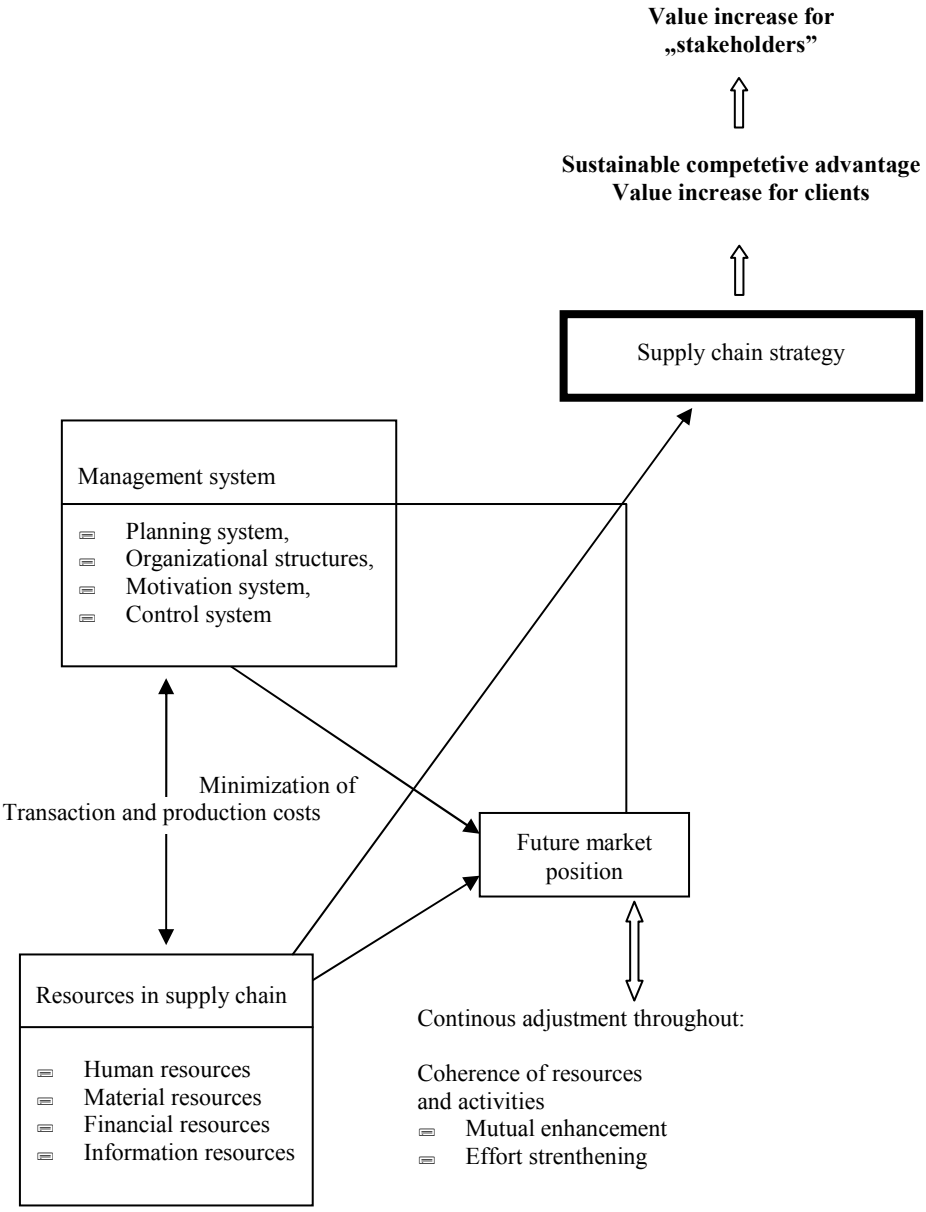

Fig. 5. Interdependence of factors crucial for building and pursuing supply chain strategies

Source: J. Witkowski: *Zarządzanie łańcuchem dostaw. Koncepcje, procedury, doświadczenia*. PWE, Warszawa 2010, p. 65.

The choice of the right market position increase the chances of gaining competitive advantage. However, to make it sustainable, continuous adjustments of strategic decisions and activities undertaken by supply chain members are necessary. Otherwise followers will reach the same competetive position.

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THE ROLE OF STRATEGIC ANALYSIS IN A LOGISTICAL MANAGEMENT

The essence of a strategical management

The growing competition and related changes force a need to define new forms of an organization's activity. Changes in economy have never been so rapid, fast, deep and wide. All of this makes the conditions of management particularly unpredictable; dynamic transformations are accompanied by new, not monitored yet processes. The contemporary organization management is marked with a complex variability and an increasing uncertainty. Changes are natural and affect the environment as well as the inside of the organization. It comes out of a peculiar density of the external and internal environment of organization, that is enormous number and complication of direct and indirect connections between phenomena occuring in the environment and inside organization. Managers face the vast problem of reconciliation and merging the determinants of contemporary management.

The answer to these difficulties may be a strategical management. The key factor of the strategical management is constant thinking about the future and taking advantage of happening chances and opportunities. It is a process of long--term thinking in terms of building an organization adjusted on directed development and success. It is a way of managing that has to merge the operational management with the strategical management correctly. Managers are quite often focused on solving current problems, they limit themselves to administration, but cannot notice and do not take advantage of development possibilities. The essence of such thinking inspires to look beyond the present and, therefore, distinguish from the average. The strategical management is a search of the best way to develop an organization, it is a constant aspiration for creating an organization which will stand out from the others. It is a skilful

combination of operational conception based on a few key and completing one another choices which have to enable gaining competitive advantage and achieving extraordinary results. The effective strategical management should have one more unique feature resulting from the mankind's pursuit of perfection – skills based on ideas, dreams, aspirations and passions of managers. Researches and experiments describing business activities indicate that big corporations achieved their success mostly thanks to managers, who may be called visionaries. They are people of broad thinking horizons who change the world, who can look beyond the present, for whom there are no limits, barriers or mentalities restricting the possibilities of development. In the literature one can find examples or such organizations as: IKEA, Apple, 3M, Microsoft, Intel, Southwest Airlines, Ryanair, Nokia, Toyota, Virgin, Ford, Wal-Mart, or on the Polish market: Nasza Klasa, Kruk, Selena, Work Service. As Krzysztof Obłój writes in his book "...the strategical management is an interpretation of the environment, setting the company limits, defining goals and priorities and, what is most important, a role of the passion, the intuition and dreams, as they are essential like never before. The passion is the source of innovations and changes – it tells to reach the future, to make ambitious objectives, cross the obvious borders, break bounds of thinking. The passion builds a motivation and a commitment which gives sense of existence, also gives the managers and workers a chance for a real commitment and a bit of a simple joy. When companies operate strategically, then the world of importances, dreams and hope shows in their actions beside the world of effectiveness"[1].

It results from the content above that the strategical management is a purposefully selected touch of appropriate rules and elements of the strategical management such as: the ability to set goals of organization, building the development strategies, the analysis of the resources of the inside and outside organization's environment, the conscious choice of markets, creating missions, visions, the strategical analysis and the above-mentioned touch of passion and dreams which creates a new dimension of organization management. Even though one can possess the knowledge of the rules of strategical management, sadly it is not possible to learn the thinking based on imagination, inspiration and passion. That is why the strategical management is often called an art that is difficult, unpredictable but also surprising, rewards the persistent, is the subject of the constant modification, orders continuous care about the market position.

[1] K. Obłój: *Pasja i dyscyplina strategii*. Poltext, Warszawa 2010, p. 26.

The strategical analysis

One of the key elements of the strategical management is the strategical analysis. As Romanowska and Gierszewska say, "the strategical analysis is a set of actions diagnosing the organization and its environment, enabling building a strategical project and realisation of the latter. In the instrumental sense, the strategical analysis is a set of analytic methods which allow to inspect, estimate and predict the future states of the chosen elements of organization and its environment from the possibility of survival and development point of view"[2].

The more unpredictable the environment and harder to plan the future is, the more precious is the knowledge of the processes occuring in the environment and the company – the knowledge provided by the strategical analysis.

The strategical analysis is a source of valuable informations not only to form suitable to aspirations, realistic development assumptions and to make pragmatic strategical choices.

One of the most important steps in creating the strategy is the knowledge and correctness of perception and interpretation of the phenomena and informations flowing from the organization's environment. The ability to consider the significance and meaning of the environment enables the organization to create and form its own development and to properly prevent crises. The market with its constant game of supply and demand is the most important informer and message transmitter.

According to Ansoff, the significance of company's connections with the environment roots from the role of the latter. Above all, the environment determines rules of the game, especially the macroeconomical. The future possibilities of the company's development lie in the very environment. It has a particular potential, which the inside-organization potential has to be referred to. Finally, the environment is dynamic, structurally diverse, and that is followed by the need of the continouos redefining and the change of relations[3].

The goal of analysing the organization's environment is the learning of phenomena and trends that are essential for the organization, yet the latter does not have control on them. Engulfing the elements which influence the choice of the organization's strategy is a labourious challenge (because of the specifics, connections and market situation of given organization) and still does not guarantee considering all of the elements.

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[2] G. Gierszewska, M. Romanowska: *Analiza strategiczna przedsiębiorstwa*. PWE, Warszawa 2009, p. 26.

[3] H.I. Ansoff: *Zarządzanie strategiczne*. PWE, Warszawa 1985, p. 65.

Every organization has to plan its activity for many years ahead. Scenarios of changes in the environment, showing different variants of the mentioned changes and propability of the occurance, are the basis of the long-term plans. This is why the modern planning in the organization puts a pressure on the environmental research, the constant monitoring of the key processes in order to correct the scenario. The more unpredictable the environment and harder to plan the future is, the more valuable is the knowledge of the processes occurring in the environment and in organization[4].

Sojkin divides the environment of an organization into three spheres:

- "first zone environment: includes the elements, processes and environmental phenomena which stay in a constant interaction with the company, yet there is a probability of preserving such interactions in the future, also it is possible to indicate the mechanism of those interactions and their results,
- second zone environment: includes the elements, processes and environments that currently (real time) do not affect the company and vice versa, but it is possible for such connections to emerge in the future, also a statistical mechanism of interactions can be indicated as well as the distribution of their potential results.
- third zone environment: includes the elements, processes and environmental phenomena that currently (real time) do not affect the company and vice versa, also there is no possibility of such connections to happen in the future, and the mechanism of interactions and their results cannot be indicated"[5].

The most popular form of grouping the elements is the division into the external, that is from outside of the company, and internal, i.e. those which are in the range of the organization.

The analysis of the external environment (macroenvironment)

The external environment makes up an extremely important element affecting the current and the future situation of the organization. Its most important feature is the big influence on the organization's position and ability to work, and the organization cannot change those conditions[6].

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[4] M. Romanowska: *Planowanie strategiczne w przedsiębiorstwie*. PWE,. Warszawa 2004, p. 23.

[5] E. Sojkin-Urbanowska: *Zarządzanie strategiczne przedsiębiorstwem*. PWE, Warszawa 2007, p. 71.

[6] There are few organizations – international corporations – whose income is bigger that national budget of some countries; they have influence on particular factors, for example, legal regulations.

According to Drążek, the external environment is a set of activities serving a purpose of researching the macroenvironment and the competitive environment. The author divides the external environment into following elements: the market, the competitors, the law, the transport and the sources of energy, the line of business[7]. Giereszewska and Romanowska think that the division into the macroeconomical environment and the competitive environment, called industrial and sectorial, is common. The macroenvironment includes following segments: the economical, the technological, the social, the demographic, the political and the legal, international.

All the transactors that have cooperative or competitive connections with the company are the parts of the competitive environment. The most important elements of the competitive environment are: suppliers, purchasers, existing and potential competitors[8]. Krupski divides the environment into four segments:

- the authority – including the state-owned institutions and owners,
- the nature – including global market trends, the nature, demographic processes, cultural and mental changes for the mass scale,
- the game – purchasers, suppliers, banks, service firms, advisory firms, exchanges, insurances, agents, shareholders,
- the fight – including competitors and opponets[9].

Obłój names the external environment the farther environment, and defines it as an environment that affects the further activity of the company with its changes, but is not under the influence of the companies.

The author divides the further environment into following elements: economy, society, politics and law, technology, demography. Those segments overlap each other; the events in one segment affect trends and events in the others[10]. Obłój thinks that all the segments are vital from the strategical point of view because:

- phenomena and trends in the five segments have short-term as well as long-term implications on the organization's functioning
- new events, changes of trends and the dynamics of mutual relations between segments cause the redefinition of branches' and markets' borders and the competition mode on them,

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[7] Z. Drążek: *Zarządzanie strategiczne przedsiębiorstwem*. PWE, Warszawa 2003, p. 40.

[8] G. Giereszewska, M. Romanowska: *Analiza strategiczne przedsiębiorstwa*. PWE, Warszawa 1995, following: R. Krupski: *Zarządzanie strategiczne.* Wydawnictwo Akademii Ekonomicznej, Wrocław 1998, p. 114.

[9] *Zarządzanie. Teoria i praktyka*. Ed. by A.K. Koźmiński, W. Piotrkowski. Warszawa 1995, following: R. Krupski: *Zarządzanie strategiczne*, op. cit., p. 114.

[10] K. Obłój: *Strategia organizacji*. PWE, Warszawa 2007, p. 208.

– the same trends and events have not only a different meaning for various branches and markets, but also for the firms enframed in one branch or market[11].

Romanowska names the external environment the macroenvironment. "Macroenvironments are a set of operational rules of all the companies functioning in given place and time. The organization chooses the macroenvironments only once – when it decides where to set itself"[12]. Romanowska divides the macroenvironments in: the political, the technological, the macroeconomical, the legal, the demographic, the social.

Gliński suggests a division of the external environment into following elements:
– the economical,
– the technological,
– the social-cultural,
– the political-legal,
– the international[13].

Koźmiński defines the external environment as the one that defines the general functioning conditions of an organization by creating barriers, threats and chances. Following sectors are assigned to the general environment: the legal, the physical, the economical, the technological, the social, the political, the cultural[14]. Griffin divides the external environment into following dimensions: the international, the technical, the economical, the social-cultural, the political-legal[15].

The analysis of the internal environment (microenvironment)

The essence of the internal environment comes down to the following, vital issue: in relation to the external environment, the organization must conform with the changes, trends in the environment, however in the case of the external environment, the organization has a possibility of creating its own relations with the elements of the environment. We deal with the two-sided interaction, that is the elements of the internal environment affect the activity of the organization, but also the organization can influence, form relations with the segments of the

[11] Ibid., p. 209-210.
[12] M. Romanowska: *Planowanie strategiczne*..., op. cit., p. 47.
[13] M. Gliński: *Zarządzanie strategiczne*. KEY TEXT, Warszawa 1996, p. 58.
[14] A. Koźmiński: *Zarządzanie. Teoria i praktyka*. PWN, Warszawa 2002, p. 34-35.
[15] W.R. Griffin: *Podstawy zarządzania organizacjami.* PWE, Warszawa 2007, p. 77-81.

internal environment. The microenvironment is easier to identify and observe, because it can foresee the future states, reactions and behaviors of its competitors, due to the direct interactions with them. The authors, describing the internal environment use the defintions such as: closer, competitive, sectorial, technological, industrial, microenvironment.

On the one hand the internal environment defines the conditions of functioning and development of organization in given sector and on given geographical market, on the other hand the external environment affects all the organization in given area, for example, a country, regardless of their location and branch.

The internal environment consists of following elements:

- competition – concerns present competitors and potential competitors willing to join the market, branch, etc.,
- suppliers,
- consumer,
- substitutes.

The organization is able to take up a fight with the current competition by differents means that can cause a success or a defeat. The organization may also influence the potential competitor's limited possibilities of joining the market. The organization can freely form their relations with customers, it can search for the customers that will satisfy its needs. Above all, the organization can create its relations with customers by, for example, the proper price or marketing policy. Also the customers can influence given organization by using its services, buying its products, etc. They express their attitude to presented services, products of given organization.

During the environment analysis one has to be cautious when forming the final results without the proper, in-depth analysis that allows to enclose all aspects that affect the organization. The most fundamental mistake of the competitive environment analysis is narrowing it just to the close environment of the branch. The organizations that focus on the branch analysis, think by definition in categories of existing technologies, competitors, legal regulations, suppliers and consumers. That is how they lose sight on the wide environment of pervasive industries and economies, distant from the events and trends that are weak signals of the future changes[16]. The division into the internal and external environment is more theoretical than practical. Both environments pervade and complement one another. For one organization the elements of the internal environment will be crucial, for another the external environment will

[16] K. Obłój: *Strategia organizacji*, op. cit., p. 208.

be most important, and for others the specific combination of the elements from both areas. It is essential not to narrow the discussed aspects' point of view. The environment has to be examined from the wide perspective, because only then it is possible to properly identify the proper informations and make right and effective choices.

Logistics as the science puts a strong pressure not only on a theoretical dimension, but mostly on the practical use. This is the role of the methods possible to use in the logistical area.

Table 1

The methods of the strategical analysis

Type of analysis	Name of analysis	Description	Advantages
1	2	3	4
Macro-environment analysis	PEST	A conception based on four criterions making the acronym PEST – political, economical, social, technological. Those powers are concerned the most important external determinants of the organization's environment[17].	The goal of the analysis is to find and control the areas in which there are chances of given organization.
	Scenario methods	Building the strategy of a company based on creating a few scenarios, which have to indentify all possible events.	The scenario methods can be divided into: – Possible events scenarios – Simulative scenarios – The states of environment scenarios – The processes in environment scenarios
	Extrapolation of trends	This method is based on identification of development tendention, meaning the general direction of the chronological line development. The models of a trend are mathematical. Prognosis based on an observed trend bases on an assumption that the interesting phenomenon will change in the future in the same way as till now.	The extrapolation of trends analysis does not provide a satisfactory basis to a reliable prognosis for any moment in the future.

[17] The contemporary PEST analysis was modernised and following elements were added: environmental protection, social, technological.

Table 1 contd.

1	2	3	4
Micro-environment analysis	Analysis of 5 powers of Porter	The analysis of the activity sector by researching 5 factors forming its attractiveness for the current and future investors. These factors are: – Bidding power of suppliers and possibilities of putting a pressure on the sector's companies – Bidding power of customers – Rivalization between organizations in the sector – Threat of emerging of new producers – Threat of emerging of new substitutes	– This analysis allows to define current and planned future sector's profitability – Enables to understand the acts of the competitive environment members and theirs influence on organization's position – Allows the investors to search branches and sectors of common perspectives
	Point opinion of the sector's attractiveness	The study of the point method is based on an assumption that it is possible to create a list of factors that differ the sectors and the level of their attractiveness.	This method allows to include the most important aspects of the competitive environment; there is a freedom of criterions.
	Experience curve	The experience curve uses the relation between the scale of production and the expense of a single product.	The analysis allows to estimate the level of expenses, production, innovation and efficiency.
	Benchmarking	It is an estimated in advance set of standard data that is compared to the future actions and their results, and eventual difference are measured in relation to them.	The goal of this method is an assurance of comparison of the future results and actions to the ideal reference mark in order to increase the general results.
Analysis of a company	Key success factors	The rule of Pareto is used in this analysis; it says that only 20% of events decide on 80% of effects, and vice versa. It is essential to choose the key factors and analyse them.	The advantage of this analysis is focusing only on chosen factors which are strategically important to the organization.
	The strategical balance	This method bases on systematic, multi-cryterion analysis of the organization, allowing the estimation of all areas of its functioning.	In this method one separates the areas of the organization which undergo a systematic analysis.
	Value chain	The value of every activity of service or product undergoes analysis.	This analysis allows using the maximal resources of the organization.

Table 1 contd.

1	2	3	4
	BCG	This method allows researching the participation in the market and dynamics of the sale of given product or organization. The method is divided into phases: dog, milk cow, star, question mark.	Using this analysis comes down to diversification of the actions depending on the phase of organization.
	SWOT	Complex method of researching the environment of organization and the analysis of the inside.	Uses weaknesses and advantages as well as chances and threats.

Source: Own study based on: J. Sutherland: *Klucz do zarządzania strategicznego*. Wydawnictwo Naukowe PWN, p. 56-76, Warszawa 2007; G. Gierszewska, M. Romanowska: *Analiza strategiczna przedsiębiorstwa*. PWE, Warszawa 2009, pp. 89-94.

In a table there are presented the selected methods of management that can effectively influence the change of philosophy of activity in logistics, if they are properly adopted to the conditions of the organization.

The role of the strategical analysis in the logistical management

The effective logistical management, defined as "activity creating the wole conception of logistical enterprises, including their course in a company as well as at partners, and coordination of realisation (in broad meaning) of this conception by proper organizational units with using of the proper instruments of management and control"[18] should use tools and methods used commonly in the process of, for example, building the development strategy. The requirements set to logistics as the effective solution deciding on achieving a permanent competitive advantage, forces a necessity of the constant tracing of the trends, phenomena, changes, impulses and signs that – if they are recognized quickly and intepreted properly – can settle not only the effectiveness of the used logistical solutions, but mostly can forejudge the success or failure of the whole organization.

The tempo of changes ongoing in contemporary world cause the elaborated conceptions concerned with a logistical area work increasingly short-term. The complexity of problems that face logistics demands taking the initiave in area of constant adaptation to requirements of the changing environment. It is possible only through the process of a permanent analysis of the environment and skilful conclusions from the observed phenomena.

[18] S. Krawczyk: *Zarządzanie procesami logistycznymi.* PWE, Wrocław 2001, p. 68.

Shortening the time of order realisation, optimization of the reserves level, using the proper means of transport, the choice of a precise distribution channel – these are just examples of problems that logistics has to deal with, and this is why the necessity of identification of the internal and external conditions becomes an obvious task. The solutions cannot be based on copying the methods of realisation used by the competitors – they should feature an innovative and non-standard approach, which is possible only in case of the effective diagnosing and analysing the environment that the subject works in.

The valuable strategical analysis consists not only in identifying and confirming the common truth, but especially in supplying new development possibilities, key chances and methods which have not been discovered yet. It may concern: the choice of a new supplier, reprojecting the storage process or supply chain, or making a decision concerning co-working with given logistical partner. With reference to the macroenvironment, the global political-legal conditionings can influence development of the free trade – the speed of flow of goods in global economy, customs rules, standards concerning, for example, sanitary or ecological requirements. A considerable influence on logistical solutions is made by technological factors, concerning telecommunication, IT, etc.

The changes of customer's activities and requirements concerning products, methods of distribution, etc., are becoming essential.

Analysing the microenvironment it is vital not only to define current competitors, but also potential ones who will grow up to the first plane range in the future. Concerning the suppliers' activities, the ignorance of their plans and methods is becoming dangerous.

The recognition of the own potential concerning owned material and human resources, information flow, ways of making decisions, tendency to risk, analysis of chosen channels of distribution, solutions in the area of production and strategies concerning supply is becoming a precious share in the process of adaptation to the constantly changing environment.

The above-mentioned examples of using the analysis concerning dimensions of the environment are in the interest of logistics. Contemporary logistics is an interdisciplinary process, goal of which is a full coordination of all the areas of organization's activity.

Conclusion

The authors have not taken the goal of confirming the regularities existing in practice and forming any laws on this basis, but only pointing some values connected with the strategical analysis which, if implemented permanently into a logistical management process, will influence positively the value of logistical

solutions, giving them proper flexibility concerning the right interpretation of changes undergoing in the environment and creating logistical projects that will feature innovativeness and creativity, and will settle the success permanently.

It is recommended to go deeper into theoretical deliberations concerning the influence of the strategical analysis on the logistical activity as the gap in the literature concerning the shown issue is noticeable. The problem is so interesting and complex that it requires detailed and intensified studies.

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INNOVATIONS AND CHANGES IN THE LOGISTICS TASKS IMPLEMENTATIONS

Introduction

The platform of the modern development has become the economy based on knowledge and experience. Innovations as well as innovation processes itself are no longer can be perceived as occasional events, but more often a new invention is treated as a set of projects creating new products, patterns, technologies and services. The rapid pace of technological and organizational changes cause the situation when only companies which are ready to introduce new creations and innovative technologies in their everyday life will be able to survive in the modern competitive market. That is why nowadays most of the companies, including logistics companies are under pressure of innovations, which very often occur in different fields simultaneously (new products, new techniques and technologies, new organization ways, new relations with partners, etc.).

The current situation was defined very aptly by Peter Jordan and Ruud van Pluijm contributors of vision "2016 The Future Value Chain", who said: "We face the challenge of changing our business in an integrated value chain, while maintaining the basic principles of business and fierce competition,… We can do it only by changing our internal cultures and rethinking of the components sustainability that connect us….. It causes an impact on the development of our organization and demands to identify new ways and means of action"[1].

Modern logistics should not only keep pace with the changes, but in many cases predict expectations of its customers. The market researches and trends forecasts have become a normal part of logistic business. Such actions are realized by both logistics companies and research centers or such analysis and

[1] *2016 The Future Value Chain*. Global Commerce Initiative, Capgemini, Intel 2006.

researches could be implemented as a common project of above-mentioned organizations. The results of such researches are usually general directions and fields of changes which will coordinate logistics tasks in the second decade of the twenty-first century. It is worth to refer to results of the research titled "Excellence in logistics", conducted in 2009 by the European Logistics Association (ELA) and the company named A.T. Kernem[2]. The result of this study is not only the description of recent trends in logistics, but also indication of the most important factors that influence the logistics development. The results of these studies point to such factors as[3]:

- The significant savings on storage stocks of raw materials, intermediates and finished products,
- A comprehensive optimization and harmonization of the entire supply chain – is an essential way to cut inventory storage costs,
- The prediction that the storage of incoming goods will be decreased to around 33% and the number of distribution warehouses to about 20%,
- The network of production facilities will change for the benefit of regional structures, in the near future the majority of production facilities will serve regional markets, while the number of local or global level suppliers will undergo to further reductions in the favor of regional facilities,
- An appropriate segmentation of the supply chain should be based on the explicit customer requirements and demands,
- A reduction of inventory should be by transforming the supply chain into demand-oriented supply chain,
- The growing importance of the sustainable development concept,
- Introduction of the green transport means.

Presenting visions and concepts, it is also worth to compare with similar studies made in the same time and studies concerning the future of logistics such as: "Future Logistics Challenges"[4]. It is important to pay attention to the study Capgemin conducted in 2005 and published among others in the report "2016 The Future Value Chain", by the GCI (Global Commerce Initiative) in 2006[5], supplemented by further research and reported in study named "In a succeeding

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[2] *Supply Chain Excellence admits the global economic crisis*. ELA/A.T. Kearney, Bruksela, 2009. http://www.elalog.org/

[3] H.Ch. Pfohl: *Doskonałość łańcucha dostaw w czasach światowego kryzysu gospodarczego*. In: *LOGISTICS 2010. Logistyka wobec nowych wyzwań*. ILiM, Poznań 2010.

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[5] *2016 The Future Value Chain*. Global Commerce Initiative, Capgemini, Intel 2006.

Volatile Market 2018' in 2008"[6]. In the context of the logistics trends it is essential to point out the significant conclusions included in the study, "Global Logistics 2015 +" realized by DB Schenker in cooperation with the Technical University in Berlin[7]. It is also necessary compare these concepts with the latest studies such as "Vision 2035"[8], The Smarter Supply Chain of the Future and IBM Global Business Services[9].

Another areas of changes and innovations are the studies and documents concerning the development of transport and infrastructure. Here, above all, there should be marked a recent document "White Paper", "Roadmap to a Single European Transport Area – Towards a competitive and resource-efficient transport system". There are also other studies which are treated as the basis for the "White Paper" and for the new objectives of EU transport policy[10]. There are following documents:

- A sustainable future for transport: Towards an integrated, technology-led and user-friendly system (COM (2009) 279 (Final)[11]
- the "Transvisions" study, developing a set of long-term scenarios (2030-2050) for transport and mobility in Europe,[12]
- an evaluation study, analyzing the performance of the Common Transport Policy in reaching the objectives laid down in the year 2001 in the transportation White Paper and in its 2006 mid-term review,
- a report produced by three main groups dealing with the topics of economy and society, technology, environment, infrastructure and logistics;
- Citizens summary "Communication on a sustainable future for transport: towards an integrated, technology-led and user-friendly system", 2009 citizens summary on future of transport policy[13].

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[6] *2016 The Future Supply Chain*, Global Commerce Initiative, Capgemini, May 2008. *Succeeding In a Volatile Market. 2018 The Future Value Chain*, Global Commerce Initiative, Capgemini, SAP, HP, 2008.

[7] www.dbschenker.com/site/logistics/dbschenker/com/en/about_dbschenker/best_practice/ innovation/global_logistics_study2015.html

[8] *Logistics and transport Vison 2035*, www.ciltinternational.org/web/downloads/Vision2035.pdf

[9] *The Smarter Supply Chain of the Future*. IBM Global Business Services, Somers, 2010.

[10] BIAŁA KSIĘGA – Plan utworzenia jednolitego europejskiego obszaru transportu – dążenie do osiągnięcia konkurencyjnego i zasobooszczędnego systemu transportu. Bruksela, dnia 28.3.2011 KOM(2011) 144 wersja ostateczna.

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[12] www.xesc.cat/pashmina/attachments/2009_02_transvisions_report.pdf

[13] Citizens summary Communication on a sustainable future for transport: towards an integrated, technology-led and user friendly system, 2009_citizens_summary_future_of_transport_policy.pdf

One more important document which should be underlined is the present article is "Europe 2020"[14]. In its part devoted to transportation, two important issues were the emphasized:

1) Decarbonization:
   - A range of activities including such activities as the early infrastructure development of electric and mobile networks, intelligent traffic management, a research concerning a European green car initiatives.
   - Vision of the structural and technological changes.
2) The development of infrastructure:
   - The usage of EU financial instruments,
   - Speeding up the discharge of the largest overloads,
   - Modernization of European transport networks,
   - The development of the intelligent, interconnected transport and energy infrastructures.

All of these studies have a common feature directed to innovation as a key principle and condition for changes, emphasizing the role and importance of innovations and stressing the necessity to bring the culture of innovation up, but just in low degree point to the concrete solutions in this sphere.

Let us now turn to presenting of new solutions in the field of transport and infrastructure, which without any doubts will affect the logistics processes, especially in the overcrowded cities. However the potential innovative solutions should be viewed in a broader aspect, as only their comprehensive implementation will allow to achieve savings and environmental protection. The presented in the article assumptions of the concepts such as Integrated Vehicle-Based Systems, identify trends to install modern sensors which should support drivers and operations. Other solutions also are going to be presented in the article such as zero emissions or unmanned vehicles. New types of vehicles require the development of road infrastructure and in the present article some of new propositions will be discussed, for example Hydrogen Highways – HH, Automated Highway System – AHS and Underground Automated Highway – UAH). It is assumed that all the identified innovations as a system will directly affect the supply chain and logistics processes implemented in the coming years, being a long-term solution and supporting logistics and environment protecting companies.

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[14] *Communication from the Commission Europe 2020 a strategy for smart, sustainable and inclusive growth*, COM(2010) http://europa.eu/press_room/pdf/complet_en_barroso___007_-europe_2020_-_en_version.pdf

The fields of innovative solutions

The pace of changes in the global scale is significantly influenced by the processes of globalization. As a result, the logistics also turned into the global issue, which create challenges for the global economy. Especially since these challenges apply to all sides of society and all areas of life, so that the process of globalization and regionalization really impact on logistics processes. The process of globalization put the logistics faced to aim to get used to new conditions very quickly and effectively, so that to strengthen the current position on the market and meanwhile being a reliable partner providing appropriate services. The logistics service providers are forced to search external and internal innovative solutions to improve the level of quality in existing supply chains. These innovative solutions should be connected by five aspects presented by Kent Gourding. These aspects include: *Reliability* – the supplier meets the customer requirements in a reliable and credible manner; *time* – this aspect is usually associated with the time period between customer's demand and delivery, but also affects other logistics aspects such as warehousing, storage, costs, etc.; *convenience* – as a technical support; *communication* – as monitoring of goods, payments, information flows; *fairness* – as a fair presentation of capabilities and servicing in accordance with the declarations[15].

In general, innovations in the logistics sector are created by new and improved possibilities and processes as well as by new products and services as the essential innovation in infrastructure and in the supply chain management[16]. Innovative vehicles and new solutions in the sphere of infrastructure are essential aspects that improve the reliability, speed and safety in transportation[17]. Furthermore the external conditions are changing rapidly, creating new difficulties for the transport processes, such as traffic in the overcrowded and ever growing cities. Thus, new technologies support the logistics operators and drivers, however, they are very expensive and require technological and scientific database, but in short or long term these innovations are associated with savings.

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[15] N. Gourdin: *Global logistics management: a competitive advantage for the 21st century*. Wiley--Blackwell, 2nd ed. 2006, p. 35.

[16] www.business.nsw.gov.au/innovation/sectors/logistics.htm

[17] *Interview with Chuck Thorpe of Navlab*, NOVA Escape, November 2000, www.pbs.org/wgbh/nova/escape/piocar.html

At the beginning of this year the European commission put forward extremely important document "White paper-Roadmap to a Single European Transport Area – Towards a competitive and resource-efficient transport system", which shows the concept and principles of the European transport development for future 30 years[18]. This document is based on three interdependent principles of transport sector development: ecology, safety and innovation.

First area of innovations presented in the current article is associated with the development of appropriate vehicles and road infrastructure. These solutions will affect all aspects of logistics systems, so a complex approach is a must to realize both researches and implementations of the new solutions in order to achieve the desired final result. The innovations in this field are extremely important as they influence the quality of the staff performance directly, which will increase the flow of goods and services.

As a good example of the logistics operators support could be presented the Integrated Vehicle-Based Safety Systems – IVBSS created by Transportation Reseach Institute, Michigan University (UMTRI), coordinated by the U.S. Department of Transportation and supported by partner companies such as: Visteon Corp., Eaton Corp., Honda R&D Americas Inc., International Truck and Engine, TK Holdings, Battelle, Con-way Freight and others[19].

The concept IVBSS is a five-year long research program aimed to combine several collision warning systems into a single integrated system to enhance the passenger safety in trucks and other vehicles. Phase I (November 2005-May 2008) is called conceptual and include: the system architecture development, the identification of suitable sensors, the testing process of all human factors for the development of "driver-vehicle" interface. Phase II (June 2008-October 2010) include: the system improvement activities, the preparation of the test fleet consists of 16 cars and 10 trucks equipped in integrated security system, the pilot tests on public roads and a full analysis of the data received. Currently the final report is on the stage of preparation. This 32 million USD worth project is associated with vehicles equipped in sensors: Forward Crash Warning – FCW sensor; Lateral Drift Warning – LDW sensor, Lane-change/Merge – LCM sensor, Curve Speed Warning – CSW sensor and others[20].

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[18] *BIAŁA KSIĘGA – Plan utworzenia jednolitego europejskiego obszaru transportu – dążenie do osiągnięcia konkurencyjnego i zasobooszczędnego systemu transportu*, Bruksela, 28.3.2011 KOM(2011) 144 wersja ostateczna.

[19] *Integrated Vehicle-Based Safety Systems (IVBSS),* Transportation Research Institute, the University of Michigan, www.umtri.umich.edu/divisionPage.php?pageID=249

[20] *Integrated Vehicle-Based Safety Systems. Heavy-Truck Field Operational Test*, Key Findings Report, U.S. Department of Transportation Research and Innovative Technology Administration August 2010, p. 6.

During the second Phase (February 2009-December 2009) the test of 10 trucks was carried out. These 10 trucks had to drive 1mln km during 16 500 working hours in order to collect full data from 224 000 km. The test proved the effectiveness of installed sensors and a positive effect on drivers and their skills, however showed around 5 incorrect warnings every 160km that is considered to be too much difference. The University of Michigan was a key partner in this program as was able to find right research methodology and appropriate tools. IVBSS is an excellent example of a comprehensive approach of several partners united by a common goal.

The next direction is aimed to work out an unmanned vehicle in order to eliminate the human errors. The goal of Intelligent Transportation Systems – ITS[21] development is to build an autonomous vehicle capable to move on the road, to perform complicated maneuvers such as: joining the traffic, overtaking, parking and crossing intersections[22]. All these actions show the process of searching for innovative solutions as a natural process in the competitive conditions. Therefore, the creativity of the process participants is not limited and allow to search for the special solutions.

The next important direction of innovation is related to ecology, as the majority of vehicles throw out large quantities of the harmful gas. In this context, the transportation processes are considered as a negative contributor especially in the big cities. Thus, new types of vehicles with zero level of exhausted emissions are highly desirable and this direction is supported by the carriers. As good examples for the following solutions could be named: the electric propulsion, the usage of solar energy, hybrid vehicles, hydrogen propulsion and so on and so forth. The following cars could represent the above mentioned solution: Honda FCX Clarity, BMW Hydrigen 7 and Think Nordic Hydrogen are cars using hydrogen instead of petrol, Nissan Leaf and Mercedes F 600 Hygenius are electric models. The Mercedes F600 Hygenius is equipped with latest-generation fuel element characterized by the emission at the zero level. This kind of fuel element burns the quantity of hydrogen which is equal to 2.9l of petrol per 100 km. This solution allows pass 400 km without refueling so it is an important step in the fuel elements development. Till the year 2015 this model is predicted to be ready for a wholesale production[23].

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[21] T. Zeybek: *Intermodal Freight Transport and Logistics Research, in European Union and Turkey*. Ankara 2010, p. 3.

[22] www.darpa.mil/grandchallenge

[23] www.hydrogencarsnow.com/mercedes-f600-hygenius.htm; www.mercedes-benz.pl/content/ poland/mpc/website/pl/

The trucks also go under the process of development. During the demonstration of equipment and vehicles in Chicago in 2009, the Smith Electric Vehicles' American company presented a new truck called Smith Newton Electric. This kind of truck can transport 7380 kg of goods with maximum speed 80 km/h and pass 160 km without charging. As the examples the following trucks could be also mentioned: Vision Industries Tyrano and Phoenix Sport Utility Truck (SUT). Bikes are also appearing in this category of solution.

The current achievements in the field of innovative vehicles are very hopeful as there is a great potential for their dynamic development. A test project Intercontinental Autonomous Challenge implemented under the aegis of the European Research Council is a good example of innovations development. The project is headed by Professor Alberto Broggi from Parma University in Italy. Four smart and non-polluting, "powered by green energy" vehicles defeated 13 000 km from Italy to Shanghai successfully in different weather conditions and traffic conditions that allows to collect the data necessary for research[24].

The research are directly related with the appropriate road infrastructure development to meet new requirements of innovative vehicles, especially in urban centers. The future hydrogen vehicles are associated with the building of Hydrogen Highways – HH, which is currently under design and development. The examples are: Hydrogen highway network in the European Union, the hydrogen highways in Japan, California etc. Their purpose is to promote the H2 as a carrier of clean energy and the development of public infrastructure to implement this type of vehicle. For example Scandinavian Hydrogen Highway Project-SHHP is a regional project which combine three different projects in the same area: Danish Hydrogen Link Project, Norwegian HyNor Project and Swedish HyFuture Project. It is still being developed and in future would be connected with the network of hydrogen highways of the EU, supporting the implementation of new green vehicles on the continent.

The research program associated with the modern vehicles support and equipped with multifunction sensors, which allow to control the traffic is Automated Highway System – AHS, also known as the Smart Road[25]. It is an innovative concept that can be described as "a new relationship between vehicles and

[24] *From Europe to China: Intelligent driverless vehicle reaches end goal in Shanghai after 13 000 km*; the European Research Council, Press release, Brussels, 27 October 2010.

[25] S. Cheon: *An Overview of Automated Highway Systems (AHS) and the Social and Institutional Challenges They Face*. UCTC University of California Transportation Centre 2003, p. 3, http://www.uctc.net/papers/624.pdf

infrastructure. It refers to the dedicated lanes on the selected roads, where vehicles equipped with special elements are moving under a full automatic control". It is a fully automated system for intelligent roads, which has its origin in the existing highways. Initially there will be only short lengths. These roads will allow to move independently and at the high level of safety, increasing efficiency and staff comfort in the cities and out of them. The primary goal of modern environmental-friendly and unmanned vehicles on the new types of roads is to reduce traffic, especially during peak hours, to reduce the exhaust concentration and the noise level. It will be achieved by merging vehicles in convoys for example driving at night. The sensors will allow to monitor these convoys in real time.

As a part of this concept there are also prompts to take into consideration the Underground Automated Highways – UAH as an innovative solution that will improve the flow of goods and services as well as safety, especially in big cities. In future the majority of transport will flow through the underground systems, it is just a matter of time of around 50years when a new underground system of road will be a reality. Although there are also difficulties in UAH development such as: the necessary degree of AHS network development, still ongoing attempts to design zero emission cars as well as tunneling technologies. However some projects have already been implemented, for example, in Southern California. In Sigapore there are large underground storage centers and stores under the process of building. In China there were modern underwater highways built successfully, such as Xiang'an Harbor Port tunel and Qingdao Jiaozhou Bay Undersea Tunnel. A very ambitious project is being considered in Asia, aiming to build 209 km UAH connected Korean Island Geoje near Pusan with Karatsu in northwestern Japan. Thus, in the years 2030-2050 a combination of AHS and UAH systems will create a "giant network", which will contribute to overcoming the current and future transportation challenges, directly affecting the efficiency of supply chains[26].

The implementation of innovation solution is important in all means of transportation, as it is the basis of rail, water and air transport development. In the last few years a new type of tank-container called Swap Body becomes a very popular solution in the intermodal transport. The volume of Swap Body container is 10-20% more than Standard ISO containers. At the same time the

[26] S.E. Shladover: *Automatic Vehicle Control Developments in the PATH Program*. University of California Berkeley, Transportation Library, Berkeley, February 1991; *Scandinavian Hydrogen Highway,* www.hydrogencarsnow.com/scandinavian-hydrogen-highway.htm

Swap Body tank-container has all advantages of a standard container. This type of containers has an increased size, but it is also allowed to be transported on rails or roads. The European carriers have already calculated the profitability of such containers while transporting liquid chemicals from Russia and CIS countries[27]. The block-train solution is another modern innovation in the rail transport. The main advantage of such train is the goods transportation without reloading, in the system terminal-terminal, thus shortening the delivery time and provides a competitive advantage of the rail transport over road transport. However there is also a disadvantage in this solution as it is required to pay for the whole train even if it is not entirely loaded. In turn as an example of a more future-oriented innovation in the rail industry there can be marked the invention of Japanese scientists from Tohoku University – a train on the airbag equipped with wings and fans. This project is still at the stage of testing, but the authors of this train plan to create a connection between two cities using the flying train possibilities. This kind of train has no connection with the rails so it is much more speedy then a normal train[28].

In the sea transport there are also many modern solutions. Most of them are aimed at shortening the delivery time through the design and construction of High Speed Crafts – HSC and Super High Speed Container Ship – HTH. The fundamental concepts of the development of these transport modes include:

- The concept of environmental-friendly ships powered by compressed natural gas (concept vessel E/S Orcelle),
- The concept of new ships generation (using a solar-type kite such as Beluga SkySails),
- The concept of automated logistics systems in ports (virtual deep sea terminals) and modern containers (fordable containers)[29].

The innovative concepts in the air transport in addition to the concept of building larger and larger aircrafts are extremely focused on the protection of environment. The concept of reducing emissions in the air is not just oriented to environmental protection but the actions are also taken to reduce the fuel consumption. The results of these green innovations are noticed in some new models of aircrafts such as Airbus A380 or A350. This model need just

[27] Научно-технический журнал “Инновации транспорта” №5 июль 2011, p. 36, www.innotrans.ru/

[28] Научно-технический журнал “Инновации транспорта” №4, апрель 2011, p. 18, www.innotrans.ru/

[29] *Innowacyjny rozwój współczesnych systemów transportowych*, prof. Jan Burnewicz, Uniwersytet Gdański, www.innopomorze.pomorskie.eu

3l/100 km fuel per passenger in the comparison with 4-4,5l/100 km in the earlier models. The scientists are trying to design the aircraft using engines for biofuel to meet the requirements of ecological concepts. The first practical test of this solution (aircraft B747-400) has already been undertaken by British scientists, using coconut and bamboo oil as a biofuel mixture. The new solutions in the airline industry are focused not only on building new and modern aircrafts but also on providing changes in the construction of airports infrastructure. As an example there can be presented even building of power stations on the German airports to provide electrical energy to the parking planes and this way to reduce the fuel consumption as well as thereby minimize the amount of CO2 in the atmosphere[30].

Conclusion

Innovation and innovation processes in the modern world are not only the basis of modern economic growth strategy and business development, but also are treated as a concept and a solution in the competitive struggle. The structures of high-developed world economies continually move towards industry and services based on knowledge and experience. The knowledge-based economy has become the basis of the modern development. Innovation and innovation process are no longer perceived as separate events, but more often are treated as a complex of projects creating new products, patterns, technologies and services. The pace of technique, technology and organization changes makes only companies introducing innovative solutions able to survive in an increasingly competitive market. That is why nowadays most of the companies, including logistics companies are under pressure of innovations, which very often occur simultaneously in different fields (new products, new techniques and technologies, new ways of organization, new relations with partners, etc.).

Vehicles modernization, green transport means construction and deployment of new infrastructure simultaneously will create a synergistic effect by combining the features of all components. The comprehensive action is the only solution to achieve the desired aims. As a result, logistics processes will be more reliable, predictable and ecological as well as human errors will be minimized. The benefit of this innovative solutions will be noticed soon, especially in the

[30] *Proekologiczne innowacje techniczne w lotnictwie – na przykładzie Niemiec*, www.berlin.trade.gov.pl

big cities. The supply chains will be more efficient especially in the urban areas where logistics expectations are rising rapidly. Future vehicles supported by infrastructure will create the effect of the components interplay in the relation to the needs. The concepts of infrastructure HH, AHS and UAH are promising solutions which will be able to provide a comprehensive support for a new type of fleet in the logistics companies. These innovations will affect the evolution of logistics and transport services. To continue the development directions it is important to select the appropriate partners from the world of science, business, local and national authorities as it will guarantee the implementation of innovative solutions. As a result, innovation will give a new dimension of competition among logistics companies to be better, faster and more reliable trading partners.

From the presented considerations it is concluded that the condition to participate in today's global development processes is, among others, an activity aimed at the achievement of a competitive advantage. The innovation is a prerequisite for the logistics development, adapted the logistics to the requirements of the twenty-first century. The Innovation implementation is the way to increase competitiveness and enterprise, region as well as entire economy development conditions.

The core of innovation in the logistics is based on a crucial necessity to access the latest, the most modern and broad knowledge, which today goes beyond the capabilities of one company. Therefore, interoperability standards, which enable the wider access to knowledge and make the transfer of information and know-how easier, play a fundamental role for all companies operating in the supply chain and create their ability to be competitive on the base of innovative solutions.

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ASSIMILATION OF QUALITATIVE ANALYTICS METHODOLOGY FOR LOGISTICS MANAGEMENT

Introduction

Logistics as a task supporting economic activity, made its presence felt in Europe after the II World War. It gave an answer to the question nagging manufacturers of how to fend off ever-fiercer competition and address ever-decreasing consumer demand. Moreover, end-customers have become ever-demanding partners, who ceased to care solely about the quality and price. They learned to appreciate other product features, such as availability, time to completion and accompanying conveniences e.g. home deliveries. Logistics flourished during sixties and seventies of the last century, mainly finding applications in manufacturing organisation, whereas during eighties and nineties it was trialled to unite logistics processes under joint management on an intra-organisational scale – supply chains and networks were formed. Pragmatic search for economic benefits coincided with that development, in an attempt to monetise logistics approach put into practice.

Real-life implementations – orchestrated by hands-on managers, who sourced their ideas from achievements of military logistics – were closely followed by theoreticians. Their task was to generalise practical experiences, mostly to prepare curricula for educating aspiring logisticians – individuals trained in streamlining material flows within so called logistics systems. The work of theoreticians has generated, apart from valuable papers many misconceptions, particularly touching on:

1. nature and essence of logistics, attempts for its original definitions,
2. potential range of applications for logistics, merit (or lack of it) behind propagating logistics to other areas of life,
3. origin of methods, tools and their scope of application,
4. self-sufficiency and independence of logistics from other theoretical and practical fields.
5. connection between business logistics and military logistics,
6. impact of logistics on other branches of science.

In our opinion, search for identity of logistics[1], quite intense recently, gives evidence to overall sentiment of sincerity behind finding and distilling the very essence of this branch of science (thoroughly practical), and thereby proving the purity of logistics.

An author should not concentrate on defining logistics. Instead, they should demonstrate how logistics and numerical tools were developed, and whether those phenomena can be mutually stimulating and inspiring.

Logistics development trends and numerical tools

Military logistics

Historically, logistics was first used in the art of war. The ancient Chinese military treatise entitled The Art of War, attributed to the great Chinese commander Sun Tzu (544-496 BC), bears first signs of logistics tasks. In his deliberations, he postulated that military actions should be planned in a manner which would protect the national economic potential from destruction. He also characterised some ground rules for organising military resource management in terms of e.g. food rationing, using local resources, time management and use of space[2]. Other ruler – Byzantine emperor Leo VI the Wise also made references to logistics. In his literary work entitled Tactica, he distinguished logistics as a military science, apart from strategy and tactics, which predominantly dealt with infantry formations[3]. Mostly commonly though, The Art of War by Baron de Jomini published in Paris in 1837 has become acknowledged as the primary theoretical source for military logistics. In the sixth chapter of the work Logistics, or the practical art of moving armies, he bestowed impor-

[1] J. Szołtysek: *Problemy tożdiestwiennosti logistyki*. In: Praci Odeskogo politechnicznogo universitetu, 2011. Wip. 1(35), p. 278-282, Odessa 2011 (Ukraine).
[2] Sun Tzu: *Sztuka wojny.* Wydawnictwo Przedświt, Warszawa 1994.
[3] F.J. Beier, K. Rutkowski: *Logistyka*. Szkoła Główna Handlowa, Warszawa 1993.

tance to logistics, which propelled it to civil sciences. The general elaborates in his literary work on location and inventory supplies, planning and orchestrating marches, preparation of means of transports, assembling routes and supplies to troops[4]. The I World War has shown, how important military logistics really is. According to an English military historian, J. Keegan, all sides involved equally struggled with logistics, and all suffered defeat in that field[5]. When the II World War commenced, it had major impact of development of military logistics, which provided transport and supply processes. As the aforementioned J. Keegen claims, it was the logistics in tandem with the arms industry which were centrepiece to Allies victory in that single biggest military conflict in human history.

The burning issue of warfare is the material supplies. Those problems, on a different scale, are affecting modern military action, which requires ever--sophisticated set of tools.

Intensive development of logistics over the course of II World War was made possible by logistics officers being provided with decision support tools. Operational research was an important group. It was initiated in United States and United Kingdom, originally as a method enabling better decision-making in logistics training planning. Among other, it was confirmed that large convoys were safe.

Operational research is an academic discipline related to decision theory, which enables pinpointing a method and the solution to some issues concerning making an optimal decision. Historically, operational research traces its origins back to scientific management. Currently it has been acknowledged as a part of the decision theory. The classical decision theory deals with decision analysis and decision support. *Decision analysis* concentrates on a single case decision, made by an individual or a group. The analysis involves finding an optimal decision, and in case of wrong decisions, its origins are traced back. As far as decision support is concerned – we make an attempt to find the best solution based on certain knowledge and information resources about possible consequences. The same applies to group decision making.

W. Grudzewski[6] claims that "from the viewpoint of practical management, operational research is perceived as a scientific theory, which enables building models based on identified quantifiable situations and solving those models

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[4] Ibid.

[5] J. Keegan: *Historia wojen*. Książka i Wiedza, Warszawa 1998, after: M. Sołtysik: *Uwarunkowania logistyki w łańcuchach dostaw.* In: Logistyka. Ed. by D. Kisperska-Moroń, S. Krzyżaniak. Instytut Logistyki i Magazynowania, Poznań 2009.

[6] *Badania operacyjne w organizacji i zarządzaniu*. Ed. by W. Grudzewski. Państwowe Wydawnictwo Naukowe, Warszawa 1985.

for effective decisions, which would fulfil taken technical, economic and social criteria". T. Kasprzak[7] defines operational research by identifying discriminants characteristic for a given academic discipline. She gives the basic three:

- subject matter – strategic and tactical decisions,
- applied methods – decision modelling,
- approach to the problem – systemic analysis of decision modelling and preparation.

There are various decision modelling methods, including mathematical modelling i.e.: linear programming, discrete optimisation, zero-one programming, targeted programming, quadratic programming, non-linear programming and dynamic programming.

The aforementioned methods were among some of the first mathematical methods deployed practically. Mathematical programming is widely used in e.g. production cost structure optimisation. In terms of its first applications, operational research was employed to shed some light on problematic areas, where for some reasons decision-making was riddled with difficulties. Among those reasons are:

- high multi-variability,
- complicated decision situation (drafting rules, high service level at the lowest cost possible),
- possibility of high profits or high losses (decision on the best goal possible),
- complicated decision-making process (group decision making),
- weight of decision problem.

The above-mentioned examples show that decision theory methods are deployed everywhere where they provide bottom line value (both material and immaterial). Military operations rely on the following tasks: supplies (all--encompassing both at the front and in life), transport planning (broadly defined – for instance, historically long-haul to Normandy, today fresh food). Effectiveness of delivering those tasks rests on well-planned logistics, scheduling (of operations) etc.

Every real problem contains criteria narrowing down possible decisions. In first military applications, limited fuel supplies were those criteria. The possibility to pertinent optimisation framework to support decisions was used – transport underwent optimisation. Deployment of operational research methods proved crucial to military successes.

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[7] T. Kasprzak: *Badania operacyjne i systemowe teorie decyzji.* Katedra Cybernetyki i Badań Operacyjnych, Wydział Nauk Ekonomicznych Uniwersytetu Warszawskiego, Warszawa 1987; T. Kasprzak: *Badania operacyjne w nowoczesnym zarządzaniu.* Państwowe Wydawnictwo Ekonomiczne, Warszawa 1974.

In discussed field, logistics – through new and developing mathematical methods – is seemingly the main driving force, at least partly, behind the set of tools used in decision making. Potency of the military sector, its financial and organisation backing, did and still does provide main thrust of development and finding new application areas for logistics.

Business logistics

From the outset, business logistics attempted to integrate conceptually (and subsequently implement those solutions to) all areas of business activity related to flow of materials and information, and occasionally – financial flows. Initially, logisticians focused their interest on areas which were deemed mostly inefficient – issues related to material supplies and distribution. Both those areas are tightly connected with flow of materials, but they are also shaped by consumer demand and marketing influences. Hence, decisions made by logisticians ranged from day-to-day issues related to efficiency of material supplies, storage and arrangement of inventory, inventory levels to interdependency of neutral material flows (i.e. inventory) and different aspect of material flows. If finished output was to be approached as company material inventory, then the problem of distribution could be defined in a similar fashion. Logistics was supported back then (and nowadays) by optimisation[8] of logistics tasks and goals.

One of the most important features characterising objectives of optimisation – part of operational research – is utilisation of models. Mathematical model[9] plays a special role. By means of mathematical concepts it brings described system into quantities of interest. Three fundamental requirements a model has to fulfil are worth pointing out. It should[10]:

- give exact account of decision problem,
- correctly represent links between individual,
- elements of modelled system and its surrounding,
- be free of insignificant details.

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[8] Optimisation is a method of finding best (optimal) solution (mathematically, extremum of the function is found) with regard to selected quality (e.g. cost, routes, efficiency, time) criterion (factor). Historically, finding minimum was first attempted by G.W. Leibniz (1646-1716) and L. Euler (1707-1783), which gave grounds for optimisations used by I. Newton (1643-1727), J. Bernoulli(1655-1705) and D. Bernoulli (1700-1782). Mathematical grounds were laid by J.L. Lagrange (1736-1813) and W.R. Hamilton (1805-1865). The method of using approximation to find extrema of certain complicated functions was devised by L. Rayleigh (1842-1919), W. Ritz (1878-1909) and B.G. Galerkin (1871-1945).

[9] S. Krawczyk: *Matematyczna analiza sytuacji decyzyjnych*. PWE, Warszawa 1990.

[10] H.M. Wagner: *Badania operacyjne*. PWE, Warszawa 1980.

This approach to modelling stems from the fact that finished model is not only subject to some general deliberations on links between its elements and surrounding devoid of functional links, but also at latter stages it is used for optimisational computations, concluding with a real-life solution. Strong connection between practical issues and their models, force a research team to build models, which could be described by mathematical models, algorithisated and be fit for numerical experiments. Building such model usually involves three stages[11]:

- determining the weight of decision problem,
- deriving the conceptual model,
- formalisation of conceptual model into a mathematical model.

Bearing in mind the above-mentioned information one should note, that over the course of building a model, a situation might arise, where the model created seems redundant in practical applications. Effectively, development of those models is ceased and they are not used in day-to-day management.

Deploying well-structured models should be justified by relevant potential benefits, i.a.:

- it facilitates comprehension of system's operating principle,
- it enables repeatable empirical observations and drawing pertinent conclusions, and theoretical assumptions about the system to be verified,
- enables concentrating attention on given elements of system and their impact on the entire modelled system,
- accelerates required analyses,
- determines and facilitates testing desired system modifications,
- enabled investigating decision variables in terms of their impact on the entire modelled system,
- is more cost-effective than direct system analysis.

Today, widely used in decision-making mathematical optimisation methods[12] are the following: network programming, stochastic programming, game theory, stochastic programming, game theory, queuing theory, inventory theory, calculus of variations, functional analysis methods, transport issues (transport algorithm), travelling salesman problem.

Attempts by the manufacturing lobby striving to elongate the production process through long production batches, over-stock finished output and pushing it downstream through the distribution chain so that the end-customer would be provided with a low-cost unified product, failed miserably. Consumer pull for highly-individualised products started to be ever-stronger. To meet that demand, the benefits of integrated logistics on a wider scale were called upon. Integration commences within a single organisation, then expands to multiple organisations

[11] T. Kasprzak: *Badania operacyjne i systemowe teorie decyzji*..., op. cit.

[12] S. Krawczyk: *Metody ilościowe w planowaniu (działalności przedsiębiorstwa).* Academia Oeconomica, C.H. Beck, Warszawa 2001.

by linking them together in a supply chain, then a network and ultimately they are all perceived as a meta-organisation[13]. Joining forces logistically over larger areas, effectively increasing the number of variables, which have to be taken into account to make a quality decision, entailed handling dynamically changing quantities, representing the actual as-is state. It also meant factoring in historical data (accumulated in organisation systems, usually in an uncoordinated manner, grouped around divergent goals, and formed differently thus incompatible with each other), and forecasts. For a long time, that systemic approach was impossible within meta-organisations, due to shear number of variables, exceeding human ability to draw correct conclusions from complex data. This changed, when computer aided support became affordable and publicly available. It was based on network connectivity and network data exchange. Sharing data by different entities, its accumulation and concurrent usage (including processing), required the risk to be shared as well. That in turn meant a novel value in business – trust among competitors. The notion of coopetition has already firmly sunk into business dictionaries, but it failed to spread around businesses. Both the supply chains and networks, which emerged to manage those businesses use state-of-the-art tools for decision support. The practice of how either functions, shows high usefulness of multi-criteria optimisation methods[14]. Multi-criteria optimisation is used in a range of fields[15]: designing product and production process, finance, air plane designing, chemical industry, car design. Essentially everywhere, where decision-making requires compromises between mutually exclusive goals. Examples of multi-criteria optimisation include profit maximisation and cost minimisation, efficiency maximisation and low fuel consumption, as well as decreasing equipment weight whilst increasing each component strength.

Supply chains and networks having been identified as practical aspect of commercial activity raised a range of doubts among logisticians over its interpretation. To a large extent, they started to identify logistics chains and networks with a much wider scale phenomenon of supply chains and networks[16]. Managing a supply chain requires other aspects than logistics to be taken into account (e.g. related to retail, marketing, environment, technology and social aspects as well).

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[13] More on the subject: J. Szołtysek, S. Twaróg: *Kształtowanie systemu logistycznego meta-organizacji*. In: *Logistyka. Współczesne wyzwania*, nr 2. Ed. by J. Szołtysek, B. Detyna. Państwowa Wyższa Szkoła Zarządzania im. Angelusa Silesiusa w Wałbrzychu, Wałbrzych 2011, p. 37-52.

[14] Practical applications include both single-criteria and multi-criteria optimisation.

[15] E. Konarzewska-Gubała: *Programowanie przy wielorakości celów.* PWN, Warszawa 1980.

[16] Serve as an example can definition of logistics given by A. Harrinson, R. van Hoek: Logistics is the task of managing material flow and information flow in a synchronous way without interruptions throughout the whole supply network (A. Harrinson, R. van Hoek: *Zarządzanie logistyką.* PWE, Warszawa 2010.

Multi-criteria optimisation also requires reaching further, past financial analysis, by factoring in technical, technological, organisational, environmental and social aspects. The decision on choosing an alternative, also necessitates to investigate each alternative's impact on the entire system. Their positive, negative or neutral influence has to be recognised. Positive aspects will include benefits and opportunities, whereas negative factors related to costs and risk. Unfortunately, the aforementioned aspects are rarely quantifiable thereby difficult to evaluate. Many variables and criteria are often rated on fuzzy rating scales. Cases of multiple decision evaluation criteria are analysed by sub--discipline of decision theory called multi-criteria decision analysis[17]. There are two definitions of the multi-criteria problem under the multi-criteria decision analysis.

– multiple criteria decision making (MCDM) – used by American academia,
– multiple criteria decision aid (MCDA) – mostly used in Europe.

Those methods enable multiple criteria to be aggregated to solve the issue of choosing a ranking scale or describing available alternatives in different disciplines. One of those methods is the Multiple Criteria Decision Making (MCDM), multi-criteria decision support methods. MCDN methods are a modern sub-discipline of operational research, which are developed and implemented as tools for supporting the decision-making process. Currently, they are centrepiece to decision procedures. There are:

1. MODM Multi-Objective Decision Making Methods,
2. MADM Multi-Attribute Decision Making Methods – also referred to as Discrete Multi-criteria methods[18].

MODM methods investigate decision problems, where the set of all permissible decisions is a continuous set, containing infinite number of feasible alternatives (solutions). Those problems are described by a set of quantifiable objectives, which underpin the decision and a set of predefined restrictions on values of possible alternatives' decision variables. As far as MADM methods are concerned, their distinguishing feature is a limited and small number of predetermined alternatives, which are selected based on fixed criteria, which not necessarily have to be quantifiable. Because problems of that nature are quite

[17] French-Italian economist V. Pareto (1848-1923), formulated multi-criteria optimisation framework for economic issues, which later was named Pareto optimality. In layman's terms, a solution is Pareto optimal, if it is not possible to find a better solution with regard to at least one criterion, without having to compromise others.

[18] T. Trzaskalik: *Wprowadzenie do badań operacyjnych z komputerem*. Wydanie 2. PWE, Warszawa 2008.

common, the following methods were devised to resolve them: PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations), ELECTRE (Elimination Et ChoixTraduisant la Realite), TOPSIS (Technique for Order Performance by Similarity to Ideal Solution), SMART (Simple Multi Attribute Rating Technique), AHP (Analytic Hierarchy Process), ANP (Analytic Network Process).

The AHP method is one of the most frequently used mathematical methods world-wide. This method enables comparison between quantitative and qualitative criteria[19]. In order to select the best alternative, its positive and negative impact has to be factored in. The AHP method uses the BOCR analysis for that purpose (*benefits* (*B*), *opportunities* (*O*), *costs* (*C*) and *risks* (*R*)).

Among various multi-criteria optimisation methods, particularly interesting are:

1. *Weighted Objectives Method* – it involves bringing multi-criteria optimasation to single objective optimisation assigning weights to the different criteria by introducing an equivalent criterion – sum of weighted criteria.
2. *Hierarchical Optimization Method* – it also involves bringing multi-criteria optimisation to single objective optimisation carried out with respect to all criteria.
3. *Trade-Off Method*, e-*constraint Method* – this *a priori* method involves fixing value levels permissible for each criterion, consequently restricting feasible solutions space. A multi-criteria optimisation problem is brought to a problem of optimisation with regard to selected criterion constrained by other criteria.
4. *Global Criterion Method* – here criterion formulation for single objective optimisation is solved for an approximate solution (an extremum for criteria studied on an individual basis might be the solution).
5. *Method of Distance Functions*, *Min-Max Method* – similar to the global criterion method, where at preliminary stages of the procedure approximate solution (or ideal) is selected by minimising the distance between the ideal solution and the optimum solution (Method of Distance Functions) or according to the Min-Max Method by minimising maximum deviations of optimal solution from the approximate solution.

[19] *Metody wielokryterialne na polskim rynku finansowym*. Red. T. Trzaskalik. PWE, Warszawa 2006.

6. *Goal Programming Method* – is a general multi-criteria optimisation technique. Here, criteria are viewed as objectives, which are to be achieved or thresholds, which could not be exceeded by criteria.
7. *Utility Function Method* – known from economics[20], this method uses the heuristically determined utility function, additive with regard to investigated criteria.
8. *Evolutionary Algorithms* – are a group of methods amongst artificial intelligence techniques. Their usefulness becomes apparent only in case of problems, where the number of feasible Pareto optimal solutions can reach high numbers (order of thousands or more). Then, traditional methods are less effective than evolutionary algorithms.

All the above-mentioned methods are similar in the way the solutions are selected. In order to solve for solution, the initial multi-criteria problem is brought to an equivalent problem in terms of predetermined procedure. Consequently the problem presents less of an evaluational challenge. Every different type of application requires thoughtful selection of the way tasks are delivered and methods chosen. Various fields of practical applications are tested by those algorithms. For instance, transshipment of food at a vast seaport or flight plans compiled by airlines require different approaches due to possible consequences of incorrectly evaluated solutions by any particular algorithm. Of course, testing of those tools is only possible owing to development of information technologies and database-enabled software, capable of storing terabytes of data (e.g. the SAS system). Moreover, it is not a field limited neither to practitioners nor formal methods proposing novel solutions. Software development has also opened new opportunities in that respect.

Social logistics

The beginning of XXI century was marked by anticipation for numerous changes. P.F. Drucker[21] was the author of the new management paradigm for the XXI century. Most notably, informatisation and globalisation became much more prominent as did human, who is ever-often seen as a valuable asset. The same human, is on one hand said to long for individual utopian happiness, devoid of interpersonal relationships, barren of love and truth, deficient in responsibility and common sense – a sheer axiological, moral, spiritual void,

[20] G. Trzpiot: *Multicriterion Analysis based on Marginal Conditional Stochastic Dominance in financial analysis*. In: *Multiple Objective and Goal Programming*. Ed. by T. Trzaskalik, J. Michnik. Advances in Soft Computing Series, pp. 401-412, Springer Verlag Company 2002.

[21] P.F. Drucker: *Zarządzanie XXI wiekiem*. Muza SA, Warszawa 2000.

where personal beliefs are redundant. But on the other hand, great emphasis is put on the fact, that human is the fundamental building block of society, the source and the ultimate purpose of social life. Such perception allows to protect human dignity and statutory human rights across the board. People have to be a part of society, and social structures are created to empower and enable people to fulfil their lifelong aspirations. That perhaps a bit lengthy disquisition was brought up, to justify the importance of logistics support in ever-growing number of socially beneficial activities, often determining their success. Normally there would not be anything surprising about it, however, it sparks the need to reflect over such use of logistics, which diverges from already explored applications – often referred to as classical (military and business). The aforementioned transition involves shifting the usual bundle of goals thereby influencing the way material flows are shaped. Although military and business applications of logistics have never compelled logisticians to spare a thought, and diversity of approaches to decision-making was perfectly justifiable, doubts arose among theoreticians over social applications of logistics. They questioned the rationale behind distilling that potential new field shaping logistics decisions as a separate subjective scope. Rejecting the idea presents least hardship in addressing a few aforementioned problems, in particular:

7. could we distil the field of social logistics, is it necessary,
8. should people be included as part of material flows,
9. are there really differences in how bundle of goals is created, and consequently are they significant compared to conventional applications,
10. are tools used by classical logistics any different (divergent).

Without going into too much detail about the definition it is worth noting, that social logistics as a new field of application for logistics – requiring a new approach to issues on the table – gains ground both in Poland[22] and beyond. It is

[22] First papers concerning the subject emerged at Asian scientific centres (e.g. Takahasi Teuro, *Planning of Social Logistics*, Bulletin of the System Science Institute, Waseda University 1988; Liao Wei, He Zhenggang, Zhang Jin: *Correlation Analysis of Social Logistics Demand and Economic Activities*. International Conference of Transportation Engineering 2009, Vol. II, ASCE, USA 2009), in USA it attracted attention (e.g. Jay Deragon, *Social Logistisc and Productivity*, Conversational Currency. The New Paradigm, 14.04.2010), Europe (e.g. Sirpa Tenhunen, *Mobile Technology in Village: ICTs, Culture, and Social Logistics in India*. „Journal of the Royal Anthropological Institut" 2008; J. Szołtysek, P. Kołodziejczyk: *Epistemologia logistyki społecznej*. „Przegląd Organizacji" 2009, No. 4, pp. 21-24; J. Szołtysek: *Typologia obszarów stosowania logistyki – propozycja rozwiązania*. „Gospodarka Materiałowa i Logistyka" 2010, No. 8, pp. 2-6; J. Szołtysek, S. Twaróg: *Establishing of an objectives bundle of modern supply chain management. Conditions o social logistics establishment, Czestochowa University of Technology* 2011; J. Szołtysek: *Socialnaja logostika – novoje napravlenije razvitija teorii i praktiki logistiki*. „Logistics and Supply Chain Management" 2011, No. 2(43), pp. 13-18 (Russia)). Global concerns also seem to have started care about their social footprint (e.g. DHL intends to reduce congestion in cities by creating local courier services).

worth pointing out here, that among those applications is urban logistics, logistics concerning broadly defined safety (e.g. mass events, gatherings, waste management, humanitarian aid), leisure and recreation (sporting events, journeys, tourism) and health care (hospitals, blood donation, transplantology, sanatoriums) and to sustain democracy (e.g. electoral organisation).

Described in previous item multi-criteria methods can be deployed provided one assumption is made – scores assigned to optimisation criteria are clearly defined and are deterministic. In reality, this assumption is not always true. The information about scores is generally approximate, subjective[23], fuzzy[24]. Thus a number of methods were derived, which use non-deterministic scores[25]. Among those the most note-worthy are cognitive decision theories, which seek sufficient/effective solutions for so called *real world problems* and *ill defined problems*. Descriptive approach reflecting a typical human behaviour when being presented with a decision situation. The impact of personality traits on decision-making is taken into account, e.g. selection of subjective evaluation criteria for individual alternatives, risk propensity[26]. Social criteria are also investigated: decision maker's rank within the organisation, impact of management style, group decision making and related conflicts[27].

Additional aspect comes in form of hidden variables (*hidden/latent variable*) – variables that are not directly observed but effect directly other variables that are observed. The difference between a hidden variable and a model parameter lies in constant value a parameter takes across the sample, or at least a major part of it. Hidden variable in turn varies for different observations. That has great importance in social logistics research. Some statistical methods are meant to reproduce hidden variables occurring in those models. For instance factor analysis and PCA assume descriptive variables to be linear combinations of hidden factors.

Those methods are particularly useful in social logistics, due to the objective being different i.e. the human well-being. As far as decision-making is concerned, apart from classical quantities (available resources, service level, costs etc.) a new immeasurable quantity emerges in form of broadly defined human

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[23] M. Zawisza, G. Trzpiot: *Multicriterion Analysis based on Stochastic and probabilistic Dominance in measuring quality of life*. In: *Multiple Objective and Goal Programming*, ed. T. Trzaskalik, J. Michnik: Advances in Soft Computing Series, pp. 413-424, Springer Verlag Company 2002.

[24] T. Trzaskalik, G. Trzpiot, K. Zaras: *Modelowanie preferencji z wykorzystaniem dominacji stochastycznych*. Akademia Ekonomiczna w Katowicach, Katowice 1998.

[25] G. Trzpiot: *Statystyczna analiza danych*. Uniwersytet Ekonomiczny w Katowicach, Katowice 2011.

[26] T. Szapiro: *Co decyduje o decyzji?* PWN, Warszawa 1993.

[27] T. Tyszka: *Decyzje. Perspektywa psychologiczna i ekonomiczna*. Scholar, Warszawa 2010.

well-being. Consequently, the thus far mentioned models are insufficient for the decision-maker. In turn, the methods reflected upon throughout this section of paper are used in different disciplines e.g. sociology and psychology (e.g. examination of stressors). Provided decision-making in social logistics is founded on hidden, intangible premises, the above-mentioned methods should fundamentally improve its effectiveness, as they adhere better to sensitive mature of social intricacies.

Conclusion

Development of logistics keeps up the pace of changing social needs. References originating from military applications and emulated successfully by business undergo constant modification, which takes account of shifting bundle of goals and consequently – different way decisions are made. The process of expanding logistics applications to social objectives – as part of applications emerging for social logistics – is subject to the same ground rules of development, as previous forms of logistics were. Mathematical methods – as constituents of tools supporting decision-making – undergo constant development independently of logistics itself, however, they work perfectly fine in described field. An assumption can therefore be safely made, that concurrent development of discussed tools and logistics enables effective assimilation of qualitative analytics methodology for logistics management.

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SELECTED TOOLS OF INFORMATION FLOW MANAGEMENT IN LOGISTICS

Introduction

Analysing the logistics processes implemented in the individual companies and entire supply chains, we consider the three streams of flow: goods, funds and information. From the point of view of the efficiency and effectiveness of supply chains become increasingly emphasized the role of information as an integrating factor operators making up the supply chain. Ensuring availability of information determines the best execution of logistics processes.

The role of information flow in logistics processes

The starting point for the exchange of information between supply chain partners is the realization of the proper flow within the enterprise. Effective logistics management in the enterprise is based largely on the flow of information, that should occur as smoothly and quickly as possible, so as to provide managers with comprehensive knowledge. The information provided within the company must meet several conditions, which determine their usefulness in decision--making. These can include:

– adequacy (completeness) of information, which is dependent on the measurement methods, its accuracy and degree of interference,
– reliability of the information, which affect the characteristics set input and output channels and types of decision rules present to the receivers
– usefulness, or relevance for senior and middle managers[1].

[1] J. Bendkowski, M. Kramarz: *Logistyka stosowana*. Wydawnictwo Politechniki Śląskiej, Gliwice 2006, p. 484.

Mindfulness for the collection and production of information with the highest value should be the pursuit of all companies forming the supply chain, because the quality of individual information attests to the quality of the information stream. While an information stream combines elements of various subsystems of economic organization and management system with a set of algorithms for data processing and an information system, which is the foundation of the company. The information system is a multi-level structure or functional element of the decision-making in the management system, enabling through appropriate procedures and specific information processing models of input on the desired output information.

Logistical decisions, which are closely linked with other activities in the sphere of management, require acquiring information obtained, collected and processed in the entire business' logistics system. The usefulness of the information determined by such characteristics such as: timeliness, relevance, completeness, and reliability of absorption[2]. Availability of information that meets the above conditions is possible thanks to the logistics information system. According to J.C. Coyle, E.J. Bardi, and C.J. Langley[3] "The logistics information system is a structure of interconnected people, equipment and procedures to ensure logistics managers for the relevant information needed for planning, execution and control of logistics activities". To develop and strengthen the position of the logistics information system contributed to the development of computer technology, computer tools have been applied, so that it becomes possible to the functioning of the logistics information system as part of enterprise-wide information system. According to J. Kisielnicki and H. Sroka[4], an information system is a "multi-level structure that allows the user to transform this system to enter specific information about the desired output by means of appropriate procedures and models". The information system meets certain features, like:

- planning individual logistics processes, such as demand forecasting, planning, material requirements, creating relationships with customers,
- coordination of the flow throughout the chain of movement of goods,

[2] L. Bukowski: *Problemy przetwarzania informacji logistycznych w zintegrowanych systemach produkcyjnych*. In: Wybrane zagadnienia logistyki stosowanej. Materiały VII Konferencji Logistyki Stosowanej – Total Logistic Management. Oficyna Wydawnicza TEST, Kraków 2004, p. 223.

[3] J.C. Coyle, E.J. Bardi, C.J. Langley Jr: *Zarządzanie logistyczne*. PWE, Warszawa 2002, p. 524.

[4] Kisielnicki J., Sroka H.: *Systemy informacyjne.* Placet, Warszawa 2005.

- monitoring and control of logistics processes, such as purchasing, sales, gathering and maintaining inventory,
- control processes at the operational level particularly in supply, transport and storage.

The information activities resulting from the above-mentioned functions vary depending on the specific processes occurring in the enterprise. Cz. Skowronek and Z. Sarjusz-Wolski[5] distinguished three main functions of information and decision-making:

- developed planning functions in the processes of purchasing, production and distribution. In making their decisions an important role is played by information technology tools for demand forecasting, market research, operative production planning and material requirements planning. These processes are dynamic, and therefore any created database should be continuously updated and developed to allow for the flexibility to satisfy the needs of clients and effectively collaborate with suppliers.
- coordinating functions, which in logistics processes play a particularly important role, and their highly complex nature of the resulting flow of supplies and information streams for many of the organizational business requires coordination of many individual events and processes. With this it is possible to obtain high efficiency of the entire logistics system, but it is necessary to use computer systems not only in the enterprise, but also in conjunction with suppliers and customers.
- monitoring and control of logistics processes that affect a broad spectrum of phenomena that are described in the databases of computer systems. This function includes records of inventories, supplies, sales, costs, which gives the possibility to obtain information for assessing the efficiency of logistics processes, and enables other functions of an information system, which may include planning and control of logistics processes.

M. Christopher[6] however indicates the four functions that have to meet the information systems for logistics, to which include logistics information system (LIS – Logistics Information System). Containing a collection of data allows managers the freedom to analyse logistic processes. Depending on the needs, they are general analysis or more detailed statistical analysis. The most important functions that it meets for the companies are:

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[5] Cz. Skowronek, Z. Sarjusz-Wolski: *Logistyka w przedsiębiorstwie*. PWE, Warszawa 2008, p. 343.

[6] M. Christopher: *Strategia zarządzania dystrybucją*. PLACET, Warszawa 1999, p. 120.

- **planning** – one of the fundamental characteristics of the logistics information system is the ability to predict customer behaviour, their demand for specific products. In this regard, it must be able to predict demand. With prognostic information and the time necessary to execute the supplies, the company is able to plan their inventories,
- **control** – this feature is to control all processes taking place in the whole logistics system, logistics companies mentioned herein may be: customer service, sales and delivery. Appropriate standards are established processes for which data are collected,
- **co-ordination** – this function is responsible for establishing cooperation between specific actions to carry out the sale in accordance with accepted standards in the enterprise customer service and controlling its implementation. Coordination requires a smooth flow of information between cells, interacting with each company,
- **communication and customer service** – in order to fulfil the tasks set by the company's customers, it is necessary to organize effective communication--based telecommunications and data transmission channels of communication. The importance of communication is particularly the case for urgent and non-custom orders – when the flow of information depends on the ability of companies to implement them.

With the implementation of these Logistic Information System functions, individual companies forming the supply chain have both a positive and a negative nature. What is important is the positive role played by information in the supply chain management, or integration partners. However, a negative phenomenon occurs when the information is treated as a factor contributing to the competitive struggle between enterprises in the chain, and does not affect the creation of value-added chain as a whole.

Using IT solutions in logistics system

The effective functioning of the logistics information system requires the use of computer hardware and technology transfer. The development and implementation of information systems should take into account the information needs of a company at various levels of management. Initially, computer programs functioned as independent modules. The flow of data from one system to another, created the necessity to manually move and enter them into the program. The solutions used in the individual companies were not compatible, it would also be impossible to combine them, because of the diversity of data formats and input output systems. With the development of information techno-

logy one started to pay attention to the strategic importance of IT systems. Consequently, programs developed in the direction of their solutions to combine and thus create more complex solutions. Individual systems began to be treated as modules. This allowed integrating different areas of enterprise information, such as supply and distribution, as well as closing cooperation of companies. Placing economic partners within a single information system significantly strengthens contacts between them, clearly reducing, at the same time, the circulation of the flow of goods and accompanying documents[7]. The resulting Integrated Information Systems, which as a result of extending the scope of the entire company became a very powerful and indispensable tool in strategic management. The integrated system is characterized by a modular structure. Its analysis is based on an examination of the efficiency of individual modules, as well as the quality of existing links between these networks and relationships. The whole design reflects the phenomena generally occurring in the enterprise information.

Activities in the area of logistics, which are closely related to other activities of management, require information gathered, collected and processed within the whole information system in the enterprise. The used information systems might contribute to improvement or delay in the process of decision-making at different stages of management. Difficulties to define proper information support for corporate governance in public companies originate from problems with determination of fundamental mission of the company – is it supposed to consist in maximization of shareholders value or to realize social and economic policies. States can strive for realization of both goals, which is often difficult to compromise. Proper corporate governance must be clearly defined, which is possible to be achieved through adherence to good disclosure standards. Performance of these tasks is possible through employing external auditing firms with good reputation to attract attention of shareholders to individual aspects connected with risk and poor results. Audits should be carried out according to international auditing standards.

Total disclosure of critical information in right time must encompass at least: financial results with clear explanation of unusual transactions; entire remuneration of all the directors and members of the board; key risk factors; details of the most important events and changes which might considerably impact on enterprise's results; enterprise goals; access of general public to information. In public companies, being entirely controlled by the state, typical aspects of corporate governance, such as enhanced enforcement of shareholders

[7] A. Śmigielska: *Integracja systemów informatycznych a zmiany biznesowe*. In: *Strategie informatyzacji i zarządzanie wiedzą*. Ed. by Z. Szyjewski, J.K Grabara, J.S. Nowak. WNT, Warszawa 2004, p. 193.

rights (especially minority shareholders) are of low priority. Independently of this fact, good practices relating to shareholders are a strong signal which proves how seriously the enterprise treats the issue of corporate governance. Considerable impact on corporate governance is from respecting procedures by the board of directors and management. In the case of public company, which is under total control of the state, the board is the only body which manages company's operation, being potentially able to guarantee themselves the scope of competence independent of state interests connected with implementation of its policies and of interest of management appointed by the state. Proper governance also depends on transparently defined roles assigned to the directors and managers. Their ability of efficient work is also determined by the quality, experience, skills and qualifications necessary for holding particular positions. They should be capable of, and even obliged to make independent decisions to the best interest of the company.

The main purpose, for which the company continues to invest in modern information technology, is a desire to meet the growing demands of customers and gain a competitive advantage. Improving information systems are interestingly influenced by a number of logistic processes[8]. However, while individual programs, optimize only specific areas, is an integrated information system by treating the company as a consolidated whole, allows for complex optimization.

Used in logistics integrated ERP systems is planning and allows one to:

- obtain information for strategic planning and decision-making management of the enterprise,
- provide information to planning and decision making at the level of middle management,
- obtain information needed in operations and control, the possibility of processing orders and handling transactions.

There are different solutions for functional requirements, which have common characteristics, which include basic scopes of business: finance, production and distribution. Individual users have specific tasks performed by linking computer packages, i.e. data processing tools. As noted by J. Majewski[9] the computer system takes some action of man and becomes a participant in the organization. Elements forming systems are both computer algorithms and procedures, as well as people, computer equipment and supplementary procedures. Information systems for implementing the objectives are elements of integrated logistics ERP.

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[8] Ibid.

[9] *Logistyka*. Ed. by D. Kisperska-Moroń, S. Krzyżaniak. ILiM, Poznań 2009, p. 321.

The areas of use include elements of business systems requiring access and exchange of information both on the physical movement of goods, as well as cash flow and its projection in the form of financial analysis. There is considerable variation applied to solutions resulting from the nature and scale of operations, the maturity degree of workers to the use of modern tools, and the individual needs arising from the specific company activities[10].

All logistics are based on information obtained from different databases structured and managed by IT systems. Data relevant to the logistics, which are subjected to processing, must be properly obtained from outside, stored and transmitted outside the system. This flow is aided by information systems, without which today modern logistical implementation would be inefficient[11]. ERP (Enterprise Resource Planning), which supports the company mainly in the sphere of planning, production and distribution are made up of a number of applications that integrate different areas of the business. They bring many benefits to business operations. Several major may include:

- extending the possibilities of using multiple information in a manner without losing their accuracy and transparency,
- integration of the various organizational units of the distributed enterprise and facilitating management of the global market,
- impact on the growing importance of information systems for companies that do not serve solely as auxiliary functions, but serve to comprehensively implement operational and strategic functions aimed at improving the competitiveness of companies in the market,
- minimize the difficulties found in existing systems that were less flexible. ERP systems are tailored to the individual needs of the enterprise,
- outreach to users, a large number of employees with access to the system helps to increase its transparency and thereby facilitate the use of the available data[12].

Important elements of the solutions used are sourced data which is the starting point in deciding on the type of application used in specific units and substantially determining the effectiveness and efficiency of supply chains.

Moved in logistic channels and stored in nodes of logistic systems, information pertaining to huge quantities of various goods and their current position need to be continuously monitored and recorded. Such action may take place by manually entering information into the computer system on the basis of documents relating to the exchange of goods or through automatic identification (Automatic Identification) or automated collection (ADC *Automatic Data*

[10] I. Fechner: *Zarządzanie łańcuchem dostaw.* WSL, Poznań 2007, p. 149.
[11] J. Majewski: *Informatyka dla logistyki.* ILiM, Poznań 2006.
[12] *Instrumenty zarządzania logistycznego.* Ed. by M. Ciesielski. PWE, Warszawa 2006.

Capture). Thanks to the use of identification technology it is possible to control the movement and location of materials, as well as gather information about the progress of each operation in the chain[13]. A detailed breakdown of activities and the potential benefits of automatic identification, is shown in table 1.

Table 1

Activity during product flow in the supply chain
and streamline obtained through automatic identification

LOGISTICS ACTIVITIES IN THE SUPPLY CHAIN	POTENTIAL BENEFITS OF THE APPLICATION OF AUTOMATIC IDENTIFICATION
Goods modifications according to individual customer requirements	Better understanding of expectations and ability to respond to individual needs
Collecting information about the level of wear or deterioration	Minimization of possible misconduct, quick response by obtaining information in real time
Supervision of parts and materials inventory	Increase efficiency by integrating operations with the information obtained
Required maintenance work on schedule	Facilitate decision making related to planning activities
Provide after-sales service	Quick identification of the defective product or a danger to the user

The recorded data are transmitted directly to a database system that stores information about the products. Providing high quality information system is only possible thanks to the complex information obtained from logistic labels after the manufacture of a product derived.

The use of automatic identification technology has a significant impact on the flow of information within logistics chains. It allows one to obtain the information necessary to effectively implement the management process. It is commonly used as an essential element in management systems, as well as contributes to the management of electronic data interchange (EDI).

Conclusion

The implementation of logistics processes in supply chains operating today relies heavily on the shaping of an effective system of information, ensuring collaboration in the supply chain partners to implement a common policy on the

[13] C. Bozarth, R.B. Handfield: *Wprowadzenie do zarządzania operacjami i łańcuchem dostaw*. HELION, Gliwice 2007, p. 604.

exchange of information, choice of tools related to streamlining the supply chain processes and methods for their monitoring. The implementation of information policy as formulated in the supply chain entails the need to implement standardized procedures and to identify clear directions for action. Furthermore, it is also planning the development of applied information systems based on the proper choice of software and sets of clearly defined procedures for the control and flow of information. The main tasks in terms of availability of information faced by companies in supply chains include:

- application systems that allow the implementation of chain operation principles on a partnership basis, which allows for overcoming the prevalence of information gaps,
- the use of an information system allowing for the collection, processing, sharing and analysing data that are processed into useful information,
- having staff training, which is considered as a decisive factor in the increase or decrease the quality of information,
- accuracy and availability of information,
- configuration of information systems architecture for the development in line with future business needs with regards to information.

Implementation of the above requirements for systems used to support the management process allows one to ensure the efficient flow of information, which is essential to the proper execution of business processes.

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Chapter Two

TRANSPORT

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RAILWAY INTEROPERABILITY AS A FACTOR OF DEVELOPING TRANSPORTATION FLOWS IN 21ST CENTURY SUPPLY CHAINS

Introduction

It is a place to say that the basis of all integration processes in the international dimension, is the free movement of all resources such as: information, staff, materials, raw materials, finished products. Free movement of these resources is conditioned and stimulated on many levels, particularly the economy level (including demand and supply of these resources), location of production level, legal considerations level (especially the current international economic law), trade level and many other factors. However, it is important, that the necessary resources should be physically available in the right place and time, in sufficient quantity and at the right price (cost). The implementation of these proposals corresponds to logistics. It is more and more difficult to implement the logistics demands (briefly known as 6R) in the global economy. The global economy causes: greater time distance (the phenomenon of outsourcing of production), shorter lead times of logistics tasks, lower prices (costs) due to competition, together with simultaneous need to ensure the highest standards of customer service. In that way, the problem of international economic cooperation, the bilateral one and cooperation within the framework of systems and economic groups, is focused on the problem of logistic support for the modern economic systems and their internal processes such as: economic, cultural, commercial, leisure time, etc. All these processes require efficient (in terms of praxeology) logistics support. The efficiency of logistics support is determined by both the efficiency of logistics processes and the efficiency of logistics systems. The logistics systems are necessary to implement any of the logistics process. The logistics process contains many activities and subprocesses, such as ware-

housing, storage, picking stocks, and more. It is hard to imagine the logistics process without transport. It is usually the most important part of the logistics process, due to its costs, lead time and need to ensure the safety of transported resources. Since the transport process is almost constant component of the logistics processes, it is obvious that transport systems are components of logistics systems in the individual national economies, and within the cooperating countries. Within so expanded economic systems, it is impossible to have efficient transport services and the efficient logistics service without standardization at various levels, both the transport processes and transport system. Standardization as a tool of rationalizing the logistics service found its deeper understanding in most transport modes such as shipping, aviation, and trucking. The least standardization process occurred in rail transport. At this moment, rail transportation system functioning in Europe is very far from the features that allow to determine it as an interoperable one. Despite of adoption the three packages of rights and principles of railway operation in the EU, rail transport is still regulated by domestic law of individual countries where operate more than 20 signaling systems, several systems of traction power supply, five widths of tracks and five standards for axle load on the track and gauge rolling stock and civil engineering. There are significant differences between national regulations and technical specifications used on the railways. The source of these differences is individual in each country-specific techniques and solutions of local domestic industry. This situation prevents the smooth passage of trains throughout the Community. Closure of the national railway management, over the decades resulted in a very close business relationship between the national railway industry and the national railways, closing the market for the supply of railway equipment and subsystems against the competition. In order to improve their competitiveness, it is necessary to open up the national markets for the Community market. Already, these few examples provide a knowledge about wide-ranging disaggregation of European railways, and give sufficient justification to take up the work on interoperability of the European railways.

Conditions for the standardization of the European rail system

Logistics is very strongly linked to the concept of integration. Integration is a fundamental process of economic co-operation within countries and regions, an objective and a tool for cooperation within the European Union. Logistics cannot be operated in efficient way without integrated activities across all levels

and across all components of logistics systems[1]. A rail transport is an important part of the European logistics system. It is co-responsible for the physical implementation of EU rules on free movement of goods and services. Rail transport is a component of the internal market in logistics services. The process of standardization, interoperability and finally the integration is a direct result of the provisions included in the Treaty on European Union (TEU) establishing the European Community (in particular Article. 71 and 156), which aim is to enable the Union citizens, entrepreneurs and regional and local authorities to participate in total benefits of establishing an area without internal borders. The tasks of interoperability, are specified in art. 155 of the TEU. Furthermore, on 12 December 1997 was signed the Kyoto Protocol, where the European Union committed itself to reducing greenhouse gas emissions in the closest future. Transport is a major emitter of these gases. Railway transport has the essential advantage at that aspect and the interoperability of rail is a way to increase this advantage.

Integration of rail systems is able to provide additional benefits – synergistic effects, impossible to achieve without interoperable actions. Integration is the goal to achieve, it is a certain ideal, which is virtually unattainable in a sustainable manner, due to continuous process of technical and organizational innovation, creating ever new ways of deepening the integration process. Therefore, in practice, we can talk rather about the process of synchronization, coordination, standardization, or the consistency. The aim is to ensure interoperability. "Interoperability" means the ability of the rail system to ensure the safe and uninterrupted movement of trains which accomplish the required levels of railway lines performance. This ability depends on the legal, technical and operational conditions which have to be provided to meet the essential requirements[2]. Interoperability in turn means a state of technical-technological, organizational and legal system that will provide the necessary capacity of the railway system and the conditions for the safe and uninterrupted movement of trains, according to the needs. In practice, it means that the interoperable rolling stock will be able to navigate the interoperable rail infrastructure of the individual countries without having to stop at the borders in order to exchange locomotives or drivers and without taking any activities by drivers.

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[1] More about Logistics Support System in: M. Chaberek: *Makro- i mikroekonomiczne aspekty wsparcia logistycznego*. Wydawnictwo Uniwersytetu Gdańskiego 2002, and M. Chaberek, G. Karwacka: *Logistyka jako praktyczne urzeczywistnienie prakseologicznych zasad dobrej roboty*. „Ekonomia XL", Nauki Humanistyczno-Społeczne, z. 391, Toruń 2009.

[2] *European Parliament and Council 2008/57/EC on the interoperability of the rail system within the community.*

Thus interoperability will raise the value in use of rail transport in the EU economy, not only because of the higher efficiency of rail use, but also through practical realization of sustainable development, because rail transport is considered to be more environmentally friendly. Interoperability is achieved by standardizing the individual components of the rail system starting from standardization of the parts and assemblies included in the locomotives, cars, roads, railways, up to the standardization of procedures, rules of railway traffic and the legal conditions of rail. The basis for standardization are aspects of legal, technical and operational associated with the fulfillment of the requirements specified in the relevant Directives[3]. One of the main principles of the European Union functioning is to create conditions for free movement of goods and services. However, this freedom of movement cannot take place without any evaluation and supervision. Each entering the market requires an assessment of compliance and supervision. Interoperability is one of the main conditions for free movement of goods and free movement of services. It is a new, global approach to technical harmonization, research, standardization and certification of the products, logistics processes and components of logistics systems. Therefore, it is assumed that in the future, the trans-European rail system will consist only of those components of the national conventional rail systems that were designed, constructed and installed according to essential requirements of the system into which they will be enabled.

An important prerequisite that determines the need to ensure compatibility of national systems for rail transport is the need to ensure the health, safety and security of passengers and goods. Standardization of trans-European networks contribute to the attainment the major Community objectives, such as:

- improving the efficiency of the internal market,
- increasing economic and social cohesion of the Community,
- social benefits, interoperability will raise the standards of logistics in social processes that require greater mobility of the population of the Community,
- additional jobs offers,
- realization of sustainable development, through the use of a greater range of more environmentally friendly and high performance security transport mode.

It is assumed that, European railway interoperability policy will be unable to 2020 reach the following goals:

- doubling in passenger traffic on European rail market,
- tripling freight flows on European freight market (calculated in tonne-km),

[3] Especially 96/48/EC and 2001/16/EC replaced Directive 2008/57/EC.

- triple increase in efficiency of rail transport,
- elimination of rail disasters in European traffic,
- increase in energy efficiency in 50%,
- reduction of harmful emissions in 50%,
- increase rail network capacity.

Interoperability combines aspects of different areas such as:

- policies and different aspects of economic policy,
- differentiated technical right of individual countries,
- effective administrative cooperation with the European administration (different information systems),
- standardization,
- quality management systems,
- accreditation,
- conformity assessment within:
  - research,
  - certification of products,
  - inspection and supervisory activities.

A representative example of interoperability in EU is the European Rail Traffic Management System (ERTMS). This system includes a unified radio communication GSM-R (Global System for Mobile Communications-Railway) and a unified European safety control system ETCS (European Train Control System). Those systems are important components of European policy of removing barriers, increasing the capacity of railway lines, and assure the safety of transport in terms of limitation technical barriers and creating common rail market. The ETCS system is responsible for ensuring a high level of security. It provides a traffic information to the driver's cab of the devices installed on the railway lines. In Poland, there are ETCS and GSM-R systems which are used as a medium for the information transmission to the train. Both systems are prepared to operate the conventional trains at speeds up to 200 km/h and high-speed trains. ETCS replaced a number of previous national systems. ETCS not only improves the rail safety, but also eliminates the barriers resulting from the previous use of dozens of national solutions in the data transmission between track and train, and many systems of drivers communication, both with respect to the driving cab signaling and rail-track signaling. GSM-R system is a digital radio communicator designed to provide both voice (between dispatchers and drivers), and digital data transmission (necessary in operating various systems supporting railway transport processes).

Formal and legal basis for the creation of interoperability in the EU

In the context of previous issue may arise a question about any rules and regulations leading to technical and organizational standardization of international railways. That is obvious, that international rail traffic has existed since decades and since then, wagons with both passengers and freight have crossed borders. Serious operational problems arise from the diversity of technical solutions. The restrictions in the efficient movement of goods were sometimes sought to be removed. In most cases solutions were limited only to the mutual agreement made on a forum of international railway organizations such as International Union of Railways (UIC), international agreements such as regulations of the reciprocal use of wagons in international traffic – RIV, RIC (International Wagon Regulations and International Coach Regulations), OPW (Common Wagon Park), RID (Regulations concerning the international carriage of dangerous goods by rail). Those activities were always limited to selected issues, and therefore not comprehensive, limited to regulate the particular behavior no full harmonization of international railways. In practice the activities were based on the following scheme: certain needed areas have been the subject of specific regulation of international agreements (eg. COTIF, AGC, AGTC); on the basis of those acts have been made international specifications (UIC, RIV, RIC, EN standards) and finally the national legislation have decided about acceptance of those international regulations.

This kind of principle in operating could not be maintained in a situation of the EU integration procedures. The membership in the European Union rises the number of entities involved in the process of harmonization of the national railway system. This is done on the basis of a fairly complex package of regulations necessary to implement the projects interoperable, with keeping the fixed procedures. Of key importance in this regard have had:

- Council Directive 91/440/EEC on the development of the Community's railway,
- Directive 2001/16/EC of the European Parliament and of the Council of 19 March 2001 on the interoperability of the trans-European conventional rail system amended by Directive 2008/57/EC of the European Parliament and of the Council and
- Decision No 1692/96/EC of the European Parliament and of the Council of 23 July 1996 on Community guidelines for the development of the trans-European transport network.

Formally, the harmonization aspect is a point of interest the European Union, in practice, represented by the European Commission and the European Railway Agency (ERA) established by Parliament and Council Regulation

No. 831 of 2004. Thus, the national railway system has become an integral part of the community rail system. Its objectives, conditions of existence and development are subordinated to the common terms and conditions, according to the rules laid down in the EC Treaty and the Act of Accession. It means that the technical and organizational development, changes on the transport market and political factors (in economic terms) make up the external conditions for existence of the national railway system, as well as the integrity of the internal conditions of the system. In this context, interoperability in meaning of EU legislation can be understood as the basis for the cohesion of the Community. In relation to the national system, interoperability became the basis for consistency with Community rules applicable to the railway system of the country.

Finally, there is a group of basic normative acts related to the implementtation, application and monitoring of the interoperability principles application at the national level:

- Law of 28 March 2003 on railway transport (Journal of Laws of 2003 No 86, item 789, as amended),
- Low of 29 August 2003 amending the low of conformity assessment system (Journal of Laws No 170, item 1652 of 2003, as amended),
- Regulation of the Minister of Infrastructure dated 7 January 2008 amending the Ordinance on essential Requirements for interoperability and Conformity Assessment Procedures for the trans-European high-speed rail system, Journal of Laws of 2008 No. 11, item 64,
- Regulation of the Minister of Infrastructure dated 7 January 2008 amending the Ordinance on essential Requirements for interoperability and Conformity Assessment Procedures for the trans-European conventional rail system, Journal of Laws of 2008 No. 11, item 65.

The main regulations of the railways harmonization at community level are:

- Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the Community,
- Directive 2008/110/EC of the European Parliament and of the Council of 16 December 2008 amending Directive 2004/49/EC on safety on the Community's railways (Railway Safety Directive),
- Directive 2004/49/EC of the European Parliament and of the Council of 29 April 2004 on safety on the Community's railways and amending Council Directive 95/18/EC on the licensing of railway undertakings and Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification (Railway Safety Directive),

- Regulation (EC) No 881/2004 of the European Parliament and of the Council of 29 April 2004 establishing a European railway agency (Agency Regulation),
- Regulation (EC) No 1335/2008 of the European Parliament and of the Council of 16 December 2008 amending Regulation (EC) No 881/2004 establishing a European Railway Agency (Agency Regulation).

In a broader look at the interoperability should also be noted that in practice other regulations that directly relate to the conditions governing the internal integrity of the national rail system are still applied. It refers to construction law and law on construction of products used for construction of railway infrastructure. The main assumptions of the current approach to interoperability in the Directive 2008/57/EC reflects the policy of the European Parliament and the Council in the field of the rail system interoperability within the Community. The procedure for adopting EU directives ensures a political consensus for the solutions because Directive adopted by the European Commission and the Council had to be passed by the European Parliament. To determine the technical and organizational conditions needed to meet in order to guarantee interoperability, the railway system is divided into subsystems, which requirements are determined and presented in the TSIs (Technical Specifications for Interoperability). The trans-European rail system is divided into:

1) Structural subsystem:
   a) infrastructure,
   b) energy,
   c) control,
   d) the rolling Stock.
2) Operational subsystem:
   a) rail traffic,
   b) maintenance (procedures, associated equipment, logistics centers for maintenance work and reserves allowing the mandatory corrective and preventive maintenance to ensure the interoperability of the rail system and the required performance),
   c) telematics applications for passenger and freight. According to Annex 1 to Directive 2008/57/EC, this subsystem comprises two elements:

- applications for passenger services, including systems providing information before and during the journey, reservation and payment systems, luggage management and management of connections between trains and other modes of transport,
- applications for freight services, including information systems (monitoring of freight and trains in real time), marshalling and allocation systems, reservation, payment and invoicing systems, management of connections with other modes of transport and preparation of electronic documents.

Moreover, the railway system structure consists also of:
- interoperability constituents – for each subsystem or part of subsystem is proposed list of constituents and aspects relating to interoperability at the time of drafting the relevant TSI and
- interfaces, constituting the relationship between the individual subsystems.

Technical Specifications for Interoperability (TSI) are the main platform of the regulatory rules. TSI are the European legislations rules which override the national acts of the particular scopes. The European standards draw on the TSI. Only on the basis of the TSI and European standards national railway legislation can be created.

The market surveillance. The acceptance of the railway systems into service

The very definition of the TSI does not determined yet the implementation and application of the contained findings. Requirements of achievement the rail system interoperability contained into the EU directives include activities related to designing, building, commissioning, upgrading, renewal and maintenance of infrastructure and rolling stock. To achieve the set goals there are some procedures and organizations laid down in the EU directives:
- holding the market surveillance,
- giving the authorization of conformity assessment Dobies,
- procedures for authorization the subsystem into service stadion.

Market surveillance is an important instrument for the implementation of New Legislative Framework (NLF). The aim of surveillance is to ensure compliance with the provisions of the relevant Directives throughout the Community. Citizens have the right to an adequate level of protection within the Single Market, regardless of the origin of the product. Market surveillance is also to prevent unfair competition. Member States of EU are obliged to designate or establish authorities that are responsible for market surveillance. Market surveillance involves monitoring by the supervisory authority of conformity of products placed on the market with the relevant provisions of national law (taking into account the NLF), and if necessary take appropriate action to ensure compliance. Assessment of compliance may include[4]:
- internal control of design and production by the manufacturer,
- examination of the type by a third party in connection with the internal control of production by the manufacturer,

[4] www.mg.gov.pl/Wspieranie+przedsiebiorczosci/Bezpieczenstwo+produktow+i+uslug/Ocena+zgodnosci/Dyrektywy+Nowego+Podejscia

– examination of the type or project together with the approval of product or production quality assurance system or the product verification by a third party,
– design verification and production by a third party, or
– approval of full quality assurance system by a third party.

Conformity assessment system consists of:
– horizontal Laws[5],
– national acts transpose EU law (Polish acts transposing national law into EU legislation which are called the "acquis communautaire". These are mainly the Old Directives and the New and Global Approach Directives,
– Polish national acts.

Institutional structures of the conformity assessment system are:
– Ministry,
– Polish Accreditation Center,
– Polish Standardization Committee,
– notified bodies,
– market surveillance.

At the design stage, the producer has to determine which directives are related to his product .The product must comply with the directives at the first time is placed on the market and/or put into use. The NFL directives specify the products and detail requirements referring to that product and to the procedure of testing. Those directives are prescriptive. They provide detailed requirements for the product, which greatly facilitates the control of compliance. There is a difference between the Old Approach Directives and the Directives of the New and Global Approach. The amendment processes of the Old Approach Directives were very slow and they inhibited technological development. Therefore, there was a need to change approach to conformity assessment. The New Approach, supplemented later by the Global Approach has led to some simplification and harmonization of conformity assessment procedures. Issues included in new directives are so general that contain all possible cases relating to their subject matter. First of all, directives indicate aims to be achieved, and courses of actions to reach them. New regulations leave free choice how to achieve the

[5] Law of 30 August 2002 on conformity assessment system (notice the Polish Marshal dated. 13 July 2010 on the publication of the consolidated text of the Law on conformity assessment system – "Journal of Laws", No. 138, Item 935). This Act provides, among others basis for the transposition of the Directives of the Old and New Approach. Law of 12 December 2003 on general products safety ("Journal of Laws", No. 229, Item 2275). It is a transposition of the Directive 2001/95/EC of the European Parliament and of the Council of 3 December 2001 on general product safety. The Law of 2 March 2000 on the protection of consumer rights and liability for damage caused by a dangerous product ("Journal of Laws", No. 22, Item 271). It is a transposition of the Council Directive of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products (85/374/EEC).

stated objectives. Therefore do not impose the solutions, in terms of achieving its objectives - require invention and activity of the users. Most New Approach Directives specify requirements relating to safety of use the products by elimination of threats to life and health of humans and animals, private property and environment. Some of them take into account other aspects, such as energy savings, the accuracy of meteorological measuring instruments, transport safety devices.

New Approach directives are total harmonization directives and supersede all corresponding national regulations, which should be repealed. Member States of EU are required to move these rules to the proper level of national legislation.

For the confirmation of product compliance with the New Approach Directives is provided the CE mark. The New Approach improved the conformity assessment procedures. The Global Approach entailed a modular approach, which means the division of the conformity assessment procedures on a number of separate operations (named modules). These modules differ according to: the stage of the product development (e.g., design stage, prototype, full production), the method of evaluation (inspection of documents, type approval, quality assurance) and the person conducting the assessment process (a producer or a third party).

Producer can prove that his product is compliant with the requirements through the use of harmonized standards. That gives him the privilege of presumption of conformity. Application of harmonized standards is not obligatory. That means a manufacturer may not use them and has a possibility to prove the compliance of a product in different ways, eg on the basis of other specifications, their own or other. Some products may be covered by several New Approach directives. This requires from producer a general overview of the existing directives and arrangements applicable to a given product, as well as assigned to them harmonized standards. Despite of voluntary, they are recommended to use, because it is the easiest, surest and cheapest way to demonstrate conformity to product requirements.

The authority guarding the products marketed in Poland is the President of the Office of Competition and Consumer Protection. The supervisory authority carries out its tasks with the help of specialized organs, which control the properties of products to be marketed. Specialized bodies are:

- Trade Inspection,
- National Labour Inspectorate,
- Chairman of the State Mining Authority,
- President of the Office of Telecommunications and Post,
- The Chief Inspector of Building Control,
- other bodies specified in separate acts, if they are listed as specialized bodies, including the Office for Railway Transport.

Specialized authorities carry out checks on products marketed in meeting the essential requirements of the products specified in the regulations or in separate laws. If, in the result of the inspection, it is found that the marketed product does not meet the essential requirements specified in the regulations or in special laws, the authority may:

- order the removal of the product non-compliant with the essential requirements, within the prescribed period,
- order, by decision, the withdrawal from the market the products which do not meet the essential requirements,
- prohibit, by decision, to place on the market the batch of the product that does not meet the essential requirements.

Under the circumstances indicating that the product does not meet the essential requirements, the power body recommends the specialized laboratory to conduct the tests. If the investigation confirms that the product does not meet the essential requirements, the authority may require the decision to withdraw the product from the market. The costs of the product examination are covered by the manufacturer or his authorized representative or the importer. The supervisory authority is obliged to gather information about not in conformity with the essential requirements products, derived from domestic and foreign entities, and make them available to authorized agencies and entities. When non-conforming with the essential requirements product poses a threat to life, health, property and the environment, a specialized body transmit forthwith to the competent customs offices information about these products. If the customs authority during the customs control of products which are to be covered by the marketing authorization procedure, finds that the product is incompatible with the essential requirements or may pose a threat to life, health, property and the environment, stops the product and dedicates it to the authorities for an appropriate review. If the authority issues a qualified opinion confirming that the product is incompatible with the essential requirements or poses a threat to life, health, property and the environment, the customs authority shall withdraw the product abroad. The third institution of market surveillance is an authorization of conformity assessment bodies system. The authorization relies on qualification by the minister or the head of the central body proper for the object of conformity assessment, the individual or laboratory applicants to the notification process. The notification means notifying to the European Commission and to the Member States of the European Union authorized certification bodies and inspection bodies and laboratories authorized to perform the appropriate actions specified in the conformity assessment procedures. Authorization is granted at the request of the certification body, inspection body or laboratory, meeting certain criteria. In the railway industry in Poland, the President of the Railway Office can authorize by way of administrative decision, as appropriate:

– the inspection body,
– product certification bodies,
– testing laboratories.

The third element of the supervision of the rail system interoperability is the procedure for exploitation of the subsystems. The infrastructure manager, railway company and railway siding user, as well a company performing transport within the siding can operate only on the types of buildings and equipment admitted for railway traffic operation and can use the types of rail vehicles, which got a certificate of release to service from the President of Railway Office (subject to Article 23, paragraph 2 of the Law on rail transport). In the Polish legal system, certification of release to service is regulated by the Law of 28 March 2003 on railway transport (unified text: Journal of Laws No. 16 item 94, as amended. Amended.), and in particular Article 23[6].

To get the certificate of release to service may be requested by:
– producers,
– rail carriers,
– contractors of the modernization,
– infrastructure managers,
– railway siding user,
– companies performing transport within the railway siding.

Every subsystem, after releasing to service need to be subject to a verification procedure to ensure that it is operated and maintained in accordance with the essential requirements which apply to the subsystems constituting the rail system. The verification should guarantee the authorities responsible for authorizing their placing in service assurance at the design, construction and exploitation that the result is in accordance with existing technical and operational regulations. The verification should enable manufacturers to equal treatment regardless of the country. It is therefore necessary to create a module or modules that define the terms and conditions applying to verification of EU subsystems.

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[6] Moreover, the procedures in the implementation of provisions relating to certificates of release to service are governed by the following acts:
Minister of Infrastructure Regulation of 26 September 2003 on the list of types of buildings and installations designed for railway traffic and the types of railway vehicles, which are issued a certificate of release to service ("Journal of Laws", No. 175, Item 1706).
Regulation of the Minister of Infrastructure of 30 April 2004 on certificates of release to service-type buildings and installations designed for railway traffic operation and the type of railway vehicle ("Journal of Laws", No. 103, Item 1090, as amended).
Regulation of the Minister of Infrastructure of 12 October 2005 on the scope of studies necessary to obtain licenses for exploitation of types of buildings and installations designed for railway traffic and the types of railway vehicles ("Journal of Laws", No. 212, Item 1771, as amended).
Regulation of the Minister of Infrastructure of 29 February 2008 on the activities performed by the President of the Railway Transport Office, for which charges are made, and these charges and their collection mode ("Journal of Laws", No. 47, pos. 276).

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3. Consolidated versions of the Treaty on European Union and of the Treaty Establishing the European Community.
4. *European Parliament and Council Directive 91/440/EEC on the development of the Community's railways.*
5. *European Parliament and Council Directive 2001/14/EC on the allocation of railway infrastructure capacity and the levying of charges for the use of railway infrastructure and safety certification (Railway Safety Directive).*
6. *European Parliament and Council Directive 2001/16/EC on the interoperability of the trans-European conventional rail system.*
7. *European Parliament and Council Directive 2004/49/EC on safety on the Community's railways and amending Council Directive 95/18/EC on the licensing of railway undertakings.*
8. *European Parliament and Council Directive 2008/57/EC on the interoperability of the rail system within the community.*
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10. *European Parliament and of the Council Regulation (EC) No. 881/2004 establishing a European railway agency (Agency Regulation).*
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12. *Kyoto Protocol to the United Nations Framework Convention on Climate Change.*
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16. *Law of 12 December 2003 on general products safety*. "Journal of Laws", No. 229, Item 2275).
17. Regulation of the Minister of Infrastructure dated 7 January 2008 amending the Ordinance on essential Requirements for interoperability and Conformity Assessment Procedures for the trans-European high-speed rail system. "Journal of Laws" 2008, No. 11, item 64.
18. www.mg.gov.pl

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CONTEMPORARY SUPPLY CHAIN TRENDS AND WORLD'S FREIGHT TRAFFIC

Introduction

Today's global world is characterized by great numbers of supply chains of various industrial branches. All companies whether from industrial sphere or tertiary sphere striving to gain competitive advantage and to manage their flows effectively. One way to reach high level of competitiveness is to design or optimize single supply chain in global view and simultaneously in relation to other supply chains[1].

In the current global world's economy, each industrial branch, whether e.g. air, automotive, pharmaceutical, food, or metallurgical industry, has got its own supply chain formed by huge material, financial and information flows. All three kinds of flow must be planned and manage to reach required level of competitiveness and simultaneously to minimize negative impacts on living environment. As a main result of positive trend of total world's merchandise trade volume, see fig. 1, is growing volume of world's freight traffic. Logistics is a science playing significant role in today's global world, it has got developed methods, approaches to effectively plan and manage all three mentioned flows and thereby also world freight traffic. It develops new methodologies to manage more and more complex supply chains. Through developed and new developing logistics methods, approaches and methodologies to plan and manage, it's possible considerably contribute to enhance gross domestic product (GDP) of single countries thereby also to enhance world gross domestic product[2].

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[1] M. Hart: *Logistics and Its Indisputably Growing Importance in Current Global World's Economy.* Carpathian Logistics Congress, High Tatras, Slovak Republic, September 2011, pp. 197-206.

[2] The World Bank, www.worldbank.org/ (04.08.2011).

The evolution of world gross domestic product along first decade of the 21st Century had positive growing trend, see fig. 1. In the fig. 1 it's evident the global economic crisis of 2008 and 2009 which caused the total merchandise trade decline thereby also the world's GDP decline[3].

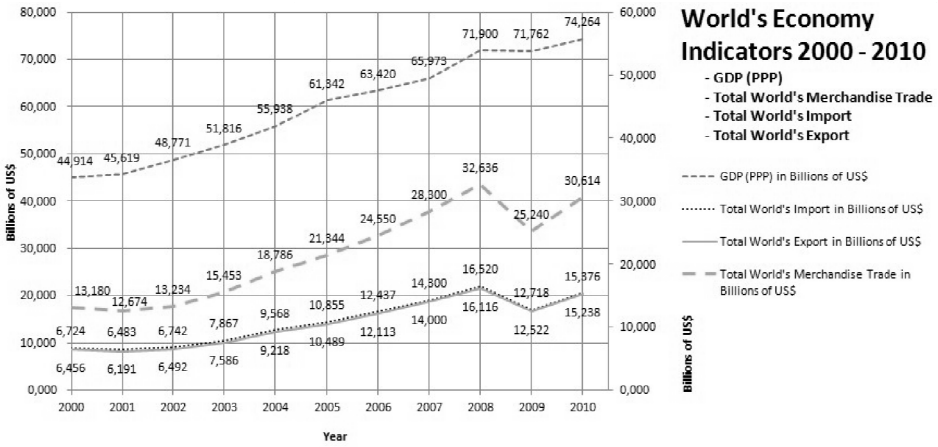

Fig. 1. World's Economy Indicators 2000-2010

Source: The World Bank, http://www.worldbank.org/ (04.08.2011); Central Intelligence Agency, https://www.cia.gov/ (05.08.2011).

For better notion, in 2011, the largest economies in the world, which considerably affect the world's GDP pattern, are the United States, China, Japan, Germany, France and the United Kingdom, see table 1.

The reality is that international trade is the indisputable foundation for economic growth and prosperity[4].

[3] Ibid.
[4] Ibid.

Table 1

Leading Economies in The World in 2010

Rank	Flag	Region	GDP (PPP) in Billions of US$ / year 2010
-	-	World	74,264
-		European Union	15,170
1.		United States	14,658
2.		People's Republic of China	10,086
3.		Japan	4,310
4.		India	4,060
5.		Germany	2,940
6.		Russia	2,223
7.		United Kingdom	2,173
8.		Brazil	2,172
9.		France	2,145
10.		Italy	1,774

Source: International Monetary Fund, http://www.imf.org/external/index.htm (07.08.2011).

Supply chain

A supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturers and suppliers, but also transporters, warehouses, retailers and customers themselves.

A supply chain is dynamic and involves the huge flows of information, product and funds between different stages. Each stage of the supply chain performs different processes and interacts with other stages of the supply chain.

A typical supply chain may involve a variety of stages. These supply chain stages can be (see fig. 2):

– Customers,
– Retailers,
– Wholesalers / distributors,
– Manufactures,
– Component / raw material suppliers[5].

A structure of particular supply chains is given by industrial branch character (e.g. automotive, food or pharmaceutical industry). They are usually consisted by hundreds or thousands of companies and institutions which are connected through huge material, information and financial flows.

[5] Ibid.

Supply chains are crucial networks or links that connect all inputs and outputs of all organizations within the scope of concerned industrial branches. Traditional challenges have included lowering costs, ensuring just-in-time deliveries, and shrinking transportation times to allow better reaction to business challenges and minimize negative impact of logistics activities on living environment.

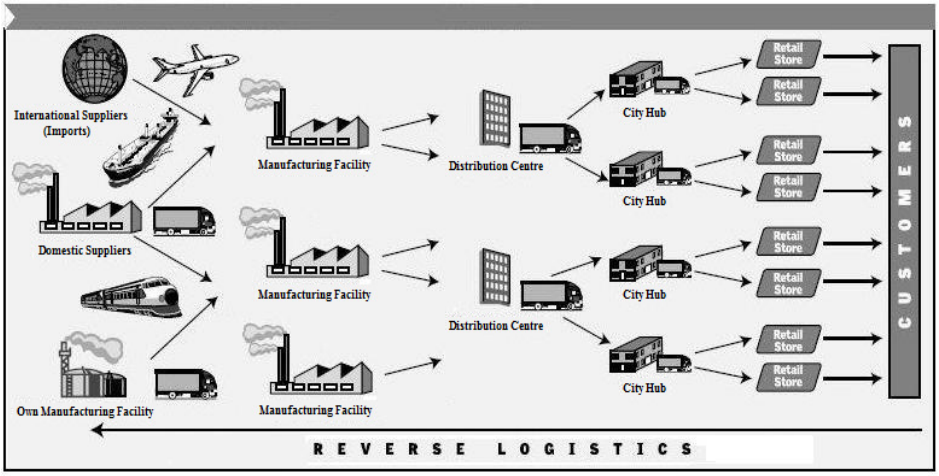

Fig. 2. General Illustration of Supply Chain

Source: http://www.thehindubusinessline.in/bline/2007/03/12/stories/2007031201160600.htm (07.08.2011).

Supply chain management

Supply chain management (SCM) involves the management of huge flows between and among stages in a supply chain to maximize total profitability[6].

SCM is the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders, see figure 3.

Thousands of activities are performed and coordinated within a company, and every company is by nature in some way involved in supply chain relationships with other companies. Successful supply chain management requires integrating business processes with key members of the supply chain. Valuable resources are wasted when supply chains are not integrated, appropriately streamlined, and managed. The value of having standard business processes

[6] S. Chopra, P. Meindl: *Supply Chain Management – Strategy, Planning and Operation*. 1st Edition, Prentice Hall, Inc., New Jersey 2001. 5-2.

in place is that managers from different organizations in the supply chain can use a common language and can link-up their firms' processes with other members of the supply chain, as appropriate[7].

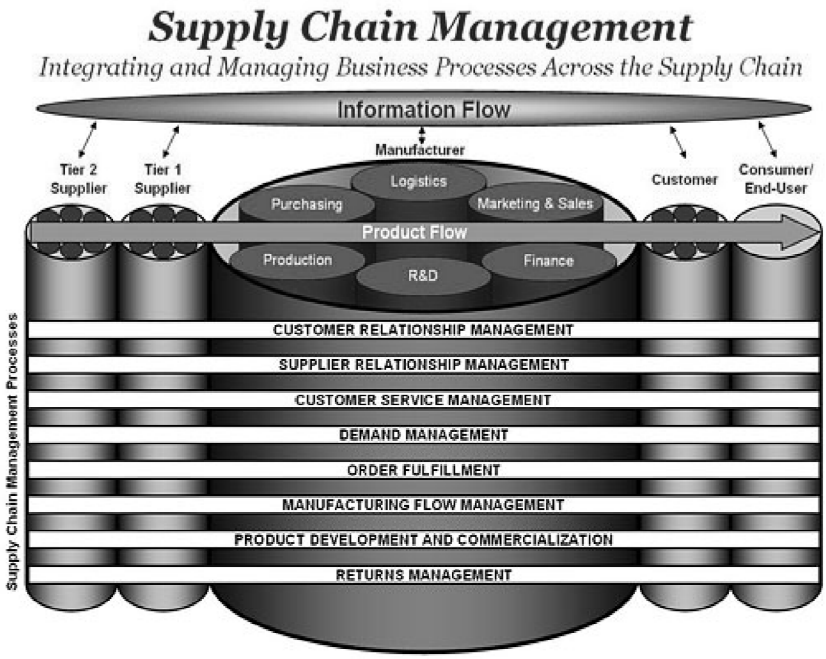

Fig. 3. General Illustration of SCM

Source: http://scm-institute.org/Our-Relationship-Based-Business-Model.htm (22.07.2011).

Supply chain management co-ordinates flows of information and product through integrated logistical networks. In today's marketplace efficiency, cost--effectiveness, appropriate customer service, and sustainability unlock profitability and competitive advantage. Every enterprise has its unique characteristics and dynamics. In a rapidly shrinking world, many logistical issues now have an international dimension. Selecting the right supply chain options is an increasingly complex task[8].

With increased globalization and offshore sourcing, global supply chain management is becoming an important issue for many businesses. Like traditional, supply chain management, the underlying factors behind the trend are reducing the costs of procurement and decreasing the risks related to purchasing

[7] www.scm-institute.org/Our-Relationship-Based-Business-Model.htm, (22.07.2011).
[8] www.supplychaineurope.com/ (22.07.2011).

activities. The big difference is that global supply chain management involves a company's worldwide interests and suppliers rather than simply a local or national orientation[9].

Because global supply chain management usually involves a plethora of countries, it also usually comes with a plethora of new difficulties that need to be dealt with appropriately. One that companies need to consider is the overall costs. While local labor costs may be significantly lower, companies must also focus on the costs of space, tariffs, and other expenses related to doing business overseas. Additionally, companies need to factor in the exchange rate. Obviously, companies must do their research and give serious consideration to all of these different elements as part of their global supply management approach.

Another big issue that should be addressed when dealing with global supply chain management is time. The productivity of the overseas employees and the extended shipping times can either positively or negatively affect the company's lead time, but either way these times need to be figured into the overall procurement plan. Other factors can also come into play here as well. For example, the weather conditions on one side of the world often vary greatly from those on the other and can impact production and shipping dramatically. Also, customs clearance time and other governmental red tape can add further delays that need to be planned for and figured into the big picture[10].

Global supply chain trends 2010-2012

The global economic crisis of 2008 and 2009 provided significant disruptions and high demand volatility in supply chains for companies across many industries. In a number of sectors, demand and supply almost came to a halt, forcing companies to enact short-term measures to tightly manage inventories, costs, and cash flow.

Compare this with early 2010. As the global economy continues to recover, most of the companies surveyed now believe there will be a significant upturn in demand from their customer base as well as a significant increase in company profitability over the next few years.

However, this widespread optimism may be premature. Our findings indicate that many companies lack the capabilities critical for meeting growing demand or for managing an increasingly complex and global supply chain. Driven by short-term exigencies, many companies did not strengthen critical

[9] www.epiqtech.com/supply_chain-Global-Management.htm (22.07.2011).
[10] Ibid.

capabilities during the recession. Only a small percentage truly improved supply chain flexibility and processes needed both to capture an increase in demand and to better manage high volatility. The degree to which companies can capture benefit from an eventual upturn will depend largely on how they deal with five key supply chain challenges or trends, see table 2.

Table 2

Current Main Trends of The Global Supply Chains

Global Supply Chain Trends				
Trend 1	Trend 2	Trend 3	Trend 4	Trend 5
Supply chain volatility and uncertainty have permanently increased	Security growth requires truly global customer and supplier network	Market dynamics demand regional, cost-optimized supply chain configurations	Risk management involves the end-to-end supply chain	Existing supply chain organizations are not truly integrated and empowered

Source: *An Annual Survey by PRTM Management Consultants, Global Supply Chain Trends 2010-2012*, http://www.supply-chain.org (22.07.2011).

Constantly Increasing Supply Chain Volatility and Uncertainty

Market transparency and greater price sensitivity have led to lower customer loyalty. Product commoditization reduces true differentiation in the consumer and business-to-business (B2B) environments.

Global Customer and Supplier Networks

Future market growth depends on international customers and customized products. Increased supply chain globalization and complexity need to be managed effectively. For that purpose is crucial to use sophisticated management tools, techniques and simultaneously to do research in the way of effective supply chain flow management.

Cost-Optimized Supply Chain Configurations

Customer requirements and competitors necessitate regionally tailored supply chains and product offerings. End-to-end supply chain cost optimization will be critical.

Risk Management

Risk and opportunity management should span the entire supply chain from demand planning to expansion of manufacturing capacity and should include the supply chains of key partners.

Integration and Empowering

The supply chain organization needs to be treated as a single integrated organization. In order to be effective, significant improvements require support across all supply chain functions[11].

World's freight traffic

Current world is characterized by total globalization trend which is the most typical for international trade and particular industries. There are plenty of different supply chains containing huge flows necessary to plan and manage. Almost each industry has got its own supply chain whose flows must be managed to be cost-effective and eco-friendly. As a result of the globalization trend is that the all supply chains are getting more and more complex and require more sophisticated methods and approaches to plan and manage their huge flows. For better illustration, please see figure 4, to see increasing trend of world's freight traffic 2000-2010.

It's evident positive trend of huge goods and material flow volume in the world during past 10 years. All huge flows within the scope of particular supply chains carried whether by ship, railway, road or air should be managed more precisely as a consequence of more complex global supply chains in current world's economy[12].

Logistics is a science having well-developed methods and approaches to plan, manage and control those flows and it's still developing new methodologies as a result of more complex and huge flows inside global supply chains[13].

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[11] *An Annual Survey by PRTM Management Consultants, Global Supply Chain Trends 2010-2012*, www.supply-chain.org (22.07.2011).

[12] M. Hart: Op. cit.

[13] Ibid.

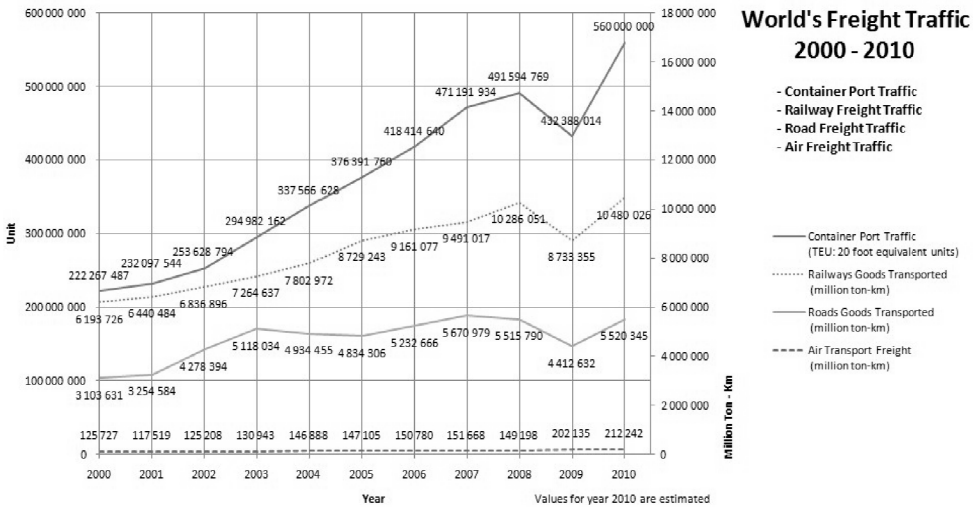

Fig. 4. World's Freight Traffic Volume in Past Decade 2000-2010

Source: Encyclopedia of the Nations, www.nationsencyclopedia.com/ (08.08.2011); M. Hart: *Logistics and Its Indisputably Growing Importance in Current Global World's Economy*. Carpathian Logistics Congress, High Tatras, Slovak Republic, September 2011, pp. 197-206 (27.11.2011).

That all should lead to enhance a level of interested industrial branches concerning flow management and as a result of the logistics management concept should be long – term enhancement of GDP whether single country GDP or total world's GDP. Well, it's evident that the analytical and systematic approach using logistics science methods and methodologies to manage all huge flows inside the great numbers of supply chains is crucial to be cost – effective and living environment – friendly in today's global economy. As a main result of systematic global logistics management should be a long – term increasing of single country GDP thereby also a long – term increasing of world's GDP[14].

Freight is generated by economic activity and the freight industry tenis to respond to fluctuations in this activity and the resultant level of trade among nations. Trends in global economic activities directly affect the volume of merchandise trade and worldwide movement of freight. The growing reliance on global supply chains means the effect of an economic downturn is not limited to exporting and importing nations. Other nations that provide freight and port services to transport traded goods are also affected.

[14] Ibid.

To move large quantities of goods across the countries and around the world, the world's economy depends on the global international freight transportation systems – a vast network of roads, bridges, rail tracks, airports, seaports, navigable waterways, pipelines, and equipment.

For example, today's U.S. households can buy fresh fruits and vegetables in mid-winter, expect fast and reliable next-day deliveries of Internet purchases, and use electronic appliances manufactured thousands of miles away, often in other countries. Because economic activities worldwide have become more integrated and globalized, more goods produced by U.S. factories and farms are bound for export, and imports originate from more than 200 countries. This pace of trade Americans have become accustomed to is made possible by the complex intermodal transportation network that blankets the country and links the United States with world markets.

The movement of international freight among nations relies on a complex array of long-distance transportation services. The process involves many participants, including shippers, commercial for-hire carriers, third-party logistics providers, and consignees. Moreover, global trade depends on seaport and airport services to move large volumes of merchandise over long distances via a variety of transportation modes. The interaction of these services and participants is vital to successful global trade[15].

Businesses rely on all freight modes to transport international merchandise trade. Often, goods are moved by a multimodal combination of airplanes, maritime vessels, trains, and trucks.

Seaports and airports are vital components of the freight system. They enable global trade and facilitate international economic activities[16].

Shipping lines, airlines, all-cargo air couriers, trucking firms, and railroads provide services that link shippers, ports, and consignees, all is a part with its own important within the scope of global supply chains. Managing product supply chains and transporting goods globally involves considerable interaction across the carrier industry. During the past decade, businesses expanded sourcing of raw materials and finished goods from multiple locations around the world, and the air and ocean freight carrier industries that provide overseas services adapted their freight operations in response. Globally, the leading all--cargo air carriers include FedEx, UPS, DHL, and TNT. Leading airlines that provide cargo services include Lufthansa, Korean Air Lines, Singapore Airlines, British

[15] U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, *Freight Transportation: Global Highlights 2010*, Washington, DC 2010 (27.11.2011).

[16] Ibid.

Airways, and Air France. The air-freight carrier industry continued its heavy reliance on hub-and-spoke operations that allow carriers to connect several origins with multiple destinations without having all the points connected directly.

Expanded use of hub networks allowed the airlines to control fleet size and capacity while serving many markets. It also allowed them to cut operating costs and offer improved integrated cargo delivery services.

Worldwide, the leading ocean container carriers include APM-Maersk Line, Mediterranean Shipping Company, CMA CGM, Evergreen Line, and American President Lines (APL). During the past decade, the ocean-shipping industry continued consolidations begun in the 1990s. Carriers engaged in vessel-sharing arrangements that allowed them to serve multiple ports by connecting to larger hub seaports. These hub ports provide feeder vessel services to smaller ports and often use intermodal rail and truck carriers for deliveries to final destinations. Some of the major inter-carrier alliances, mergers, and acquisitions include Maersk and Sea-Land, Neptune Orient Line and APL, and Maersk and P&O Nedlloyd[17].

Conclusion

The issues regarding supply chain management and logistics are getting more and more important in context of international trade growing positive trend and totally global world's market. To be engaged in classical and newly developing logistics methods to plan, manage, optimize and control all huge flows across global supply chains is getting to be necessary to be cost effective, competitive and eco-friendly in long – term time period of sustainable growth.

There are dynamic industry-wide changes that continue to influence and shape the global freight industry as worldwide international trade is transformed by the global economy.

The principal forces that are likely to affect future international merchandise trade and freight movements include the following:

- changes in reliance on imported consumer products,
- China's expanded role in the world economy and global trade,
- fluctuations in fuel prices and transportation costs,
- environmental concerns, and
- a rise in Internet shopping and on-demand deliveries[18].

[17] Ibid.
[18] Ibid.

These global forces and the pace of reliance on imported consumer products may affect the movement of freight from, to, and within the particular countries.

Changes in the global economic situation as well as trade between nations will continue to affect the choices of transportation modes used in transporting traded goods around the world and in the particular countries. Resumption of growth in worldwide merchandise trade is likely to create more demand for intermodal freight services. Continued integration of global economic activities and resumption of growth in ocean-borne and air cargo would increase demand for freight transportation services.

Global economic activities will continue to shape where and how goods are produced and distributed. Expanded trade among countries will ultimately affect the movement of freight internationally as well as into and out of the particular countries. Fuel costs, changes in logistics supply chains, out-sourcing, just-in--time inventory management systems, and online shopping could impact the demand for freight transportation[19].

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[19] Ibid.

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19. U.S. Department of Transportation, Research and Innovative Technology Administration, Bureau of Transportation Statistics, *Freight Transportation: Global Highlights, 2010*. Washington, DC 2010.
20. Waters D.: *Global Logistics & Distribution Planning.* 3rd Edition, Kogan Page, 2000.
21. Waters D.: *Global Logistics: New Directions in Supply Chain Management*. 6th Edition, Kogan Page, 2010.
22. www.epiqtech.com
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PROBLEMS OF TRANSPORTATION PROCESS RELIABILITY MODELLING

Introduction

Generally speaking a transportation system is a system in which material objects are moved in time and space. Thus, the function of transportation is to realize the movement of persons and goods from one place to another by safety and efficient way with minimum negative impact on the environment[1]. Thus, identification of transportation system needs knowledge in three major areas:

- identification of components of the system,
- identification of activities involved in putting the transportation system in place, from planning to operation and maintenance,
- identification of issues that may not be included in the transportation decision-making processes, although they may be affected by the decisions.

The transportation system is a very complex one with different functional characteristics depending on medium of movement, the particular technology used and demand for movement in the particular medium. Aspects of the modes are[2]:

- vehicle – each mode has particular vehicle that provide carriage and flow (also non-motorized like walking or bicycle),
- the way – each mode has what is called a road, guide way, right of way etc.,
- control – two form of control are usually present in transportation:
  - control of the system,
  - control of the vehicle,
- the technology of motion – each mode uses a specific technology to facilitate the movement of the vehicle in its way,
- the technology of power – each mode has a particular type of engine designed to provide the most efficient power source for that mode,

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[1] J.D. Fricker, R.K. Whitford: *Fundamentals of Transportation Engineering. A Multimodal Systems Approach*. Pearson Education, Inc. Upper Saddle River, New Jersey, USA, 2004.

[2] *Handbook of transportation engineering.* Ed. by M. Kutz. McGraw-Hill Companies, Inc., 2004.

– intermodal transfer points – points of connectivity between modes or within a mode,
– payload – something must be transported; either passengers and/or freight,
– drivers and pilots – the requirements to be placed on a vehicle operator must be a part of the designed process for a transportation system.

Each particular mode of transport has a set of specific functional and operational characteristics. The list of transportation system performance measures is very wide depending on the analysis user. To the most often estimated factors belong[3]:
– availability or operational readiness,
– reliability,
– safety.

Reliability theory and transportation modelling problems has gained much interest in recent times (see fig. 1 and 2). Although, there is a quite clearly set system of terms concerning transportation, it is necessary to define some of terms to have a unique basis of approach.

Issues for reliability relates to ability to meet its overall mobility requirements while meeting the social, health, economic and access goals of the community, i.e.: mobility/accessibility (also accessibility for handicapped persons), equity (effect on poor and underrepresented groups of people), government regulations, international trade, transportation labour, the politics of oil, environmental factors, driver behaviour, safety and security[4].

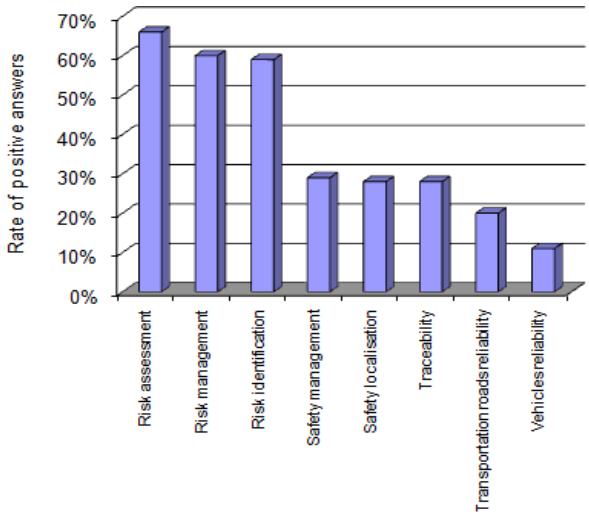

Fig. 1. The most important aspects of transport/logistic process

Source: F. Straube, H.-Chr. Pfohl: *Trends und Strategien in der Logistik – Globale Netzwerke im Wandel*. DVV Media Group GmbH/Deutscher Verkehrs-Verlag, Hamburg 2008.

[3] Ibid.

[4] J.D. Fricker, R.K. Whitford: *Fundamentals of Transportation Engineering. A Multimodal Systems Approach*. Pearson Education, Inc. Upper Saddle River, New Jersey, USA, 2004.

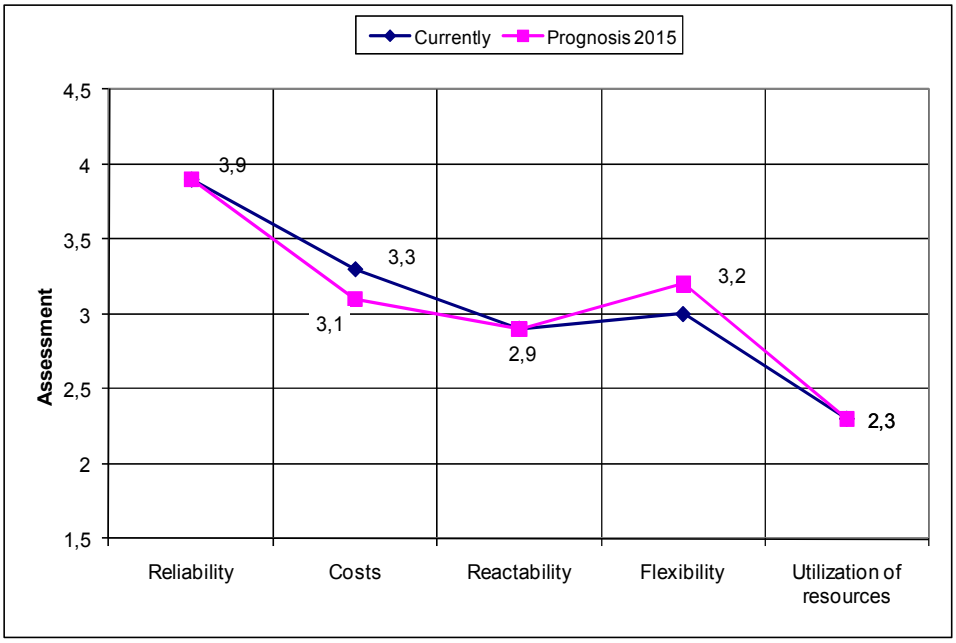

Fig. 2. The most important features of logistic process (industry)

Source: Ibid.

Modelling the transportation system is focused on identification of a structure and characteristics of structure elements, while the concept of movement is related to conveyance units travelling through a transportation system, and referred to as cargo flows through transportation system elements[5]. The model of transportation system TS is defined as an ordered four[6]:

$$TS = \langle G, F, P, O \rangle \tag{1}$$

where:

G – transportation system structure graph,
F – set of functions defined over TS elements,
P – volume of transportation tasks/cargo or persons flow,
O – TS organization.

[5] T. Ambroziak, D. Pyza: *Selected aspects of transportation system modelling*. "Total Logistic Management" 2008, Vol. 1.

[6] M. Jacyna: *Modelling and appraisal of transportation systems (in Polish)*. Publication House of Warsaw Technical University of Technology, Warsaw 2009.

If it is required to define some quantitative characteristics (also reliability) of the TS it is useful to redefine the system concept[7]:

$$TS = \langle G, F_I, F_U \rangle \tag{2}$$

where:

G – is a graph given by formula (1) and,
$F_I = \{f_1, f_2, \ldots, f_n, \ldots, f_N\}$ is a set of functions defined on the set I (set of vertices of the graph G):

$$f_n : I \rightarrow R^+, \tag{3}$$

$f_n(i) \in R^+$, $n = 1, 2, ..., N$

$F_U = \{g_1, g_2, ..., g_k, ..., g_K\}$ is a set of functions defined on the set U (set of edges of the graph G):

$$g_k : I \times I \rightarrow R^+, \tag{4}$$

$g_k(i, j) \in R^+$, $k = 1, 2, ..., K$

and the quantities $f_n(i)$ and $g_k(i, j)$ have some defined interpretation (technical, economical or mathematical, i. e. probability of transition).

Modeling reliability of transportation process

Passenger transportation process realised by transportation system – is a complex process concerning a set of activities allowing the transportation task. Thus, transportation is an activity with tree actions and three elements involved (see fig. 3).

Reliability of passenger transportation system depends both on its configuration and on the way it is managed during the design phase and in operation. As a result, reliability modelling process of transport system performance needs recognizing and analyzing the existence of various problems connected with[8]:

- possible vehicle unreliability (failure rate, maintenance tasks optimization),
- infrastructure unreliability (failures of rail or power),
- random accidents occurrence,
- dispatcher wrong decisions.

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[7] T. Ambroziak, D. Pyza: *Selected aspects of transportation system modelling*. "Total Logistic Management" 2008, Vol. 1.

[8] A. Jodejko, B. Molecki: *Methods of number of redundancies determination in the example of tram network* (in Polish). "City and Regional Transportation" 2008, No. 1; S. Werbińska: *Model of logistic support for exploitation system of means of transport*. PhD Thesis, Technical University of Wroclaw, Poland, report: PRE 3/2008.

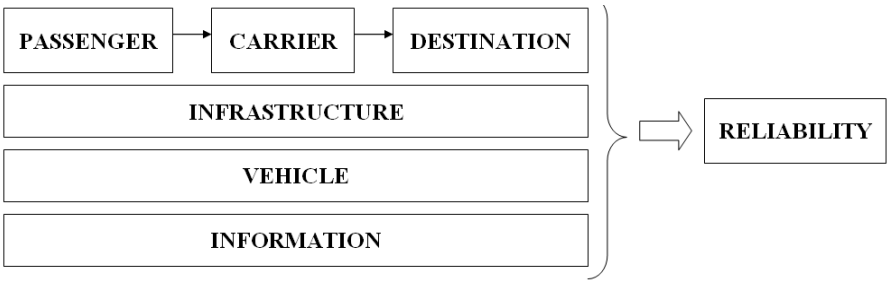

Fig. 3. Passenger transportation process model

Source: M. Mlynczak, T. Nowakowski, F. Restel, S. Werbińska-Wojciechowska: *Problems of reliability analysis of passenger transportation process.* Proceedings of the European Safety and Reliability Conference 2011. A.A.Balkema, Leiden.

All of these problems can affect transportation process performance. As a result, transportation process reliability refers to "ability that the system operates as planned during the planning horizon. The term transportation process reliability is used to express the probability of a transportation system to complete fulfil the passenger demand of transportation service without any unwanted events occurrence, resulting from failures of vehicles, infrastructure or other transportation facilities"[9]. Lack of attention to the recognition phase at the system design stage can result in developing the wrong transportation solutions e.g. from the passenger point of view.

Managers have to face the problem: how to define the transportation system reliability level and how to investigate and increase it for a system in operating. This is typically concerned with questions such as:

– How often should a vehicle be serviced and when should it be replaced?
– Is a system structure safe?
– What is the gain derived from maintenance effort in terms of components/ system downtime and operating costs?
– Is the transportation delay acceptable?

The target and objective of much of the known modelling work in this research area is to assist management by prediction the consequences of alternative sets of decision variables available to them. However, the problem of reliability level maintenance is strictly connected with definition of performance criteria[10].

[9] T. Nowakowski, S. Werbińska: *On problems of multicomponent system maintenance modelling*. "International Journal of Automation and Computing" 2004, Vol. 6, No. 4, pp. 364-378.

[10] *Reliability and Maintenance of Complex Systems*. Ed. S. Ozekici. NATO ASI Series/Computer and Systems Sciences, Springer, Berlin 1996.

First problem of vehicle reliability and maintainability analysis has been extensively researched for many decades[11]. The main maintenance tasks for a transportation company are to keep vehicles in an acceptable operating condition by regular servicing and, as necessary, repairing. This task must be carried out in an effective and efficient manner measured usually in terms of such performance criteria as[12]:

– maintenance cost,
– safety level,
– rate of breakdown during/on the road,
– vehicle downtime,
– availability,
– service levels to the passengers.

Commonly used analytical techniques for reliability evaluation in this area are applied probability theory, renewal reward processes, Markov decision theory, and Fault Trees. Each of these techniques has advantages and disadvantages and the choice depends on the system being modelled.

All of them require simplifying assumptions about time to failure behaviour of the system components. Moreover, Markov method analyses the system by identifying all the different states in which the system can reside and is able to produce accurate system reliability measures by assigning rates of transition between these states. However, the Markov method has its own drawbacks in its application for a relatively large system to establish the state transition model is an intractable task.

But, the real problem is how to measure the reliability of transportation system infrastructure? This task is strictly connected with definition of possible hazard events for chosen system and its measurable terms (e.g. number of hazard events per 1 km of road). Unfortunately, little attention has been given to this problem in reliability literature.

Usually reliability of transportation infrastructure has been investigated as one of the criterion of infrastructure investment decisions and transport policies assessment[13] or multi-national transport infrastructure projects performance[14]. Moreover, there can also be found models of transportation infra-

[11] See e.g. T. Nowakowski, S. Werbińska: Op. cit.

[12] S. Werbińska: *Model of logistic support for exploitation system of means of transport*. PhD Thesis, Technical University of Wroclaw, Poland, report: PRE 3/2008.

[13] See e.g. O. Alvarez, P. Cantos, L. Garcia: *The value of time and transport policies in a parallel road network*. "Transport Policy" 2007, No. 14, pp. 366-376.

[14] T. Nowakowski, M. Zając: *Analysis of reliability model of combined transportation system*. Advances in safety and reliability. Proceedings of the European Safety and Reliability Conference 2005. A.A.Balkema, Leiden.

structure management refer o maintenance optimization for transportation infrastructure facilities[15]. There also must be specified company design performance criteria. Usually companies are interested in definition of total costs of operation the system during the chosen time. However, from the passenger point of view – reliability of transportation system is perceived in terms of delay occurrence (travel time reliability). As a result, the possible performance criteria can be:

– effectiveness of transportation process,
– operational costs,
– system/process availability,
– delay time.

In the literature, there can be found lots of travel time reliability models in passenger transport. The review of recent travel time reliability models can be found in[16], where travel time reliability is studied in terms of measuring the variability in travel times over repeated journeys.

The last problem regards to transportation system configuration. One of the most common techniques to improve reliability is to add redundancies. For a system in parallel (tram and bus systems operating together) only one must be in operational state at a specified time. However, the redundant system can be very costly. Also, there is a significant problem how to design and model such a dynamic multistate system of systems[17].

Following this, reliability of passenger transportation process is shown in the function:

$$R_{TP}(t) = f(Q, A, T, C) \tag{5}$$

where:

Q – quality of process, no damage,
A – availability of a transportation system,
T – time of transportation process realization,
C – total cost of transportation.

[15] P.L. Durango-Cohen: *A time series analysis framework for transportation infrastructure management*. "Transportation Research Part B" 2007, No. 41, pp. 493-505.

[16] L. Zheng, D.A. Hensher, J.M. Rose: *Willingness of pay for travel time reliability in passenger transport: A review and some new empirical evidence*. „Transportation Research Part E" 2010, No. 46, pp. 384-403.

[17] S. Werbińska: *Model of logistic support for exploitation system of means of transport*. PhD Thesis, Technical University of Wroclaw, Poland, report: PRE 3/2008.

Data sources in reliability and safety analysis

Reliability analysis and assessment of transportation system require empirical data acquired or intentionally collected from real operational system[18]. In reliability concept the main role takes failure as an undesired event and depends on maintainability time to restore as bringing object to the state of readiness. More detailed analysis requires also description of failure mode, cause, consequence and way of repair.

Statistical assessment of variables which describe failure are essential in this procedure and is based on data processing directed on average value, standard deviation, probability distribution and statistical tests parametric as well as non parametric. That complex process requires collecting credible data of sufficient size.

Safety of transportation system involves several concepts that are necessary to consider in analysis and assessment of the system. In this approach, due to passenger transportation system, it is recognized[19]:

- hazard – possibility of developing an undesired event,
- undesired event – not completing transportation task or delay greater than acceptable by a single passenger, any charm influencing passenger health or life,
- risk – possibility of running a hazard expressed by frequency of undesired event over given period or travelled distance multiplied by amount of losses.

Measures of undesired event relate to[20]:

- measure of possibility – frequency over given time of developing an undesired event,
- measure of losses – mean number of fatalities regarding to undesired event, degree of disability, time of delay, monetary equivalent for lost time or delay or equivalence of not gained profit because of not completed journey.

In the approach described in the paper the following variables are expected to collect[21]:

- date and time of an event, mileage, number of cycles, total transported goods since the previous event, etc.,
- place of an event, terrain topography,
- elements of transportation system and infrastructure taking part in the event, relations to other transportation systems,

[18] M. Mlynczak, T. Nowakowski, F. Restel, S. Werbińska-Wojciechowska: *Problems of reliability analysis of passenger transportation process.* Proceedings of the European Safety and Reliability Conference 2011. A.A.Balkema, Leiden.
[19] Ibid.
[20] Ibid.
[21] Ibid.

- number of casualties other losses (fatality, injuries, number of people delayed),
- duration of disturbances for traffic: direct (closing a road), indirect (detour),
- event consequences, loss of properties, loss of transportation mean, loss of technical infrastructure and environment,
- event cause,
- way of repair, clear away consequences.

Reliability and safety data concerning regional or national transportation system may be obtained at various levels of management. The highest level of administration provides general assessment of safety in form of reports or statements usually issued yearly. According to road transportation there are several data sources, though data are processed and concerns statistical image of the process.

Reports issued by Polish Police are ordered in months and years, concerns state regions, road users, distribution of accidents due to time, terrain, cause, consequence and severity (victims). The national program concerning life protection of road users GAMBIT exists since 2001 and after first phase GAMBIT 2000 it was introduced second phase GAMBIT 2005 with main target as decreasing in half number of victims until 2010. Program GAMBIT is operated by State Board of Road Safety. This institution also announces annual and half--yearly reports covering cross sectional analysis of accidents and actions undertaken on road safety improvement.

Web service of GDDKiA (General Headquarters of Polish Roads and Highways) provides information about local traffic restrictions and disturbances, like road building and rebuilding or road and infrastructure failures.

State Fire Service collects data concerning all rescue actions involving fire brigades. Data are collected in form of very precise data base. Application of these data to reliability and safety assessment is possible after processing and being restricted to events developed in transportation system.

President of Rail Transportation Office announces, according to Directive 2004/49/WE of European Parliament, annual report on rail transportation safety based on information delivered by regional managers of rail infrastructure and rail transportation operators. Reports contain general information about rail infrastructure and statistical data of accidents.

It is very difficult to achieve description of single accident to perform investigation directed on cause-consequence analysis that is valuable in reliability and safety approach. In many cases data are fragmentary and do not provide important variables. Value of data is continuously improved but unfortunately very often still not credible due to reorganization and bad quality of informatics' system regarding data exchange[22].

[22] Ibid.

Multi-phased system reliability model

Multi-phased system

There are many systems whose operating life consists of a series of separate time intervals. In each of those intervals, the system carries out different tasks, the results of which contribute to the achievement of the final goal. Such systems are referred to in the literature[23] as phased mission systems (PMS). Examples of such systems, beside transportation and logistics systems, can be found in many areas of application such as the nuclear power industry, aviation, shipbuilding, the telecommunications industry, the construction industry, electronics, and many others.

Because the concept of periodic execution of tasks by such complex systems as a transportation or a logistic system is related to a much wider set of systems than suggested by the concept of mission, the term multiple-phased systems was proposed in *Dependability Modeling and Evaluation of Multiple--Phased Systems Using DEEM*[24].

In multiple-phased system, the individual phases may be characterized by many different properties[25]:

- a task executed in a given phase may differ from the tasks executed in the remaining phases,
- the requirements regarding performance and reliability may differ among phases,
- during some of the phases, the system may be subjected to a particularly strong influence of the environment, which may cause a considerable increase in failure rate,
- the structure of a system may change over time depending on the functional and reliability requirements formulated for the currently executed phase,
- proper execution of tasks within a given phase may bring other effects for the system than those obtained in other phases.

Reliability model

In system reliability modelling, the use of the concept of a multi-phased system allows better approximation of reality on account of the following assumptions:

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[23] See e.g. A. Bondavalli, S. Chiaradonna, F. Di Giandomenico, I. Mura: *Dependability Modeling and Evaluation of Multiple-Phased Systems Using DEEM*. "IEEE Transactions on Reliability" 2004, No. 53, 4.

[24] Ibid.

[25] Ibid.

– a system's operational structure is not constant; it may change between phases depending on the importance/criticality of a given phase,
– the history of failures or repairs of a given component in a given phase affects the behavior of the system in the following phase. Hence, the state of a component at the beginning of a given phase depends on the state of the component at the end of the previous phase.
– the criteria defining the level to which the requirements related to performance and reliability are met may differ in a given phase from those for the next phase.

These assumptions are used in various ways in the models known from the literature. There are two types of models: synthetic models, which cover a system's entire operating life and models in which the particular phases are considered separately.

Synthetic models, in which all phases are represented together[26], have a number of advantages as they make it possible to use similarities among phases to obtain a compact model in which all phases are adequately embedded. The construction of a synthetic model like that may be neither easy nor convenient in the cases where differences outweigh the similarities among the individual phases.

Separate modelling of each phase[27], in turn, enables immediate characterization of the differences among phases with respect to failure rate and structural requirements. Each phase can be solved separately, and the results obtained can be combined with those from other phases to give total results for the system. The main weakness of the separating approach to modelling (which does not occur in synthetic models) is how it deals with the relationships among phases, which have to be taken into account when distributing components among the phases. Such an approach requires clearly specified mapping of the states of a component at the end of a phase relative to the state of the same component at the beginning of a following phase. A task of this sort is conceptually simple, but may be inconvenient and is a potential source of errors for complex systems.

The most difficult decision in the process of modelling regards the way in which the individual phases are combined into a single model and the way in which the reliability characteristics of the entire system are estimated.

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[26] E.g. M. Alam, U.M. Al-Saggaf: *Quantitative reliability evaluation of repairable phased-mission systems using Markov approach*. "IEEE Transactions Reliability" 1986, No. 35, pp. 498-503; B.E. Aupperle et al.: *Evaluation of fault-tolerant systems with non-homogeneous workloads*. 19th IEEE Int. Fault Tolerant Computing Symp 1989; J.B. Dugan: *Automated Analysis of Phased-Mission Reliability*. "IEEE Transactions on Reliability" 1991, No. 40, 1; M. Smotherman, K. Zemoudeh: *A nonhomogeneuous Markov model for phased-mission reliability analysis*. "IEEE Transactions Reliability" 1989, No. 38, pp. 585-590.

[27] E.g. J.D. Esary, H. Ziehms: *Reliability analysis of phased missions*. "Reliability and Fault Tree Analysis". SIAM, Philadelphia 1975; M. Smotherman, K. Zemoudeh: *A nonhomogeneuous Markov model for phased-mission reliability analysis*. "IEEE Transactions Reliability" 1989, No. 38, pp. 585-590.

An analysis[28] was conducted for an example system described by the following assumptions:

- a system made up of three components (A, B and C),
- during its operating life, the system goes through 3 successive phases (I, II and III),
- the failure rates for the individual components are constant over the time of duration of a given operational phase, but may differ among the individual phases (λij, i = A, B, C, j = I, II, III),
- the components can be serviced or repaired; the failure rate in the particular phases is constant, but may also change in successive operational phases (μij, i = A, B, C, j = I, II, III),
- the system's reliability structure is a "k-out-of-n" threshold structure; the parameter k is phase-dependent and is kI = 1, kII = 2, kIII = 3, at n = 3.

A Markov model – fixed phase duration

The Markov model may turn out to be an effective tool for reliability analysis of complex systems which show variable behaviour during execution of a task, such as, for example:

- varying transition probabilities between phases, or
- a limited number of maintenance kits.

In the proposed modelling strategy[29], each phase of operation of a multi-phased system is modelled with a separate Markov model. It is assumed that the final reliability state of a system in phase j is the initial state for phase $j + 1$. A process diagram is shown in Fig. 4.

In phase I, executed over time T1, working states include, among others, states (111), (101), (110) and (011), and transition to phase II, to analogous working states is possible. States (100), (010) and (001), in turn, will be failed states in phase II, and the final probabilities of being in these states will add up to give the probability of system failure. Obviously, a system may also fail in phase I – state (000). For phase III, only the state in which all components are working (111) is a working state.

Inconveniences of this method of modelling the reliability of multi-phased systems are connected with the difficulties in relating the corresponding states of the system among the individual phases. Other complications arise if a given

[28] T. Nowakowski: *Reliability of logistics systems* (in Polish). Wroclaw University of Technology Publishing House, Wrocław 2011.
[29] Ibid.

component is subject to failure in one phase but does not fail in another or when failures in one phase are not diagnosable until the component is used in the subsequent phase.

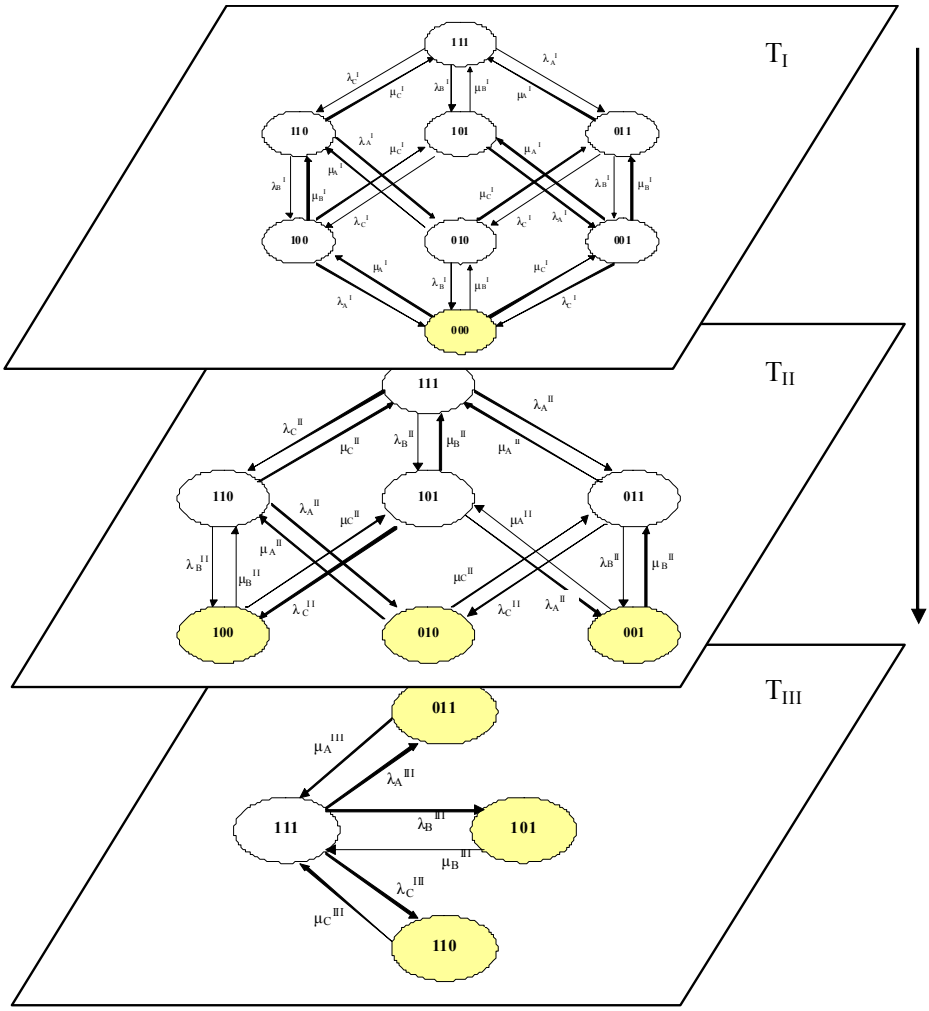

Fig. 4. A diagram of a reliability model with fixed phase duration

Source: T. Nowakowski: *Reliability of logistics systems (in Polish).* Wroclaw University of Technology Publishing House, Wroclaw 2011.

A synthetic model of the approach formulated earlier was proposed in [6]. The phase index φ_j was introduced:

$$\varphi_j = \begin{cases} 1 \text{ if } (T_{j-1} \le t < T_j) \\ 0 \text{ if } t < T_{j-1},\ t > T_j \end{cases} \tag{6}$$

where:

T_j – end-of-phase-*j* time point.

The φ_j index specifies which transition between states belongs to the given phase *j*. The use of this method does not change the state space of a system nor does it require determination of new probabilities for transitions between states. The obtained model is still a Markov model, but is no longer homogeneous – the values of transition probabilities depend on the operating time of a system. An example of such a model is shown in fig. 5. To simplify the diagram, only the components' failure rates were taken into account; the notation for repair rates is analogous. For each state number, the number of phase in which this state is a failed state has been given.

Reliability model of combined transport

The reliability model of CT system was built[30] using Markov process theory and multi-phased model that describes the changes of transportation means. The model is related to reliability states of the system. Five operation and maintenance (O&M) states are distinguished:

- S1 – standby,
- S2 – running,
- S3 – transshipment,
- S4 – preventive maintenance,
- S5 – repair.

On the basis of the defined set of states the graph of transportation system states is proposed – fig. 6. The graph describes behavior of vehicle in one of the phases of combined transportation process.

[30] T. Nowakowski: *Reliability model of combined transportation system. Probabilistic safety assessment and management*. Proceedings of the European Safety and Reliability Conference PSAM7-ESREL 2004. London [etc.], Springer.

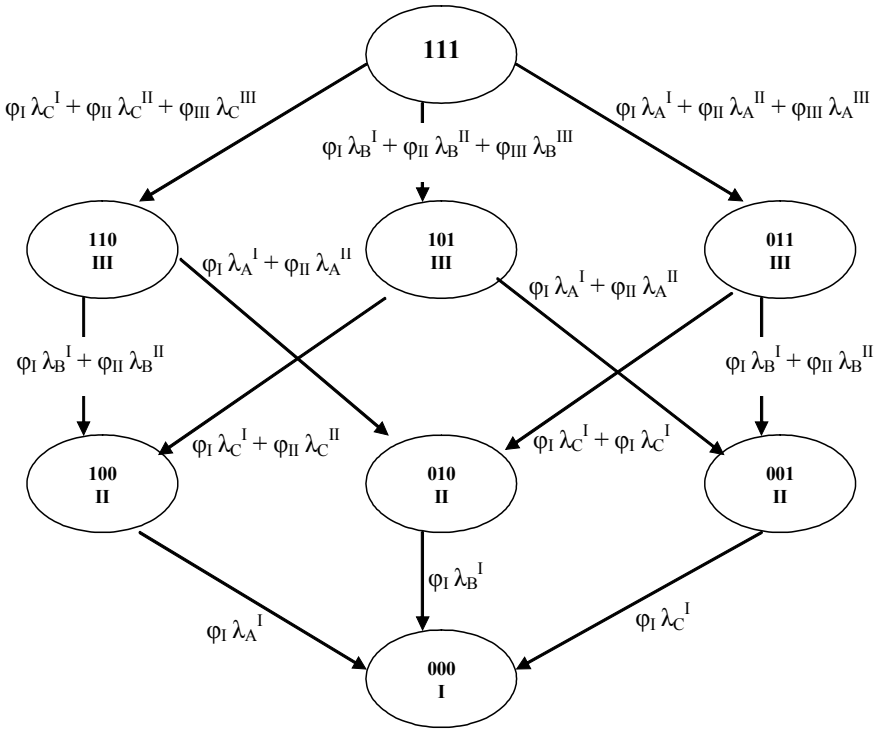

Fig. 5. A synthetic model of a sample multi-phased system

Source: Ibid.

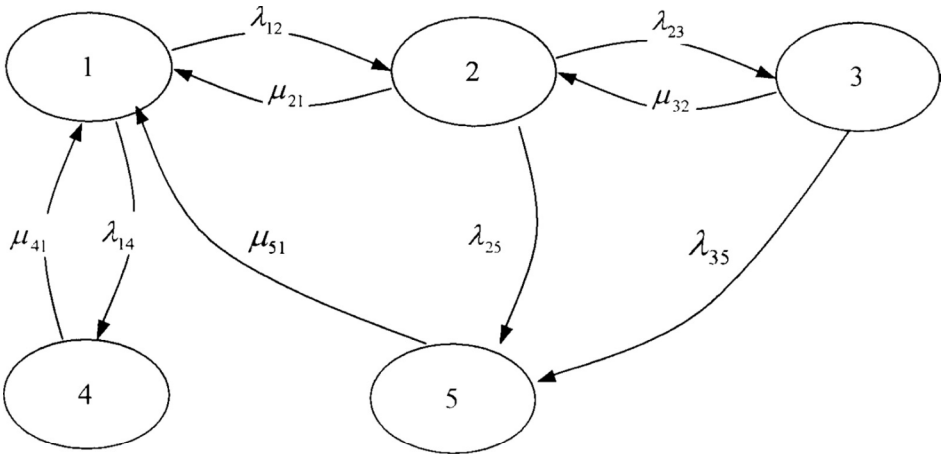

Fig. 6. Graph of the transportation system

Source: T. Nowakowski: *Reliability model of combined transportation system. Probabilistic safety assessment and management.* Proceedings of the European Safety and Reliability Conference PSAM7-ESREL 2004. London [etc.], Springer.

Thus, the model is described by the set of differential equations:

– at the first phase:

$$\begin{cases} P_1^1(t)' = -\left(\lambda_{12}^1 + \lambda_{14}^1\right)P_1^1(t) + \mu_{21}^1 P_2^1(t) + \mu_{14}^1 P_4^1(t) + \mu_{15}^1 P_5^1(t) \\ P_2^1(t)' = \lambda_{12}^1 P_1^1(t) - \left(\mu_{21}^1 + \lambda_{23}^1 + \lambda_{25}^1\right)P_2^1(t) + \mu_{32}^1 P_3^1(t) \\ P_3^1(t)' = \lambda_{23}^1 P_2^1(t) - \left(\mu_{32}^1 + \lambda_{35}^1\right)P_3^1(t) \\ P_4^1(t)' = \lambda_{41}^1 P_1^1(t) - \mu_{41}^1 P_4^1(t) \\ P_5^1(t)' = \lambda_{25}^1 P_2^1(t) + \lambda_{35}^1 P_3^1(t) - \mu_{51}^1 P_5^1(t) \end{cases}$$

$$for \qquad P_1^1(0) = 1, P_2^1(0) = 0, P_3^1(0) = 0, P_4^1(0) = 0, P_5^1(0) = 0$$

– at the second phase:

$$\begin{cases} P_1^2(t)' = -\left(\lambda_{12}^2 + \lambda_{14}^2\right)P_1^2(t) + \mu_{21}^2 P_2^2(t) + \mu_{14}^2 P_4^2(t) + \mu_{15}^2 P_5^2(t) \\ P_2^2(t)' = \lambda_{12}^2 P_1^2(t) - \left(\mu_{21}^2 + \lambda_{23}^2 + \lambda_{25}^2\right)P_2^2(t) + \mu_{32}^2 P_3^2(t) \\ P_3^2(t)' = \lambda_{23}^2 P_2^2(t) - \left(\mu_{32}^2 + \lambda_{35}^2\right)P_3^2(t) \\ P_4^2(t)' = \lambda_{41}^2 P_1^2(t) - \mu_{41}^2 P_4^2(t) \\ P_5^2(t)' = \lambda_{25}^2 P_2^2(t) + \lambda_{35}^2 P_3^2(t) - \mu_{51}^2 P_5^2(t) \end{cases}$$

$$for \qquad P_1^2(t_1) = P_1^1(t_1),\ P_2^2(t_1) = P_2^1(t_1),$$
$$P_3^2(t_1) = P_3^1(t_1),\ P_4^2(t_1) = P_4^1(t_1),\ P_5^2(t_1) = P_5^1(t_1)$$

– and at the third phase:

$$\begin{cases} P_1^3(t)' = -\left(\lambda_{12}^3 + \lambda_{14}^3\right)P_1^3(t) + \mu_{21}^3 P_2^3(t) + \mu_{14}^3 P_4^3(t) + \mu_{15}^3 P_5^3(t) \\ P_2^3(t)' = \lambda_{12}^3 P_1^3(t) - \left(\mu_{21}^3 + \lambda_{23}^3 + \lambda_{25}^3\right)P_2^3(t) + \mu_{32}^3 P_3^3(t) \\ P_3^3(t)' = \lambda_{23}^3 P_2^3(t) - \left(\mu_{32}^3 + \lambda_{35}^3\right)P_3^3(t) \\ P_4^3(t)' = \lambda_{41}^3 P_1^3(t) - \mu_{41}^3 P_4^3(t) \\ P_5^3(t)' = \lambda_{25}^3 P_2^3(t) + \lambda_{35}^3 P_3^3(t) - \mu_{51}^3 P_5^3(t) \end{cases}$$

$$for \qquad P_1^3(t_1) = P_1^1(t_1),\ P_2^3(t_1) = P_2^1(t_1),$$
$$P_3^3(t_1) = P_3^1(t_1),\ P_4^3(t_1) = P_4^1(t_1),\ P_5^3(t_1) = P_5^1(t_1)$$

The analysis of the model[31] was focused (among the others) on sensitivity of the modeled system availability on the rate of the rail phase. Taking into consideration results of CT reliability data analysis it was assumed that:

– one transportation cycle is analyzed,
– there are three phases of transport,
– intensities of transition are taken from field tests,
– the rate of rail phase is from 0.5 to 0.8 of total cycle time.
– the results of estimation are shown in fig. 7 and 8.

The influence of the phase changing is evident for availability function and repair frequency. Reliability function is almost smooth – the phase limit is not visible. The obtained results of the system dependability are insufficient – 0.8 probability of successful realization of transport task is absolutely too low.

[31] Ibid.

Conclusion

In the presented paper, there have been discussed the main limitations of known modeling methods used in transport process reliability analysis. The problem is focused on use multi-phase system concept and the example of combined transport system was discussed.

Analysis of reliability model of CT system indicates the possibilities of increasing the system availability but the obtained numerical results are still disappointing. The problem concerns the used input data – they are estimated for relatively old rail cars and locomotives and quite new and modern road cars.

But, the sense of more detailed modeling of the transportation system is still restricted by uncertainty of the available data. Reliability data acquisition and analysis remains one of the general tasks to carry out.

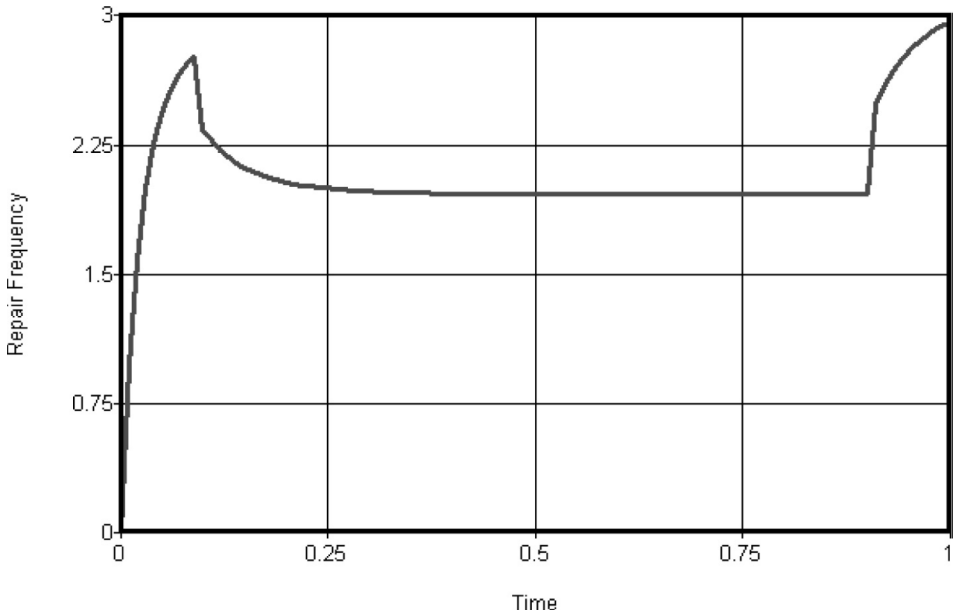

Fig. 7. Repair frequency of CT system for 0.8 rate of rail phase

Source: Ibid.

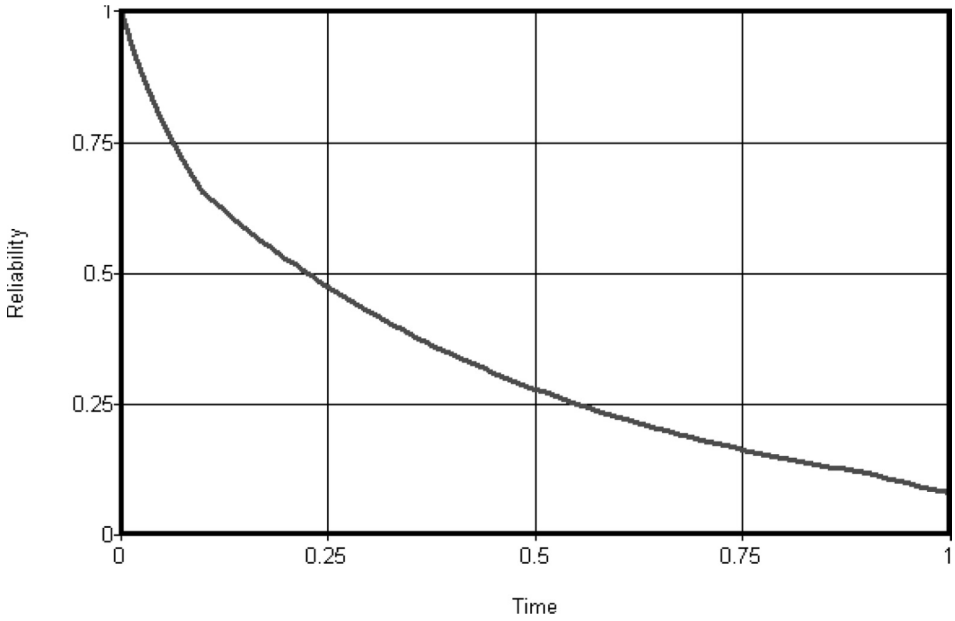

Fig. 8. Reliability function of CT system for 0.8 rate of rail phase

Source: Ibid.

Thus, the presented paper can be the starting point of consideration about searching new analytical ways of real-life system performance estimation taking into account also the transportation process time parameters.

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SIMULATION OF TRANSPORT FLOWS AND THEIR ANALYSIS

Introduction

Warehouse and transshipment infrastructure of seaports that does not meet the demand to process rising cargoes flows generates congestions at the hinterland. From the other hand, inefficient access from/to seaports can lead to transport congestions. V. Roso[1] stresses that progress only in the maritime part of the transport chain and in seaport terminals, without improvements in seaport inland access is not sufficient for the entire transportation chain to function.

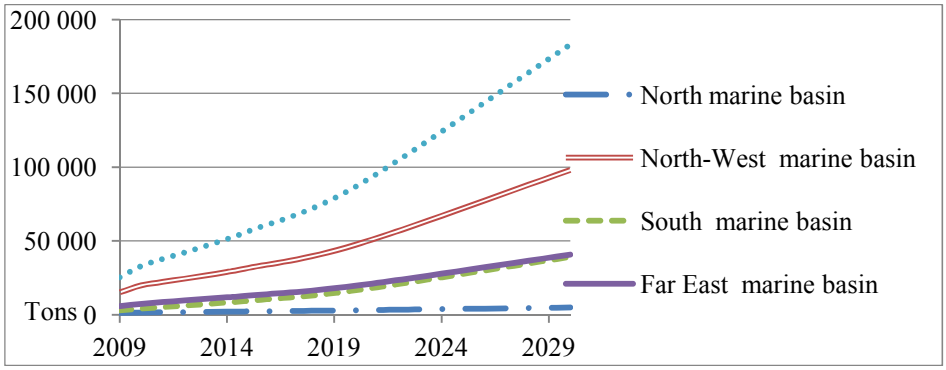
The main gateway of Russia (St. Petersburg seaport) locates at the North--West marine basin. Currently the total throughput of the seaport is around 50 Mt (million tons) with a 20 Mt of container cargoes. Seaport is considered will be able to maintain leading positions in future. However, there are impediments that restrict its further development. Among ecological impacts the geographical location of the seaport within the urban infrastructure has negative effect. For the latter reason, seaport cannot be extensively built at the site.

Almost all coast lands of the seaport are occupied. Moreover, the capacity of the maritime part of the seaport exceeds the capacity of inland access to the port by 20-30%.

According to the Strategy of seaport infrastructure development by 2030, the demand for transshipment of container cargoes at the North-West marine basin can reach 97.9 Mt in case of moderately-optimistic scenario (fig. 1). That

[1] V. Roso: *The dry port concept*: Thesis for the degree of doctor of philosophy. Chalmers University of Technology, Göteborg, Sweden 2009, p. 80.

is why it is planned to increase capacity of the terminals operating at the seaport: The First Container terminal by 4 Mt up to the year 2012, Petrolesport by 23.5 Mt (2013), and Forth Stevedoring Company by 10.5 Mt (2012).



Note: Figures are multiplied by thousand.

Fig. 1. Forecast of container cargos throughput in Russian marine basins

Source: *Strategy of seaport infrastructure development by 2030*.

The necessity to simultaneously develop transport system of the hinterland and seaport infrastructure construction is mentioned in the Strategy. Despite this fact the opponents of the Strategy, argue that construction of one road (West speed diameter) to the seaport is insufficient[2]. By their estimation the bottleneck of the road (toll bridge) causes difficulties even now. And in future when thousands of lorries appear on the road it will be paralyzed. Thus, the problem of managing transport flows is becoming acute.

Transport flows managing

Currently there are a number of variants for solving transport congestions (technical tools, information technologies, mathematics methods, and simulation models for managing). The methods allow to find dependencies and analyze the processes in organizational and technical environment, for example, in transport system. The management of transport flows is an area where to make an experiment is hardly possible. In this situation the simulation modeling is be-

[2] Novayagazeta.ru. (2011). *Each capital has a collapse*. Available at: www.novayagazeta.ru/society/49346.html

coming the sole instrument for empirical evidence and measured decisions[3]. The advantage of simulation in comparison with analytic solutions in transport flows management is numerous experiments with a system in finding a better solution.

At this article the problem of congestions on the road from/to seaports analyzed from the aspect of imperfection of queuing systems (toll bridge). Queuing system is a complex of channels, stations, tools (operators, sale counters, telecommunication lines and so on) that processes an entities coming to the system at random or determined moments[4]. The queuing system is set up if the following propositions are in place:

- Distribution function that characterize the inter-arrival time of entities to the system.
- The system comprise from queue block to store entities, and service block to process entities.
- The service time follows one of the distribution laws.
- The rules that control the amount of entities within a system.
- The queuing discipline that defines the order in which entities are serviced.

Simulation of queuing system was performed in AnyLogic program that was invented by Russian company XJ Technologies. The program has been occupied by more than 15,000 users in 60 countries[5]. The name for the program was given due to unique technic that enable to use system dynamic, discrete event and agent modeling simultaneously. In this paper a discrete event modeling is applied. This method is broadly used for simulating processes as a sequence of events upon the entities. Entities could be people, documents, lorries and the like. It is a method for modeling queuing system practically of any complexity. This type of modeling is related to the medium level of abstraction when the physical dimensions of objects, their speed, and distances are not important. But the time for processing entities, the delivery period from one point to another is considered. Depending on the type of the model AnyLogic allows to put a call to a probability distribution functions. For instance, into the Delay time parameter of a Delay or Service object. Each entity passing the object will get a new sample of the distribution.

On the ground of queuing theory in the circumstance of irregular traffic the questions of optimal amount of technical equipment were researched by Bezel

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[3] I.V. Makarova, R.G. Habibullin, K.A. Shubenkova: *Improving the management of transport system by simulation*, 2009.

[4] Y. Karpov: *Simulation of the systems. Introduction to AnyLogic 5*. 400 p., 2006.

[5] Website of simulation software and services. XJ Technologies. Available at: www.xjtek.ru /anylogic/

B.S., Degtyarev G.N., Matunin I.E., Padnya V.A., Smehov A.A, Klyushin Y.F., Pavlov I.I., Yolkin A.V. The goal of queuing theory is to produce recommendations for efficient modeling of queuing systems, their rational work, and regulating of entities flows. The tasks related to this theory are to find relations between the work of the queuing system and its technology, character of the entities flow, the capacity and the queuing discipline. The analysis of the system allows to determine the performance measures like the average number of entities in the queue, or the system; the average time spent in the queue, or the system, the probability the queue is full, or empty. Random generator of entities leads to uneven loading of the system. At the entrance can be accumulated the queue of entities waiting the service (overloading of the system) or the amount of entities can be less than spare channels (underutilization of the system). The effectiveness of the system is estimated by the quantity of entities that are processed.

In the article the task is to model queuing system (tall bridge). The time of lorries arrival is described by different distribution laws. Lorries leave the seaport and directed to the entrance of West speed diameter (tall bridge). The distance between seaport and entrance to the road is 21 km. Speed of the lorry is 50 km per hour. The delay time for processing entity (lorry) is always distributed triangularly. The triangular distribution is often used for service times, travel times, or, in general, for the duration of operations in conditions of limited sample data. From observations is known that it takes a minimum of 2 minutes, most likely 3 minutes, and a maximum 4 minutes to process a lorry. The delay time associated with this operation in AnyLogic is modeled by function triangular (min, mode, max) with these parameters: triangular (2, 3, 4). The time of running model equals 1 month.

The Discrete Event model was compiled from the objects of Enterprise Library of AnyLogic program (fig. 2). The queuing model was built from five objects Source-Queue 1-Conveyer-Queue-Delay-Sink:

Source generates entities that are distributed in accordance with probability function.

Delay has triangularly distributed delay time.

Queue and Queue1 is used as storage of entities because objects of Conveyer and Source do not able to store entities.

Conveyer is used to transfer entities along the way with installed distance and speed of the lorry.

Sink deletes entities from the system.

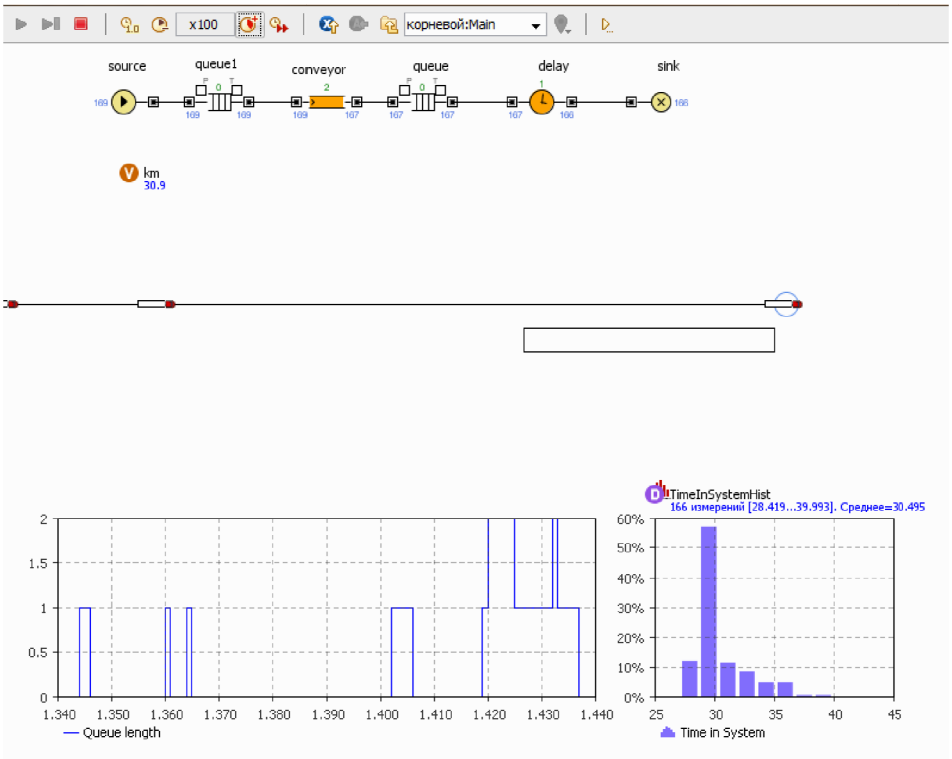

Fig. 2. Screen short of the Discrete Event model

Six experiments will be performed with a model. In each of them the flow of lorries (or probability distribution function) will be changed. The analysis of model is focused on estimation of the average time of lorry in the system and average number of served lorries.

In the first experiment the entities (lorries) are generated in accordance with Poisson distribution (or Poisson law of small numbers). It is a discrete probability distribution that expresses the probability of a given number of events occurring in a fixed interval of time and/or space if these events occur with a known average rate and independently of the time since the last event. Thus, lorries leave the seaport at fixed intervals. The intensity is one lorry per ten minutes. Randomness is set in the object of Source in the Interarrival time box: 0.1/minute(). The results of running the model over model time of 1 month shows that maximum length of the queue at the toll bridge is 6 lorries. The mean time of lorry in the system reached 30.67 minutes. Total amount of served lorries equals 154.

The second experiment characterized by the flow of lorries that is described by Exponential function. The function indicates the time between events at a Poisson process, i.e. when events occur independently at a constant average rate. Exponential distribution is used as inter-arrival time of customers, parts, calls, orders or lorries like in this model process. Lorries leave a seaport at a certain global average rate. One lorry moves out the seaport on average every ten minutes. Source object of the Enterprise library calls to probability distribution function: exponential (0.1)* minute ().

After running the model the results were generated. The efficiency of the model is 166 lorries that were served over the model time of 1 month. The longest queue of lorries is 3, with an average time of entity in the system of 30.5 min.

In the third experiment the distribution function was changed to uniform distribution function. It is widely used in practice to generate a flow of entities that are evenly spread over a rectangular area. It is applied when known the minimum and the maximum values but there is a zero knowledge about how the values are distributed in between, i.e. you do not know if there are any values more frequent than others and assume a constant likelihood of a value being in any place between min and max. The Source object calls for uniform distribution law by AnyLogic function: uniform(10,12)* minute(). It means, that the maximum interval is 12 minutes and minimum of 10 minutes. The performing of this model allows to find stochastic measurements: the number of lorries that was processed in the system (128), with the mean time of 29.21 min. The queue was empty.

The fourth experiment was conducted with a lorries flow followed by triangular distribution function that was described previously in simulating the time of servicing the entity. Here, the Source object will generate entities by AnyLogic function: triangular(10,12,15)* minute() where 10 is minimum value, 15 maximum value and12 is most likely. The amount of lorries that passed through the system of 114, and mean time spent in the system of 29. 26 minutes. The queue in the system was not identified.

The experiment number 5 was with lorries flow that was distributed by normal law. Normal distribution function gives a good description of the data that tend to cluster around the mean. For example, the height of an adult male person, the observation error in an experiment, etc. By calling AnyLogic function normal(1,5)*minute(), lorries will leave the seaport over the time periods distributed in diapason 5–1 and 5+1 i.e. with period from 4 to 6 minutes. Thus, the expected value is 5 minutes, dispersion is 1 minute. The output of the model is as follows: total amount of lorries 283 with a queue length of 1 lorry, and mean time of 29.52 minutes.

In the sixth experiment, the input data was based on discrete uniform distribution of lorries' flow. This distribution is used to model a finite number of outcomes that are equally probable, or when you have no knowledge about which outcomes are more likely to occur. Example, a person chooses a friend to communicate an idea. In this case minimum and maximum values are included in the set of possible results. So a call of uniform_discr(7,10) may return 7,8,9, or 10 minutes. After the simulation, were detected an average time of lorry in the system (29.3 minutes), and the total amount of lorries that were processed (168).

Conclusion

At present time the problem of traffic congestions is snowballing, especially for the marine cities. In Russia the most difficult situation on the roads is in Moscow and soon to be expected in St. Petersburg that is a main gateway from the sea. According to Strategy of seaport infrastructure development the throughput of the seaport will be dramatically increased. However, it is considered that the transport network at the hinterland will be developed not in coherence with enlargement of seaport infrastructure. The bottleneck of the road called West speed diameter could be the toll bridge.

In the article the queuing system (toll bridge) was performed in AnyLogic program. The analysis of the system, that was compiled from objects of Enterprise Library, allowed to determine the performance measures like the average number of entities (lorries) in the system; the average time spent in the system, the probability the queue is full, or empty. The experiments with a system have differed from each other by the flow of lorries that were generated in accordance with the six probability functions. The analysis of the system allows to find a better way for servicing lorries, and respectively increase the amount of lorries that can be processed in the system. On the ground of provided input data, the biggest number of lorries and minimum queue were fixed in the experiment when lorries flow followed by normal probability distribution function.

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SUSTAINABLE DEVELOPMENT ANALYSIS IN TRANSPORT PROCESS

Introduction

Transport is one of the largest sources of environmental pollution in Europe. The large number of significant environmental impacts associated with transport range from local through to global and cut across a large range of issues. Many of these impacts are increasing. Others are beginning to decrease but these impacts may start to increase again in the longer term unless action is taken to reduce transport growth. The environmental impacts associated with transport include energy and mineral resources, land resources, water resources, air quality, solid waste, biodiversity, noise and vibration, built environment impacts and health effects. Impacts across these categories are outlined below. Having outlined the environmental impacts of transport, the importance of establishing policy targets is discussed. Targets can help focus effective action to reduce the environmental impact of transport. These targets should he challenging, but not unrealistic, and they should be amenable to measurement, monitoring, and adjustment over time. It shows that reducing the environmental impacts of transport requires action not just in terms of transport policy, but also in terms of the organization and structure of the transport sector as well as general economic policies.

Sustainable Development in Transport

Energy and mineral resources. In 1970, the transport sector accounted for 14 per cent of Europe's energy consumption. By 1995, it was responsible for more than 21 per cent. Energy equivalent to 285 million tonnes of oil was consumed by the transport sector in 1995. In 2006 transport sector was re-

sponsible for consumption of 370 million tones of oil that means 31 per cent of all consumption[1]. The transport sector is now the largest and fastest increasing consumer of energy due mainly to the growth in road and air transport. The last decade saw large increases in the use of energy intensive modes such as cars and aircraft for the movement of passengers and freight. Over the same period there was a decrease in the use of energy efficient modes such as walking and cycling. Passenger vehicles became more fuel efficient but factors such as catalytic converters, higher safety standards, air conditioning and higher vehicle performance tended to counter the fuel efficiency gains from improved engine design.

Land resources. Transport occupies substantial areas of land and the amount of land used for transport infrastructure currently probably amounts to over 20,000 hectares per year (approximately equivalent in area to a square whose sides measure 14 kilometers). Roads occupy approximately one-fifth of the urban surface area and railways take up around a further four per cent of the surface of large cities. Every kilometer of three-lane motorway requires 4.2 hectares of land[2]. In addition to the land consumed for roads, significant amounts are also used for the storage of vehicles. The effects of this land loss include the loss of productive agricultural areas, the loss of biodiversity, and the fragmentation and severance of local communities.

Water resources. Transport accounts for much of the consumption of petroleum products and must therefore bear a large part of the responsibility for oil spills in coastal and marine waters. The oil spill from the Sea Empress in February 1996 off the coast of Milford Haven is a re cent example of a major water pollution incident with serious impacts on biodiversity, recreation and tourism. 72,000 tones of crude oil were released into the sea, of which between 3000 and 5000 tones reached the shore, affecting 200 kilometers of shoreline in the United Kingdom.

Air quality. Transport produces a number of emissions that are detrimental to air quality. These include global pollutants (such as carbon dioxide which contributes to global warming), national or regional pollutants (for example nitrogen oxides which produce acidification or 'acid rain') and local pollutants (such as particulates which contribute to respiratory problems including the increased susceptibility to asthma). Transport's contribution to environmental pollution in urban areas is particularly large, where transport is by far the most significant contributor of most emissions. The temporal trends in air pollutants from transport are mixed. Some emissions continue to increase, others are

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[1] *EU Energy and Transport in Figures.* Office for the Official Publications of the European communities, Luxembourg 2009.

[2] D. Banister: *Introduction: transport policy and the environment*. In: *Transport Policy and the Environment*. Ed. D. Banister. Spon Press, London 1998.

beginning to fall. However, some of the emissions that are decreasing may be a problem in the future if the growth in transport increases faster than improvements in technology[3].

Transport is responsible for 21% of total greenhouse gas (GHG) emissions in EU-15 (excluding international aviation and maritime transport. From 1990 to 2004, EU-15 greenhouse gas emissions decreased in most sectors, particularly energy supply, industry, agriculture and waste management. During the same period, emissions from domestic transport increased by approximately 26%. Even with all planned reduction measures included transport GHG emissions are projected to grow slightly.

The growth in GHG emissions and energy use in the transport sector is the result of increased transport volumes. Road transport is by far the biggest transport emission source (93% share). Emissions have increased continuously both for passenger transport (increase of 27% between 1990 and 2004) and for freight transport (increase of 51% between 1990 and 2003).

Despite reduced road transport exhaust emissions across Europe, there have been no significant improvements in concentrations of PM_{10} and nitrogen dioxide (NO_2). As exhaust emissions decline, tyre and brake wear are making a growing contribution to total road transport emissions of air pollutants. For example in the United Kingdom this contribution has increased from 15% in 1990 to 42% in 2006[4]. Although NO_x emissions are declining due to reduced exhaust emission limits, nitrogen dioxide (NO_2) concentrations are relatively stable. This may be due to an increase in the proportion of NO_x emitted as NO_2 by vehicles (primary NO_2 emissions), the result of increased sales of Euro 3 diesel vehicles fitted with oxidation catalysts and the fitting of catalytically regenerative particle traps to heavy goods vehicles[5]. These technologies can produce excess NO_2 as a by-product.

In addition to measures that reduce road transport demand in particularly sensitive areas, the 'Euro' exhaust emission standards for all new vehicles are the main tool to reduce vehicle emissions of regulated air pollutants. The Euro 5 standard for light duty vehicles has now been agreed for September 2009 and Euro 6 for January 2014. Euro 5 is expected to reduce particulate emissions from diesel cars by 80 % compared to Euro 4 (EC, 2007d). The Euro 6 standard should include a method for regulating particle number and should significantly reduce NO_x from diesel cars. For heavy duty vehicles, the Euro V standard came.

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[3] D. Banister, D., Stead, P. Steen, J. Akerman, K. Dreborg, P. Nijkamp, R. Schleicher-Tappeser: *European Transport Policy and Sustainable Mobility*. Spon Press, London 2000.

[4] *National Atmospheric Emissions Inventory NAEI*, 2009.

[5] *Trends in primary nitrogen dioxide concentrations in the UK*. AQEG, Air Quality Expert Group. Defra Publications, London 2007.

Solid waste Transport accounts for a significant proportion of solid waste due to the high rate of vehicle scrappage. Millions of road vehicles are scrapped annually, resulting in millions of tonnes of waste material requiring recycling, reclamation and disposal. Vehicle residues for disposal are rapidly increasing as the proportion of steel used in vehicles declines. Plastics are increasingly being used in vehicle manufacture but few of these are recycled at present. Waste tires present another major solid waste problem: millions of tires are scrapped each year.

Biodiversity Infrastructure construction and maintenance often leads to losses of vegetation-rich land including hedgerows and verges. Newly planted verges are generally not an adequate replacement. Where new infrastructure cuts across natural or semi-natural habitat, the effects on biodiversity will depend on factors such as the habitat's sensitivity, the sitting of the infrastructure and the area of land used for construction. Transport infrastructure such as roads, airports or railways may act as a barrier to the movement of species which may result in the separation of populations and a decline in numbers. Rarer species may disappear if the population becomes too small.

Noise and vibration EU Member States reported standardized noise data in a structured way for the first time in 2007, following the adoption of the Environmental Noise Directive in 2002. As a result, it is now possible to start looking at noise exposure across Europe.

In the 1970s it was established that many Europeans suffered ill health due to high noise levels, especially around roads and airports but also near railways and other local sources not necessarily related to transport. A number of local and national investigations were carried out and most of them showed that it would be quite a challenge, not least economically, to achieve the noise limits recommended by the WHO to protect human health.

Since then some emissions reduction measures have been implemented, including building noise barriers and improving window insulation. It is obvious, however, that increasing transport activities have exacerbated noise problems. One contributing reason is that during the late 1970s and 1980s public focus shifted towards the air pollution produced by transport, while noise more or less disappeared from the agenda.

Transport is the most pervasive source of noise for many people in Europe. It is estimated that around 80 million people (or 17 per cent of the population) in Europe are exposed to noise levels above 65 dB(A), which the OECD defines as an unacceptable noise level. The exposure to noise varies by country: from around 4 per cent of the population in the Netherlands to 23 per cent of the

population in Spain. The most common sources of transport noise (in order of importance) are road traffic, aircraft and trains. Road traffic is generally considered to be more of a nuisance than most other sources of noise. Conclusive evidence of the health effects of noise is limited to eases of hearing loss and tinnitus caused by long periods of exposure to high noise levels – more than 75-80 dB(A)[6]. It is unlikely that most people are exposed to traffic noise at these levels over a sufficiently long period to cause these health effects, although traffic noise may aggravate or contribute to stress-related health problems such as raised blood pressure and minor psychiatric illness In addition, transport movement causes vibration which may be another contributory factor to stress--related diseases Excessive noise from traffic may also discourage social interaction in streets and reduce the attractiveness of walking or cycling.

Built environment Transport's impact on the built environment includes the damage to property as a result of accidents, structural damage to transport infrastructure (such as road surfaces and bridges) and damage to property and monuments as a consequence of corrosive local pollutants. Road damage is dependent on factors such as climate, the road surface and the axle weight of vehicles using the road. Because road damage is related exponentially with axle weight, heavy vehicles with few axles cause most of the damage.

Health effects. The road transport is the most dangerous of all means of transport, because it has the biggest death rate. Plane or rail crashes with hundred of victims are difficult to accept in our society, but motor transport with its tragic consequences and victims seem to be minor. In the other hand we can't compare road danger with danger in air transport, because everyday on all European roads die as many people as in one medium size passenger plane crash.

1.7 million people were killed in car accidents in Europe since 1970, in year 2006 42,953 people died on European Union roads. Car accidents are also the main reason of death of young people aged between 14 and 25 years old. It is estimated that every third citizen has been injured in any car accident in their life. Direct expenses of road accidents are estimated on the sum of 45 milliard Euro per year, indirect expenses contain physical and mental looses of accidents' victims and their families are estimated on the sum of 160 milliard Euro[7].

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[6] *Transport and environment: on the way to a new common transport policy*, TERM 2006: Indicators tracking transport and environment in the European Union. EEA Report 2007, No. 1, European Environment Agency, Copenhagen 2007.

[7] E. Hedkvist Petersen: *Priorities in EU Road safety – Progress report and ranking of action*. The European Parliament, the Economic and Social Committee and the committee of the Regions COM (2000)125 – C5 0248/2000.

Statistics for European Union member countries show the number of people killed in road accidents has been systematically decreasing and in some countries like Germany or Holland the death rate in road accidents decreased more than four times in 2006, comparing with results in 1970, in other 15 member countries of European Union it has decreased a little less, but important.

Conclusion

Transport process has a great impact on environment regarding to its infrastructure and functioning. Therefore it is especially important to develop managerial skills in transport infrastructure planning and transport operation to introduce sustainable development idea that allows to improve of the quality of life and welfare of mankind under the conditions of a limited availability of natural resources, taking into account the far-reaching consequences of this branch. That means assurance of common responsibility and solidarity of the present and future generations[8].

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[8] Compare: J. Adamczyk, T. Nitkiewicz: *Programowanie zrównoważonego rozwoju przedsiębiorstw*. PWE, Warszawa 2007.

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TRANSPORT IN THE POLISH LOGISTICS SYSTEM

Introduction

Transport is a production process aimed at covering distance. Bearing in mind that transport adheres to economic laws, which underpin all human economic activity it is fair to say, that transport is a production process enabling people to move people, goods and energy – using limited resources – over distance in order to cater for different needs and desires[1]. The notion of freight transport refers to providing services entailing transport of goods and inherent additional services[2].

It plays an important role in social and economic development of a country, enables different sectors of domestic economy to function properly, and is a catalyst for strong growth. Transport out of tune with other domestic industries undermines the general potential for growth. There is a tight interdependence between domestic economic growth and development of the transport system as transport sustains all the other sectors of economy[3].

In the context of economic activity, transport serves as following functions: consumption, production and integrative, thus proving transport to be complementary to other sectors of economy, and consequently irreplaceable. One should remember though, that transport should provide services of ever--increasing quality, adapted to transport of goods. They should also offer a branch structure, in order to cater for an unimpeded economic growth[4].

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1 *Transport i spedycja w handle zagranicznym*. Red. T. Szczepaniak. PWE, Warszawa 2002, s. 16.
2 J. Neider: *Transport międzynarodowy*. PWE, Warszawa 2008, s. 11.
3 *Transport.* Red. W. Rydzykowski, K. Wojewódzki-Król. PWN, Warszawa 2000, s. 11.
4 Ibid., p. 13.

Modes of transport in the logistics system

Transport, being one of the most important elements of any logistics system, is charged with the task of creating a physical interface between raw materials providers and manufacturers, manufacturers and distribution centres, distribution centres and consumers[5].

The importance of branch systems to domestic logistics systems varies across the board. Road haulage plays first fiddle – both by quantity (70.4%) and tonnage (84.4%). Ranked second is rail transport – 15.4% by quantity and 11.8% by tonnage. Pipeline transport ranks third with 7.6% by quantity and 3.1% by tonnage. Forth, 6.2% by quantity and 0.4% by tonnage ranks the maritime transport. Inland waterway transport is insignificant for the domestic transport – 0.4% both by quantity and tonnage. By contributing approx. 0.1% of total freight, air transport is often ignored in statistical analyses[6] (table 1).

Table 1

Dynamics and structure of transport

MODES OF TRANSPORT	2000	2005	2009	2010	2000	2005	2009	2010
	Previous year = 100				Share in % of total			
TONNES								
TOTAL	95.7	107.4	102.1	108.7	100.0	100.0	100.0	100.0
Rail transport	100.2	95.3	80.7	106.4	14.7	18.9	11.9	11.8
Road transport	94.2	112.8	106.4	108.9	79.2	75.9	84.3	84.4
Air transport	96.0	117.5	78.1	111.1	0.0	0.0	0.0	0.0
Pipeline transport	103.5	101.7	102.5	111.9	3.5	3.8	3.0	3.1
Inland waterway transport	124.5	109.8	69.7	90.9	0.8	0.7	0.3	0.3
Maritime transport	100.1	41.6	89.8	89.2	1.8	0.7	0.5	0.4
TONNE-KILOMETRES								
Rail transport	91.6	78.5	101.3	112.1	100.0	100.0	100.0	100.0
Road transport	98.2	95.5	83.5	112.1	19.1	21.9	15.4	15.4
Air transport	106.5	108.4	109.9	116.5	26.4	52.5	67.7	70.4
Pipeline transport	92.9	114.0	80.0	134.8	0.0	0.0	0.0	0.1
Inland waterway transport	104.8	102.3	107.8	105.5	7.2	11.1	8.1	7.6
Maritime transport	114.1	119.7	80.1	101.0	0.4	0.6	0.4	0.3
Rail transport	81.4	31.1	78.8	82.9	46.9	13.9	8.4	6.2

Source: *Transport – activity results in 2010*. CSO, Warsaw 2011, p. 46.

[5] Ibid., p. 11.
[6] *Transport – activity results in 2010*. CSO, Warsaw 2011, p. 46.

The total tonnage of freight transported by all modes of transport in 2010 amounts to 1835.5 million tonnes, i.e. 8.7% more compared to 2009 and translating into 317.0 billion tonne-kilometres, i.e. 12.1% more than the year earlier. On the rise were road, rail, pipeline and air transport, whereas less freight was shipped using inland waterway and maritime transport (table 2).

Table 2

Transport of goods by mode of transport in 2010

MODES OF TRANSPORT	Tonnes			Tonne-kilometre		
	thousand	2009 = 100	total percentage	million	2009 = 100	total percentage
TOTAL	1 838 492	108.7	100.0	316 951.4	112.1	100.0
Rail transport	216 899	108.0	11.8	48 706.9	112.1	15.4
Standard gauge railway	216 767	108.0	11.8	48 705.2	112.1	15.4
Narrow gauge railway	132	90.8	0.0	1.7	95.5	0.0
Road transport	1 551 841	108.9	84.4	223 170.4	116.5	70.4
Air transport	41	111.1	0.0	114.3	134.8	0.1
Pipeline transport	56 208	111.9	3.1	24 157.1	105.5	7.6
Inland waterway transport	5 141	90.9	0.3	1 030.1	101.0	0.3
Maritime transport	8 362	89.2	0.4	19 772.6	82.9	6.2

Source: Ibid., p. 84.

Demand for transport services from entities intermediating in Poland's trade with foreign countries is dictated by the quantity and volume (tonnes) of Polish export and import. The volume of Polish international trade over the period from 2004 to 2009 is illustrated in table 3.

Table 3

International trade turnover and main partners

Parameter	million US dollars	Prime partner; percentage of trade	Second partner; percentage of trade	Third partner; percentage of trade
1	2	3	4	5
2004 Import	88156.4	Germany: 24.4	Italy; 7.9	Russia, 7.2
Export	73781.2	Germany; 30.1	Italy; 6.1	France, 6.0

Table 3 contd.

1	2	3	4	5
2005 Import	101538.8	Germany; 24.7	Russia; 8.9	Italy; 7.1
Export	89378.1	Germany; 28.2	France; 6.2	Italy; 6.1
2006 Import	125645.3	Germany; 24.0	Russia; 9.7	Italy; 6.8
Export	109584.1	Germany; 27.2	Italy; 6.5	France; 6.2
2007 Import	164172.5	Germany; 24.1	Russia; 8.7	China; 7.1
Export	138785.0	Germany; 25.9	Italy; 6.6	France; 6.1
2008 Import	210478.5	Germany; 23.0	Russia; 9.7	China; 8.1
Export	171859.9	Germany; 25.0	France; 6.2	Italy; 6.0
2009 Import	149569.8	Germany; 22.4	China; 9.3	Russia; 8.5
Export	136641.3	Germany; 26.2	France; 6.9	Italy; 6.9

Source: Yearbook of foreign trade statistics of Poland 2009. CSO, Warsaw 2009, p. 36; *Yearbook of foreign trade statistics of Poland 2010.* CSO, Warsaw 2010, p. 37.

As the table 3 shows, Poland's number one trade partner over recent years has been Germany. The running order is completed by Russia, France, China and Italy.

The world economic crisis took its toll on the global economy in 2009. Recession had hit the most developed countries in the last quarter of 2008, consequently making the downturn's presence felt in the emerging markets. Both exogenous and endogenous factors influencing Polish international trade worsened considerably. According to the International Monetary Fund, global GDP fell by 0.6% in 2009, and the volume of international trade plunged by 12%. European Union's GDP dipped by 4%. Polish international trade volumes drastically dropped, but the rate of decrease of export was smaller than of import[7].

The final quarter of 2008 saw a meltdown in Polish exports. The negative trend stretched over the period of the first three quarters of 2009, when export was falling at a rate of 20% per quarter. The fourth quarter of 2009 brought an upswing with export falling by just 0.4%. Total exports in 2009 amounted to 98.3 billion EUR, thus showing a decrease of 15.5%[8]. Import was in a similar situation. The final total value of imports amounted to 107.5 billion EUR, i.e. 24.5% less than in 2008[9].

[7] *Polska 2010. Raport o stanie gospodarki*. Ministerstwo Gospodarki, Warszawa 2010, p. 8.
[8] Ibid., p. 11.
[9] Ibid.

In the geographical structure of Polish foreign trade, EU member states were the dominant force, by receiving in 2009 79.7% of Poland's total exports and shipping 61.9% of Poland's total imports. Substantial contributions were also made by CIS member states and China. The balance of trade with EU member states was 11.8 billion EUR, whereas the trade with China and Russia shows a deficit to the tune of 8.9 billion EUR and 5.6 billion EUR respectively[10].

Following the recession in 2008-2009, in 2010 most of member states entered the stage of economic recovery. With 2010 the international trade started to recover also. The global economic growth reached 5%. In EU member states, after GDP dropping in 2009, it got back on track in 2010, by increasing 1.8%[11]. Foreign trade became an important factor facilitating the upturn. The global volume of goods and services trade rose in 2010 by 12.4%, whereas within the EU exports turnover grew by 11.4% and imports turnover grew by 9.2%[12]. The prime area for Poland's foreign trade remains EU member states, which accounted for 79.2% of exports and 59.5% of imports. Russia and China has also made valid contributions[13].

Land transport in the logistics system

In 2010 a total of 1551.8 million tonnes of cargo was transported by road transport (national and international transport) – 8.9% more than in 2009. The tonne-kilometre transport performance grew by 16.5%. Transport for hire or reward accounted for transporting 791.8 million tonnes of cargo, translating into 51.0% of total road transport volume, whereas transport on own account for 760 million tonnes, i.e. 49% of total transport volume. Transport for hire or reward per tonne-kilometre amounted to 80.0%, and transport on own account per tonne-kilometre amounted to 20.0%[14]. The most prominent in transport for hire or reward were companies classified by the Polish Classification of Activities under the category: Transport and storage management. They contributed 16.4% tonne-kilometre more than in 2009 and transported 2.9% more freight (tonnes) than the previous year. The most companies categorised under this group employ up to 9 people. Their share of freight transport (tonnes) the pre-

[10] Ibid.
[11] *Polska 2010…*, op. cit., p. 8.
[12] Ibid., p. 8.
[13] Ibid., p. 11.
[14] *Transport – activity results in 2010…*, op. cit., p. 53.

vious year was 69.7% and tonne-kilometre share – 38.1%[15]. In terms of domestic transport, it grew by 6.0% compared to 2009, with tonne-kilometre transport performance increasing by 9.0%[16].

The highest share of cargo transported by road domestically in 2010, had metal ores and other mining and quarrying products – 34.8% of total freight, other – 15.1%, and non-metallic mineral products – 14.3%. The lowest share in the structure of cargo transported on road had textiles and clothes, leathers and leather products – 0.4%.

Polish road transport accounted for just shy of 11% of total transport in the EU, ranking Poland third behind Germany and Spain but in front of France[17].

Since Poland first joined the EU, statistical offices monitor border traffic only along the Eastern and maritime border. In 2010, 1 566 513 lorries crossed the border. The volume of lorries traffic by border-crossing points over 2006-2010 is illustrated in table 4.

Table 4

Lorries traffic by border-crossing points (Eastern and maritime) (units)

Specification	Lorries traffic
2006	1 606 097
2007	1 804 445
2008	1 536 241
2009	1 430 381
2010	1 566 513

Source: *Kompendium statystyczne Służby Celnej 2006-2010*. Ministerstwo Finansów, Warszawa 2010, p. 84.

The total number of lorries crossing all border checkpoints manned by the Customs Service in 2010 is presented in table 5.

Table 5

Border traffic of lorries at checkpoints manned by the Customs Service

Specification	Lorries traffic
Total	1 566 513
Vehicles driven by Polish citizens	464 996
Vehicles driven by foreigners	1 101 517

Source: *Biuletyn Statystyczny Służby Celnej za I-IV kwartał 2010*. Ministerstwo Finansów, Warszawa 2011, p. 66.

[15] Ibid., p. 51.
[16] Ibid.
[17] Ibid.

The data presenting the number of lorries crossing borders of neighbouring countries in 2010 is shown in table 6. Analysis of tab. 6 data leads to a conclusion, that the vast majority of vehicles crossing in 2010 Eastern Polish border were vehicles driven by foreigners.

Table 6

Neighbouring countries border crossing by lorries in 2010 (units)

Country	Vehicle driven by Polish citizens		Vehicle driven by foreigners		Total
	leaving Poland	into Poland	leaving poland	into Poland	
Russian Federation	13 198	11 466	56 546	43 887	125 097
Republic of Belarus	203 546	81 919	324 344	221 519	831 328
Ukraine	78 157	76 710	256 891	198 330	610 088
Total	294 901	170 095	637 781	463 736	1 566 513

Source: Ibid., p. 67.

In 2010, the most lorries cleared customs in Biała Podlaska – 762 049, them in Białystok 432 855, in Przemyśl – 246 512 and in Olsztyn – 125 097[18].

In 2010, rail transport carried a total of 217 million tonnes of goods, which was 8% more than the previous year, and the tonne-kilometre transport performance increased by 12.1%[19].

International rail transport grew by 30.3%, whereas the highest rate of growth was recorded by transit – 55.6%. Export increased by 33.4% and import by 25.4%.

The highest share of total goods exported had Germany, Czech Republic and Austria, whereas goods imported – Russia and Ukraine[20].

The total tonne-kilometre transport performance of Polish rail transport was 13% of the total tonne-kilometre transport performance of all EU member states' rail transport, putting Poland right behind Germany at second.

In the structure of goods carried domestically by rail transport in 2010, the highest share of transported goods had black coal – 43.7%, whereas the lowest – food products and tobacco – 0.1%. Transport of machinery, devices and consumer electronics had a share of 0.0% of total goods transported. The most freight (thousands of tonnes) was carried over short distances i.e. up to 50 km[21].

[18] *Biuletyn Statystyczny Służby Celnej za I-IV kwartał 2010*. Ministerstwo Finansów, Warszawa 2011, p. 68.
[19] *Transport – activity results in 2010…*, op. cit., p. 47.
[20] Ibid., p. 48.
[21] Ibid., p. 96, 112.

Volumes of cargo transported by rail by direction of transport in 2010 were illustrated in table 7.

Table 7

Rail transport of goods by direction of transport in 2010

Specification	Tonnes (thousand)	Tonne-kilometre (million)
National transport	148 317	27 683.3
Export:		
By land	16 923	4 012.0
Through ports	9 984	5 200.3
Import:		
By land	32 323	7 173.3
Through ports	4 166	1 640.4
Transit	5 054	2 995.9

Source: *Transport – activity results in 2010.* CSO, Warsaw 2011, p. 91.

Maritime transport in the logistics system

In 2010, the maritime transport fleet carried 8.4 million tonnes of goods, translating into 10.8% less than the previous year, whereas tonne-kilometre transport performance fell by 17.1%. 6.0 million tonnes of goods were carried by linear shipping, i.e. 17.1% less than the year earlier, with tonne-kilometre transport performance falling by 17.0%. Non-linear shipping carried 2.4 million tonnes of goods, so 10.8% more, whereas tonne-kilometre transport performance soared by 17.3%[22].

Goods transported in Polish foreign trade also plunged (by 30.3%) and 207 thousand tonnes of goods were carried between Polish ports, i.e. 1.9% more than the year earlier[23].

Cargo traffic at Polish seaports in 2010 was 59.6 million tonnes. Traffic grew across the board in terms of all cargo categories. In the structure of goods transported by sea the highest share had dry bulk goods of 40.8% and liquid bulk goods – 30.6%[24]. All major Polish seaports reported increased cargo traffic.

[22] Ibid., p. 57.
[23] Ibid.
[24] Ibid., p. 58.

Their individual shares in total traffic volumes were the following: Gdańsk – 44.4%, Gdynia – 20.7%, Świnoujście – 18.0%, Szczecin – 13.4%, Police – 3.1%[25].

International sea cargo traffic in 2010 was 32.5% higher than in 2009. The total amounted to 58.6 million tonnes of goods, the bulk of which (66.8%) was the traffic with EU member states. The highest share in cargo traffic had Sweden – 13.0%[26].

Air transport in the logistics system

Air transport without a shadow of a doubt displays an array of advantages, among which the most important are regularity of supply and transport security. Despite those features, air transport is scarcely used in international trade, primarily due to: high shipping costs – thus adequately high freight rates, small cargo carrying capacity of planes, disadvantageous locations of transport network's facilities, lack of convenient intermodal infrastructure at Polish airports, long customs clearance procedures.

In 2010, air transport accounted for transporting 40.7 thousand tonnes of goods, i.e. 11% more than the year earlier. Air traffic did decrease by 0.9% though, compared to 2009. 17% freight more than in 2009 was handled at the airports. The total tonnage of domestically handled cargo increased by 3.6%, cargo shipped abroad increased by 27.9%, whereas the tonnage of cargo shipped from abroad – by 15.5%. The number of take offs and landings of cargo airplanes decreased by 0.2%. 57% of total transport of goods by air was carried by scheduled transport[27].

In 2010, Polish airports handled 14 656 tonnes of goods shipped domestically and 66 388 tonnes of goods shipped internationally (table 8). 38 033 tonnes of goods were shipped from abroad, whereas 28 355 tonnes were shipped abroad. PL Warsaw Okęcie had best results in terms of cargo handling, where transhipped were 28 928 tonnes of goods shipped from abroad, and 21 451 tonnes of goods were shipped abroad. Ranked second was the PL Katowice Airport in Pyrzowice, where 5661 tonnes of goods were received from abroad and shipped abroad were 4268 tonnes of goods. Other airports had significantly smaller cargo traffics.

[25] Ibid., p. 59
[26] Ibid.
[27] *Transport – activity results in 2010…*, op. cit., p. 55.

Table 8

Freight transhipped at airports in 2010 (tonnes)

Airports	Total		Freight arrivals from airports			Freight departures to airports		
			domestic		foreign	domestic		foreign
	domestic	foreign	total	of which mail		total	of which mail	
1	2	3	4	5	6	7	8	9
Total	1 4 656	66 388	7 329	6 680	38 033	7 327	6 469	28 355
Bydgoszcz	414	–	222	222	–	192	192	–
Gdańsk	1 407	3 080	682	537	1 960	725	450	1 120
Katowice	1 266	9 929	702	481	5 661	564	534	4 268
Kraków	1 662	2 802	828	823	1 411	834	831	1 391
Łódź	–	0,4	–	–	0,2	–	–	0,2
Poznań	1 132	90	628	590	29	505	447	61
Rzeszów	434	32	217	2 14	13	217	217	19
Szczecin	690	39	335	313	15	355	298	25
Warsaw	6 736	50 380	3 234	3 086	28 928	3 502	3 076	21 451
Wrocław	915	31	481	414	17	434	424	14
Zielona Góra	–	5	–	–	–	–	–	5

Source: Ibid., p. 199.

Conclusion

From the logistics point of view, the factor which best describes transport in logistics systems is the relation between the shipping costs and the level of logistics service.

Most often though, the decision about choosing the mode of transport is dictated by the size of cargo and the distance it has to travel.

For small freight transport over small distances the road transport is recommended. Large freight shipments over long distances require maritime transport. Railway transport is suggested for transporting heavier cargo over distances exceeding 500 km, whereas air transport – in case of smaller weight cargo over long distances[28].

The decision about which type and mean of transport to use in the logistics system, should depend on the breakdown of shipping costs against such features of logistics services like speed of delivery i.e. the time required to ship the cargo

[28] *Logistyka.* Red. D. Kisperska-Moroń, S. Krzyżaniak. Instytut Logistyki i Magazynowania, Poznań 2009, s. 149.

from sender to recipient and the level of service – reliability, security, delivery punctuality and cargo securing. Also important is the infrastructure availability (along with the door-to-door capabilities) for particular type of transport and the max weight of a single consignment. Table 9 comprises all fundamental qualities of individual modes of transport.

Table 9

Comparison of basic qualities of modes of transport

Mode / Factor	Cost	Availability	Speed	Reliability	Freight size
Road	2	1	2	1	5
Rail	3	2	3	2	4
Inland waterways	4	3	4	2	3
Maritime	5	4	4	2	2
Air	1	5	1	2	6
Pipeline	6	6	–	–	1

Source: M. Kasperek, J. Szołtysek: *Transport w systemach logistycznych.* HABEX, Gliwice 1997, p. 38.

As the table 9 shows, road transport characterises with second highest – after air transport – shipping costs, however, a well developed road network puts it in front as far as availability is concerned. In terms of speed it yields only to air transport. Furthermore it shows the highest reliability and security of logistics service. In logistics systems it should be used to transport small freight – as it ranks fifth in max weight of a single consignment.

Rail transport ranks third in terms of shipping costs, however a well developed railway network and relatively high level of cargo security rank this type of transport second as far as availability and reliability are concerned. Rail transport should be used to carry larger cargo – either bulk materials or containers (rank 4 by freight size).

Inland waterway transport dominates among other modes of water transport in terms of cost and availability. Maritime transport edges ahead though when it comes to freight size, thus it is recommend for long-haul cargo transport.

Air transport is the most expensive type of transport, but the fastest at the same time. Its use in logistics systems is justified for moderate-weight cargo (rank 6) which has to be delivered quickly regardless of cost.

Pipeline transport characterises with the lowest costs, lowest availability, but at the same enables transport of single consignments of practically unlimited volume.

In order for the national logistics system to develop well, the transport itself has to optimised, what could be achieved through adequate logistics solutions. Logistics is capable of increasing performance of different forms of transport –

including co-modal transport – thus enabling fewer transport units to carry higher tonnage. Consequently negative environmental impact will be reduced. The European Union puts an emphasis on the necessity to modernise rail and inland waterway, integrate air transport with the system, and develop deep sea shipping and its interoperability with the land transport. Everywhere where it is possible, especially in long-haul cargo transport through overloaded transport corridors, modes of transport have to be swapped for greener. At the same time, each form of transport has to be modified with greener, safer and more energy--efficient operation in mind. Co-modality, i.e. efficient use of different modes on their own and in combination, should ultimately lead to better and sustainable use of resources[29].

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[29] www.europarl.europa.eu/meetdocs/2004_2009/documents/com/com_com(2006)0336_/com_com(2006)0336_pl.pdf 2.11.2009.

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NORTH EUROPEAN LOGISTICS FLOWS WITH RIC: SPARSE AND UNBALANCED VOLUME

Introduction

After IT bubble burst in the early 2000[1] (liberalization of free trade was taken to new level with enlargement of World Trade Organization and trade agreement with China (Dec. 2001). From significant emerging countries, India joined WTO in Jan. 1995 as did also Brazil. Important for Europe, Ukraine joined organization in May 2008, while Russia is still negotiating from the membership (anticipated to realize in 2012-2013). Fostered by housing bubble burst in USA and partially Europe, along with in recent years followed sovereign debt problems swelling all over the developed world, it becomes apparent and vital to have all enlargement in world's free trade area (and emerging countries, particularly China has been analyzed to benefit greatly from this process[2]. Like it or not, world GDP growth depends on trade growth, and actually in recent decade we have needed 2.5% growth in trade to have one percent growth of GDP[3]. This greatly concern global services sector, which logistics is important part of[4].

USA led credit crunch had significant effect on long-term growth path of transportation logistics, and companies have still today difficulties to assure shareholders that growth is ahead. For example, largest sea container operator Møller – Maersk was able to turn its profitability higher than pre housing crisis level (during period of 2010-2011), but it lacks growth in revenue (and also cre-

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1 E.g. P. Chu, O. Ip: *Downsizing in the internet industry: the Hong Kong experience*. "Leadership and Organization Development Journal" 2002, No. 23:2, pp. 158-166.

2 Ghosh, Madanmohan & Someshwar Rao: *Chinese accession to the WTO: Economic implications for China, other Asian and North American economies*. "Journal of Policy Modeling" 2010, No. 32:3, pp. 389-398.

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

4 Cap Gemini: *Third-Party Logistics – Results and Findings from 12th Annual Study*. www.de.capgemini.com/m/de/tl/Third-Party_Logistics_2007.pdf (6.02.2008).

dible growth path in profits). Still today plain container transportation at sea is barely profitable[5], but terminal operations, as well as oil and gas related activities make the profit for Møller – Maersk. As growth story is missing, it is not surprising to find out that shareholder value from late 2007 has declined by 50%. Similar change is present in other shippers, such as K-line, Hanjin Shipping and China Cosco. Efficiency improvement keeps alive profitability for short period of time in for-profit companies, but as world economic model was earlier based on rigid growth of trade (and in very bold investment with debt finance, also in shipping), it is very difficult to assure globally that currently we are going back to earlier growth days again. Also freight rates (e.g. Baltic indexes[6]) have declined very severely from peak values of 2008, and currently these are at 50-90% lower level (highest decline in dry bulk). Implications of this situation could already be seen, e.g. Møller – Maersk has introduced daily departures from most important Asian and European sea ports[7]. So, waiting times at sea ports are going to be minimized, but on the other hand sea transportation fleet is planned to be sailing with slow and economical speed. This sort of strategy is only enabled by high capacity at hand, and pressure from markets to provide most efficient service possible.

Severe economic crises typically change structures for better efficiency and enabling future growth. Our interest lies in this regarding to North European companies having significant material flows at their disposal. In interest is to gain understanding from three emerging markets (RIC, namely Russia, India and China), and their interaction with Europe. As is well known, typically this interaction in the early stages starts with export activity from more advanced areas, but could change in other direction too as markets in emerging country grow large enough and possibly in the meantime provide low manufacturing cost[8]. This kind of change path has occurred with China, and we are interested to know, how companies see situation with it as well as with Russia and India. Two latter mentioned countries are different from Chinese manufacturing engine of the world as Russia is specialized in raw material exports and India is having current competence in service sector and IT. If companies in Northern Europe are offshoring, outsourcing or subcontracting more factory work from these two

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[5] E.g. Maersk: Interim Report 3rd Quarter 2011. Copenhagen, Denmark, http://investor.maersk.com/releasedetail.cfm?ReleaseID=622113 (11.2011).

[6] E.g. Bloomberg: *Baltic Indexes for Dry, Dirty Tanker and Tanker Transportation Groups*, 2011, http://www.bloomberg.com/apps/quote?ticker=BDIY:IND, http://www.bloomberg.com/apps/quote?ticker=BIDY:IND, http://www.bloomberg.com/apps/quote?ticker=BITY:IND

[7] *Daily Maersk: Absolute Reliability Website*. www.dailymaersk.com/ (11.2011). Daily

[8] This process has already caused in global scale great imbalances in container transport, like reported in Lopez, 2003 and Lun et al., 2009.

countries too, then this sort of operating mode could produce enormous trade deficit problems. We are not only interested to company reported transport flow balances, and volumes, but also use secondary data from container sea ports and trade accounts to build up accurate situation awareness.

This manuscript is structured as follows: In Section 2 we introduce the reasons for the growing importance of emerging nations, and motivate our research work. This is followed with research methodology of completed survey for North European companies in Section 3. Research environment is introduced in Section 4. Empirical data analysis of completed longitudinal survey is provided for all three RIC countries in Section 5. Discussion follows in Section 6. Conclusions are given in final Section 7.

Research Area Motivation

Most of the demand and structures have changed due to credit crunch crisis of 2008-2009[9]. However, emerging economies, like Brazil, Russia, India and China remained in the previous growth track briefly after going through economic discontinuity. In the case of Northern Europe, most influential BRIC nations are Russia and China. Former for the reason of raw material export dominance (and very close proximity), and China as it has developed as the factory of the world. During previous decade these two countries have gained very influential position in world economy; China got boost from WTO membership during year 2001 (affected in two ways: opened up their domestic market for global brands, but also gave global markets for Chinese manufacturers to export), and Russia for raw material export prices from very low interest rates of developed nations (USA, Japan and EU), extra liquidity provided by central banks as well as strong global demand. It is known that Russian GDP is totally dependent on export of oil (total value), and if this rapidly changes, so does GDP[10]. However, it should be reminded that Chinese appearance as important economic actor is having also long-term story, which probably started already in the early 80's[11].

[9] G. Turner: *The Credit Crunch*. Pluto Press, UK 2008.

[10] E. Terk, U. Tapaninen, O.-P. Hilmola, T. Hunt: *Oil Transit in Estonia and Finland – Current Status, Future Demand, and Implications on Infrastructure Investments in Transportation Chain*. Publications of Estonian Maritime Academy 2007, No. 4.

[11] M.C. Mahutga, D.A. Smith: *Globalization, the structure of the world economy and economic development*. "Social Science Research" 2011, No. 40:1, pp. 257-272.

Nowadays still old developed nations (EU, Japan and USA) hold considerable influence on global GDP[12], but structural change has been ongoing during last decade (and change for emerging economy dominance will start around 2020-2030[13]). Best illustration for this change is given in tables 1 and 2. Northern Europe is known to be advanced and industrialized region, having strong trade surplus performance. However, from mid of previous decade this all have changed, particularly in Finland (trade surplus of 7-8 bill. USD has declined to the level of 1-2 bill. USD). Interestingly, this worrying declining performance is caused by two countries, and comparative disadvantage of Finland to their structures. So, if we exclude import and export data of China and Russia, trade performance has barely changed at all[14].

Table 1

Finnish export and import account with trade balance from total trade and trade balance without taking China and Russia into account

Year	Export	Import	Trade balance	Trade balance (without China and Russia)	Difference (%)
2005	$65,238,316,354.00	$58,472,542,339.00	$6,765,774,015.00	$9,384,756,972.00	38.7%
2006	$77,279,102,962.00	$69,427,442,555.00	$7,851,660,407.00	$12,557,054,983.00	59.9%
2007	$89,798,884,876.00	$81,576,271,859.00	$8,222,613,017.00	$13,657,534,848.00	66.1%
2008	$96,896,070,517.00	$92,189,842,878.00	$4,706,227,639.00	$11,846,001,080.00	151.7%
2009	$62,860,482,542.00	$60,830,316,844.00	$2,030,165,698.00	$8,459,697,271.00	316.7%
2010	$69,404,781,172.00	$68,246,053,482.00	$1,158,727,690.00	$8,530,127,174.00	636.2%

Source: United Nations (2011). International Merchandise Trade Statistics. Available at URL: http://comtrade.un.org/ Accessed: November.2011

Table 2

Swedish export and import account with trade balance from total trade and trade balance without taking China and oil into account

Year	Export	Import	Trade balance	Trade balance (without China and Oil)	Difference (%)
2005	$130,263,720,466.00	$111,351,341,748.00	$18,912,378,718.00	$26,946,371,503.00	42.5%
2006	$147,370,407,950.00	$127,100,924,462.00	$20,269,483,488.00	$30,248,136,110.00	49.2%
2007	$169,061,476,944.00	$152,822,698,820.00	$16,238,778,124.00	$27,358,269,116.00	68.5%
2008	$183,880,641,872.00	$168,981,675,433.00	$14,898,966,439.00	$29,905,375,747.00	100.7%
2009	$131,116,175,379.00	$119,948,706,612.00	$11,167,468,767.00	$18,935,626,265.00	69.6%
2010	$158,079,152,968.00	$148,421,217,963.00	$9,657,935,005.00	$21,155,128,789.00	119.0%

Source: Ibid.

[12] K. Ohmae: *Triad Power*. Free Press, USA 1985.

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Similar situation, but within lower magnitude, is present in Swedish trade account. Surplus overall has lost half of its performance in observation period of six years. If we exclude China and oil from statistics, then half of this decline is taken away (oil, and not Russia, since Sweden has imported oil in recent years from Russia, Norway, UK and Algeria). In Finland dependency on Russian oil is more than 90% from oil imports (actually Finland is 100% dependent on oil, coal, uranium, and natural gas imports[15]. It is interesting to find out that Sweden is performing much better in high oil price environment – most probably this is caused by stronger export industry, since oil consumption in both of the countries has been declining in the observation period by 8%.

So, question remains, whether this shown restructuring of developed economies is going to develop in the future. We do not see any major threat for it in macro-scale: (1) China has reached critical mass in manufacturing operations, and offers extensive market for sales of products too, while having still comparative advantage in salaries and total costs, and (2) Russia enjoys from very loose monetary policies in developed economies (resulting on inflationary price increases in raw materials, like oil from mid 90's is nowadays ten times more expensive, having similarity with gold), and increased demand caused by underdeveloped emerging economy energy production systems (which are starved for primitive fossil fuels, like coal and oil). Many nations have sought remedies to change BRIC dominance, like free valuation of Chinese currency Yuan. However, in 70's similar currency strengthening was demanded from Japan, and it only stopped their manufacturing sector export growth – Japanese manufacturing is still alive and well in global scale[16]. In Russian case their export surplus is caused mostly by oil and partially by gas and other commodities. Even if global demand for oil would cool down, it is known fact that major producers (Russia and Saudi Arabia) have had declining oil production volumes in the recent years. Some researchers argue that major producers have reached their peak in production (like Russia[17] in 2009; entire world is having production peak soon[18]), like USA reached in 70's, and is currently producing only one third of its oil need domestically[19]. If loose monetary policies will continua due

[15] See: J. Yliskylä-Peuralahti, M. Spies, A. Kämärä, U. Tapaninen: *Finnish Critical Industries, Maritime Transport Vulnerabilities and Societal Implications*. Publications from the Centre for Maritime Studies, University of Turku, A 55. Turku, Finland 2011.

[16] R.C.K. Burdekin: *China's Monetary Challenges: Past Experiences & Future Prospects*. Cambridge University Press, UK 2008.

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[19] *BP Statistical Review of World Energy June 2010*. www.bp.com/productlanding.do?categoryId =6929&contentId=7044622 (03.2011).

to developed nations economic problems, then even in very mild demand of oil, prices will sustain (and should not have major decreases, like they did in 80's, after inflation and Bretton Woods monetary system abandonment during 70's[20]).

Research Methodology

The aim of this study is to use second hand statistics (trade as well as container handling), and logistics flow survey completed during four occasions between years 2006-2011. We concentrate in this research work on the national economies of Sweden and Finland, but also on the actor level decisions related to logistics flows and supply chain configuration.

Survey part of the research work was conducted by utilizing a web-based questionnaire, which was translated into English, Finnish and Swedish. The research sample was gathered from two leading economical magazines, Talouselämä from Finland and Affärsdata from Sweden. Both magazines gather TOP500 company listings, giving good base for our research. We either sent survey form link to directly logistics director of these respective companies or in a case of not having direct contact, sent email to respective company's info address. This practice has been seen as workable way to move forward as survey has been repeated so many times. As strategic information from logistics flows is difficult to obtain, we sent in each year initial contact email and in many cases three remainders (each respondent had own code in answering, further increasing reliability of our sample).

As not all companies listed in TOP500 lists do not have significant logistics flows at their disposal (e.g. financial, software, and insurance), the total sample was less than 1000 companies: During years 2009-2011 survey was sent roughly to 500 respondents (both Sweden and Finland together), while in the base year 2006 we contacted 768 companies. Response amounts have not been that great as in each year we have achieved below 10% response rate. Interestingly during first survey round we achieved approx. 8% response rate (maximum), and during years 2010 and 2011 response rate of 5% (minimum). However, absolute amount of answers have been above 25, giving some confidence over the analysis results.

All respondents were managers or in such a position, that were having a strong experience in the field of logistics. Due to this information, the sample's reliability is strong. Furthermore, the fact that same questionnaire was utilized in previous studies, confirms the survey's validity. We have also visited companies

[20] More see: M.A. El-Gamal, A. Myers Jaffe: *Oil, Dollars, Debt, and Crises*. Cambridge University Press, Cambridge, UK 2010.

and have completed case studies during years 2006 and 2010. These site visits confirmed that our research area is valid, interesting, and used survey form applicable to its purpose.

Research Environment: Foreign Trade Analysis from Period of 2002-2010

Trade of Finland and Sweden with RIC is far from homogenous. Most beneficial in terms of surplus is Indian trade, where in observation period both countries have enjoyed from surpluses of 20-60% (fig. 1). This is clearly driven by own export activity in boom period, and growth bypassing credit crunch year 2009 with significant growth of 2010 (fig. 2). Finnish export is more than three times higher than in base year, while Swedish growth shows above two times higher numbers.

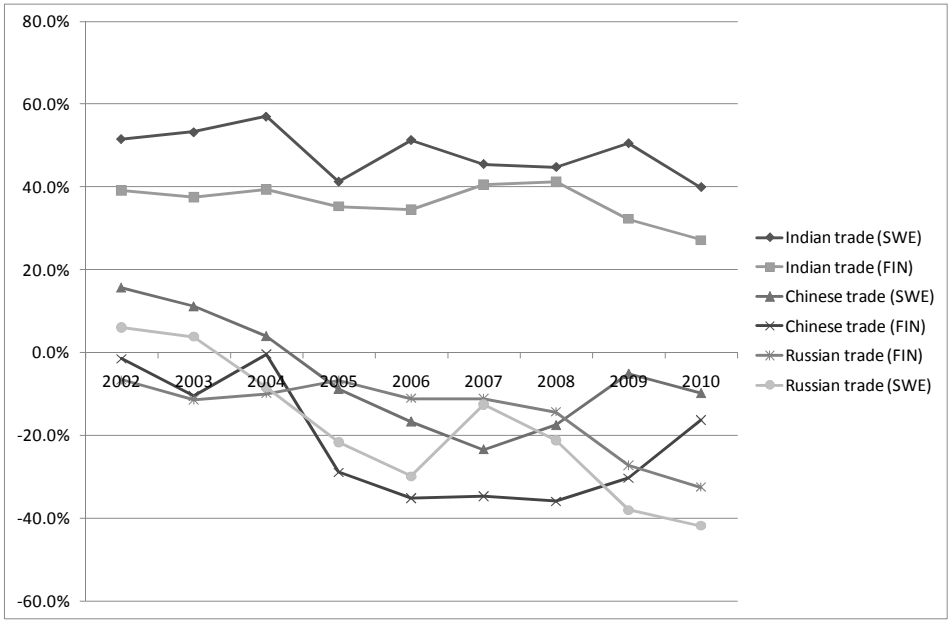

Fig. 1. Finnish and Swedish foreign trade deficit (from total trade) with RIC countries during period of 2002-2010

Source: Finnish Customs (2011). *Foreign Trade Statistics*. Available at URL: www.tulli.fi/en/finnish_customs/statistics/index.jsp Retrieved, June.2011; Statistics Sweden (2011). *Swedish statistics database concerning trade*. Available at URL: www.ssd.scb.se/databaser/makro/MainTable.asp?yp=tansss&xu=C9233001&omradekod=HA&omradetext=Handel+med+varor+och+tj%E4nster&lang=1 Retrieved, July 2011.

Chinese and Russian trade are both problematic for Finland and Sweden – their magnitude is so important, but they have also shown to be producing endless deficits during the observation period (fig. 1). A bit delighting is Chinese trade deficit recovery to level of –10-20% in the most recent year. However, as volumes in trade are so high, this still corresponds in absolute terms nearly 1 billion euros of trade deficit. Even if there is some hope in Chinese trade, Russian proportional trade deficit is all the time growing, and declines in Swedish case to –40% in the most recent observation year (in Finland it is –32.5%). Deficits are in range of 3-4 billion euros – higher absolute deficit for Finland, as its trade is having higher volume.

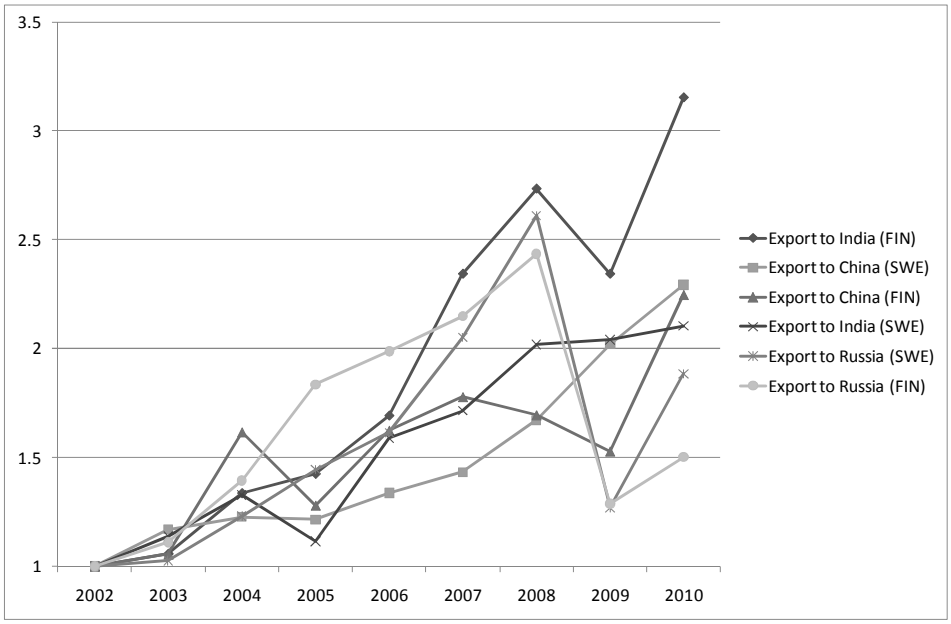

Fig. 2. Finnish and Swedish export development with RIC countries during period of 2002-2010 (base year 2002 is 1.000)

Source: Ibid.

Divergence between India and China vs. Russia could be further analyzed in fig. 2 through export's total value development. Chinese and Indian markets give some positive volume development for two North European countries, but in Russia after credit crunch recovery has been really slow. This sluggish development is especially problematic for Finland, which needs to go back nearly six years to find similar low level of exports. As negative world-wide effects of sudden US led credit crunch were eased with low interest rates, infrastructure building based stimulus and quantitative easing (money printing), it was not that surprising to see raw material prices to recover. This helped Russian economy particularly, and raw material exports combined to increased amount

of foreign direct investments on factories have benefitted Russian exports. Also many Finnish and Swedish companies have invested on factories in Russia, and this among raw material price appreciation, explains trade deficits by most part (as these products are not only distributed to Russian markets, but also to European Union).

Empirical Research Results

Northern Europe and Russia

Some indication from larger scale change of other than raw material product flows could be detected from survey responded by Finnish and Swedish manufacturers, all of which are having significant material flows at their disposal (fig. 3). During year 2006 these companies responded that Russian market is mostly going to be served from European factories (balance is approx. 70%, so on the average 85% from the flows are in eastbound, while 15% are westbound). However, level of westbound dominance declined considerably during survey years 2009 and 2010. Most recent survey year 2011 did not show continuum in this respect (actually it was reverse), but indicated that companies are still thinking that Russian originating flows are about to increase in the future.

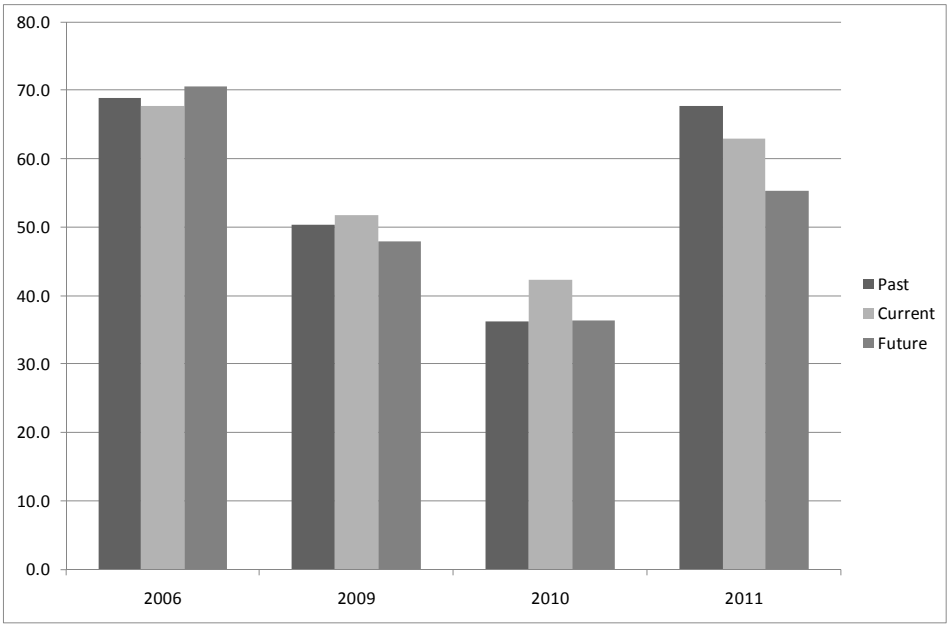

Fig. 3. Transportation flow balance (positive indicates more transport from Europe) between Europe and Russia among respondent companies during four different surveys (2006-2011)

Table 3

Volumes in TEUs within respondent companies (Finland and Sweden) during most recent survey to/from Russia (calculated with flow balance and responded class average of TEU vol.; n = 17)

	Past	Current	Future
From Europe to Russia	87130.2	95515.3	119440.0
From Russia to Europe	1025.3	2140.7	12966.0
Total	88155.5	97656.0	132406.0
Difference (EUR-RUS)	86105.0	93374.7	106474.0

If we think about transportation balance through volume (e.g. TEUs), then situation is in large parts unchanged during the most recent survey round (table 3). Of course there is clearly notable that Russian based volumes are about to increase very significantly within near future, but as very high level European based volume more than sustains, leading absolute difference to even widen. Please note the estimated volume of above 130 000 TEU within near future, which is much higher than India and China combined together (analyzed in the following sub-sections). Situation would not be so infavour of Europe, if years 2009-2010 would be used.

Northern Europe and India

As macro-economic export statistics clearly showed, Finland and Sweden both enjoy from healthy trade relationship with India – in other words export from Northern Europe is much higher than from India to other direction. This has been supported by actual product flows within varying degree. As fig. 4 shows, during survey years 2009 and 2010 flows have originated a bit more from Europe to India than other way around. However, in year 2006 situation was more or less entirely balanced, and future did not hinder then any large--scale changes in current modus operandi. However, during years 2009 and 2010 already companies reported to start to import more items from India, and especially during year 2009 export dominance trend of Northern Europe was shrinking. These early indications from possible occurring change were turned into reality within last survey, where companies reported to already use extensively Indian suppliers/factories in their material flows. So, based on this export surplus of Sweden and Finland would be experiencing the discontinuity at the moment, and actually trade would be starting to potentially repeat Chinese type of deficit pattern.

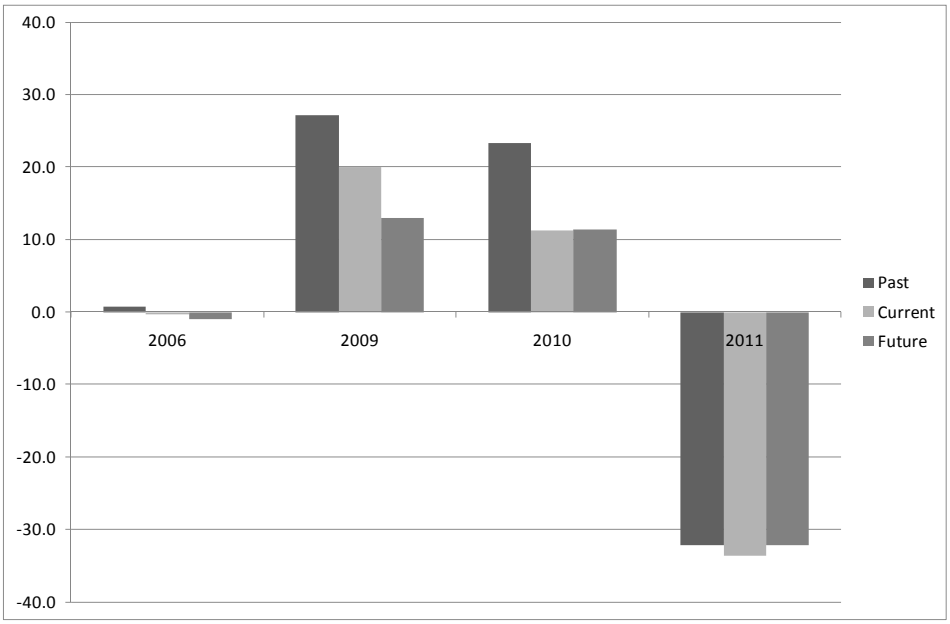

Fig. 4. Transportation flow balance (positive indicates more transport from Europe) between Europe and India among respondent companies during four different surveys (2006-2011)

Table 4

Volumes in TEUs within respondent companies (Finland and Sweden) during most recent survey to/from India (calculated with flow balance and responded class average of TEU vol.; n = 15)

	Past	Current	Future
From Europe to India	763.0	708.0	688.0
From India to Europe	1438.5	1493.5	1513.6
Total	2201.5	2201.5	2201.5
Difference (EUR-IND)	-675.5	-785.6	-825.6

In earlier we were analyzing more than hundred thousand TEUs in Russian case, but Indian overall volumes are roughly 50 times lower (see table 4). So, this market is rather underdeveloped in the respondent organizations, and even if flows from India to Europe dominate the whole three point time-scale, differences are very low (in the end below 1000 TEU).

Northern Europe and China

As earlier research environment analysis showed, trade in value between China and two examined North European countries started to be deficit oriented from year 2004 onwards. This is apparent from our survey findings out of two North European country's companies, shown in fig. 5. During years 2006 and 2009 situation was still in some sort of control, and having some standard deviation around entirely balanced transportation flows. However, even then companies were reporting to use more extensively Chinese originated flows to Europe in future. Regarding to credit crunch and economic crisis, companies decided to source and manufacture more from China, and flows even in Swedish and Finnish companies have heavily turned as significantly deficit oriented. Striking is the fact that level of 50% is reached in most recent survey year 2011. Based on the last survey round, there is some indication that Chinese led sourcing and manufacturing is a bit easing in the future, but only in very small extent.

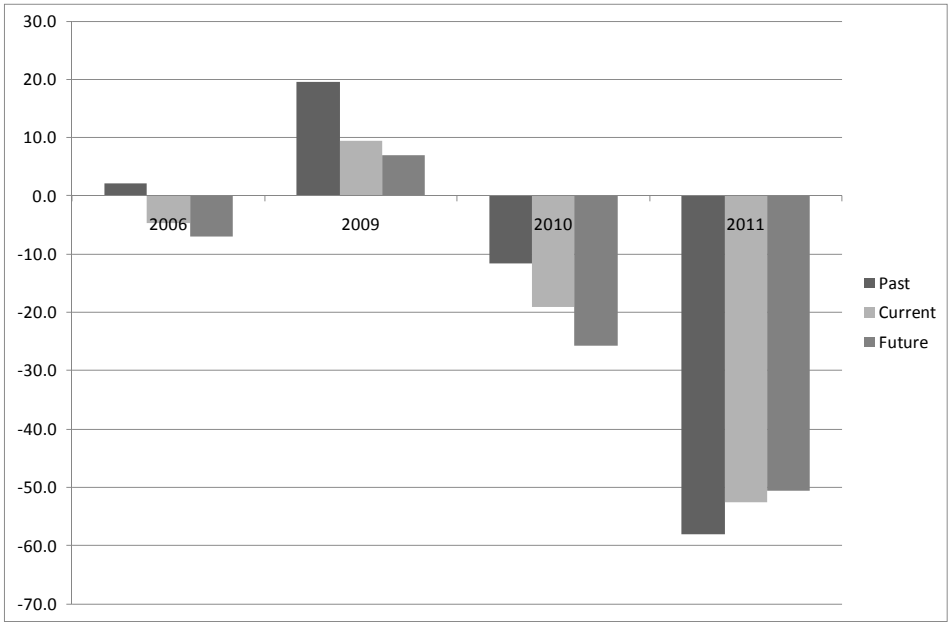

Fig. 5. Transportation flow balance (positive indicates more transport from Europe) between Europe and China among respondent companies during four different surveys (2006-2011)

Table 5

Volumes in TEUs within respondent companies (Finland and Sweden) during most recent survey to/from China (calculated with flow balance and responded class average of TEU vol.; n = 15)

	Past	Current	Future
From Europe to China	7717.1	10753.7	9201.2
From China to Europe	4935.4	33350.8	14853.3
Total	12652.5	44104.5	24054.5
Difference (EUR-CHI)	2781.6	-22597.1	-5652.2

In volume terms, companies experience at the moment peak in Chinese based volumes (table 3) as in total transportation flows are more than 44 thousand TEU. However, for the near future companies expect this to nearly halve. Surprisingly, Chinese originating volumes are going to experience very significant drop, while European based volumes are going to decrease only a bit. This change is apparent in the final row of table 5, where very unbalanced situation of current situation changes to just slightly unbalanced. We may not see this forthcoming possible change yet from fig. 5 as it does not incorporate volumes, and gives each answer equal amount of voting power. So, this contrast between table 3 and fig. 5 could be explained with basically one respondent, which is evaluating to have some growth in European based volumes to China, and in same time reports that its container flows between these two continents is about to ease in the future.

Discussion – Problem of Very Sparse Transport Volumes

During the all four survey years we have experienced similar kind of challenge in responses, where transportation volumes have with average or median numbers remained as low, but statistical sample contains some very active companies too, which transport e.g. 10-100 times more than others. As fig. 6 and 7 illustrate, Chinese and Russian transport demand is dominated by lowest class (or classes, as lowest class of 0-1000 TEU was split in two during year 2011: 0-100 TEU and 101-1000 TEU respectively). So, based on the survey findings, most significant part (70-80%) of transport demand is in the lowest class.

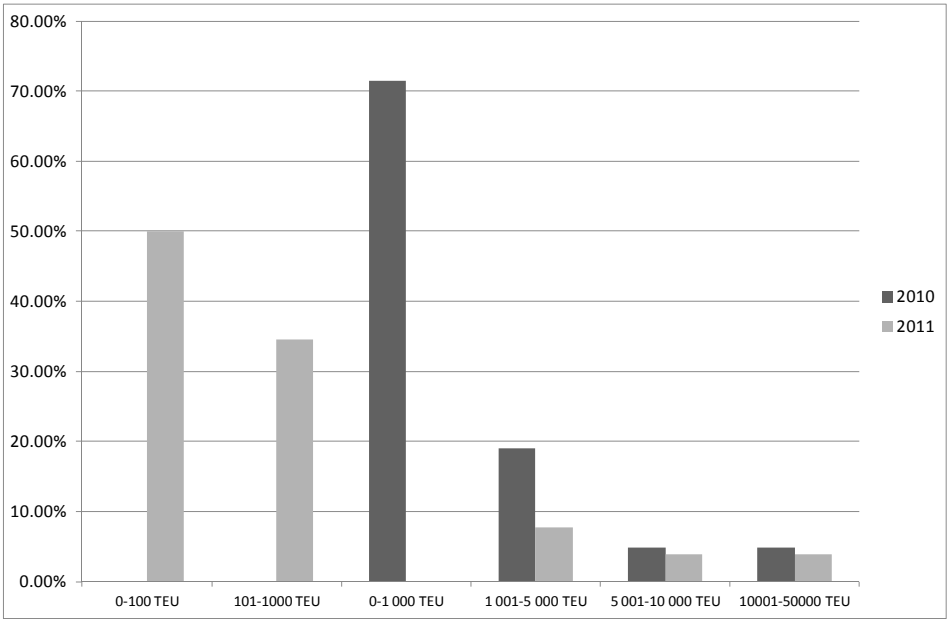

Fig. 6. Frequency histogram out of percentage distribution of transportation volume between Europe and China in respondent companies (as of currently), n = 21 (2010), 26 (2011)

Simultaneously with very low demand from large amount of actors is accompanied with very few companies having extremely high volume. As fig. 6 shows, in both of the years transportation volume between Europe and China has had companies transporting more than 10 001 TEU, also lower class of more than 5 001 TEUs has had actor in it. There does not exist any consistency or explaining factor behind these large volumes; Chinese high classes have been caused by both Finnish and Swedish companies, and they have been from diverse set of respondent classes.

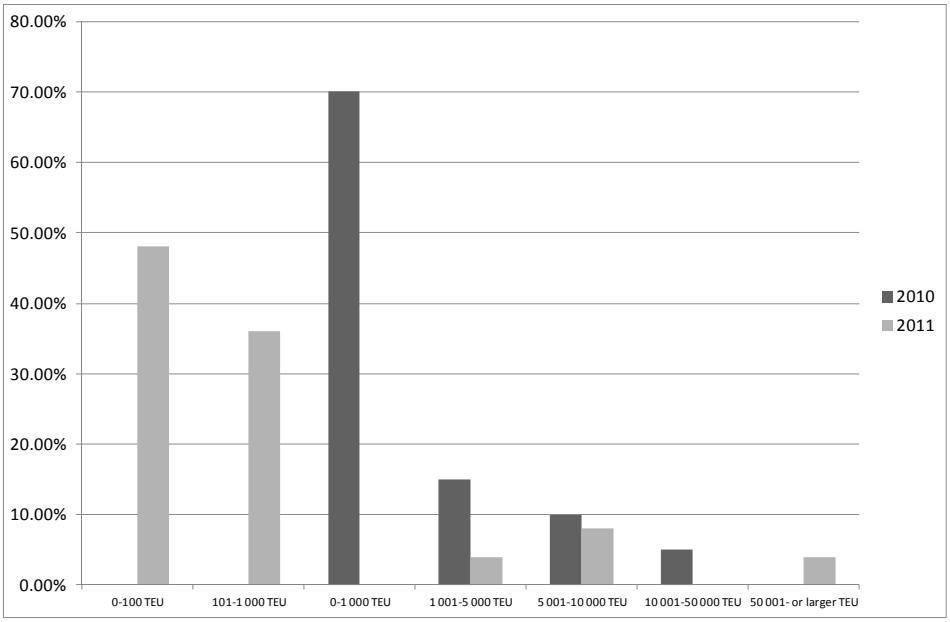

Fig. 7. Frequency histogram out of percentage distribution of transportation volume between Europe and Russia in respondent companies (as of currently), n = 20 (2010), 25 (2011)

Similarly with Chinese situation, Russian transportation volume is having some limited amount of companies in highest classes (one company in year 2011 even reported to have volume of more than 50 001 TEU). Situation in Russian market is such that Finnish companies do nearly always (in 2010 and 2011 only Finnish ones) have the high volume at their disposal. Swedish companies could be described as inactive regard of this emerging market, and nearly all answers during year 2010 fall into lowest volume class (except for one), and during year 2011 all answers are given for two lowest classes (which correspond lowest class in the year 2010).

Conclusion

This research sheds light on the future of global supply chains from the point of view of North European companies. We know that successful Swedish and Finnish companies have in the early on established presence through manufacturing operations in India and China (e.g. Ikea, H&M, Electrolux, Nokia, Kone), but also few examples exist from Russia (e.g. Nokian tyres). Based on

this research work we do not find any end in this decade ago started RIC process: China seems to be in very robust position in manufacturing and subcontracting sense, and India as well as Russia are both emerging. Seems that India is a bit better positioned and already in the action, while Russia is still having its future potential. However, in volume wise order of importance is different, it is being led by Russia, and followed closely by China. In India volumes have not taken any significant level yet, and it remains to be seen, whether companies start to integrate India properly in their global supply chains. Our research illustrated that Russian potential from North European angle is more in the hands Finnish companies, while in some respects Chinese robustness is challenged in the future from responses of high volume companies.

Results of this research work are not only indented to serve for profit companies running global supply chains – our purpose is also a bit macro-economic. As analyzed in research environment, Finland and Sweden as nations have trade surplus only with India, while China and Russia are showing impressive deficits. We do not see any major threat that India will develop like China within near future. Of course traffic flow is starting to be unbalanced, but it lacks volume. So, companies need to have at least three to five years to invest and have factories operational that export surplus in Indian trade will diminish. In contrary, Chinese trade deficit is going to hold, even if in the previous years it has a bit eased. Our research work shows that companies have strong trust on Chinese based manufacturing, and first time in year 2011 survey we identified that companies do not see this activity to increase (imports to Europe). However, respondents didn't indicate otherwise either, except of one high volume actor, who considers to use China less in the future (and has also emphasis on lower overall transport volume, so producing more inside of continent). So, we assume that trade deficit with China remains. In Russian case trade deficit has developed as enormous to Sweden and Finland due to raw material price inflation in recent years. As Russia is becoming increasingly wealthy, there exists greater possibility that manufacturing activity in the country will pick up too (eventually leading to larger trade deficits). Our survey shows that this scenario is still an option – in some companies this option has already realized, and maybe in the medium term this will change in larger crowd too.

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Chapter Three

CITY LOGISTICS

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IMPROVEMENT OF TRANSPORT SYSTEM FUNCTIONALITY AND INTEGRATION OF PUBLIC TRANSPORT IN THE POZNAŃ AGGLOMERATION*

Introduction

Work on the integration of public transport systems in Poznań and in the surrounding municipalities was first initiated in 2006 as the City of Poznań commissioned CEG Sp. z o.o. with its registered office in Poznań with a task to draw up a study specifying the possibilities of organising mass transport within the agglomeration. At the beginning of 2007, experts of CEG prepared a document including the characteristics of a few dozen or so options along with their recommendations. The selected model assumed the development of an inter-municipal union, with the key role played by an organiser and regulator of the local transport market which holds various competences, is a public entity and allows operators of different ownership structure to provide transport services. The model received political approval. In the course of further actions, the Council of Poznań Agglomeration was established, which aims at the integration of various functions provided by Poznań and particular municipalities, including also the public transport. A very important stage on the road to the full integration of public transport was the establishment of Zarząd Transportu Miejskiego (ZTM – Urban Transport Authority), an organiser and regulator of public transport, on October 1st 2008. After two years, on November 9th 2010, in line with the act adopted by the City Councils of Poznań and Luboń, based

* This article was prepared based on long-term work of the Authors as experts preparing documents of strategic importance for the City of Poznań and Centrum Badań Metropolitalnych in Poznań, inter alia: *Zielona księga aglomeracji poznańskiej* and *Strategia rozwoju aglomeracji poznańskiej. Metropolia Poznań 2020*, *Strategia rozwoju Miasta Poznania 2030*.

on the existing ZTM, Związek Międzygminny "Transport Aglomeracji Poznańskiej"[1] (ZM "TAP" – Inter-municipal Union "Poznań Agglomeration Transport") was set up. The aim of the Union is to fulfil the own tasks of the city and municipalities as regards local mass transport services, modernise and develop the existing transport system as well as unify local mass transport services and accelerate the process of integration of municipal transport systems. The tasks so far performed by ZTM and particular municipalities such as: route planning, timetable composition, ticket sale, propagation of passenger information, are to be taken over by the Union[2].

As a result, it can be acknowledged that the task of establishing a municipal public transport union with the municipalities from the metropolitan area has been fulfilled – as of October 1st 2011, all urban transport lines in Luboń and selected lines serviced by ZUK Komorniki were merged into one coherent urban transport system. This means that a unified line numbering and, what is most important, a unified ticket tariff (one ticket) have been applied to the above lines. The task, however, has been fulfilled only to a limited extent, as the remaining 9 municipalities surrounding Poznań still have their own local transport systems[3]. Hence, it is necessary to take further actions to extend the operations of the Union, mainly increasing the share of the public transport in the transport tasks within the metropolitan area.

Lack of a railway transport provider, the key operations of which would be the provision of agglomeration transport services, has led to the participation of the Marshal Office of the Wielkopolska Region in the work on prospective concept for passenger railway transport system in the region. The Wielkopolska authority unit became the organiser of regional transport services by force of the resolution on taking over regional transport services (at that time performed by Przewozy Regionalne company) adopted by the regional assembly (sejmik województwa) on September 28th 2009. The following characteristics were estimated and described: passenger streams on transport routes to the agglomeration, indispensable number of train pairs a day, location of new railway stops in the agglomeration and in Poznań[4]. The agglomeration railway transport system is to form a framework for the mass transport system operating as agglomeration transport system and urban transport system for the citizens living in the outskirts of the city. Trains on the remaining lines could provide

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1 A similar resolution was adopted by the councilors of the Dopiewo municipality on 28.02.2011.

2 www.ztm.poznan.pl/integracja/zmtap (20.12.2010).

3 The so-far conducted actions contributed to the ordering of bus numbers and introduction of zone tickets on a small area as only few municipalities signed relevant inter-municipal agreements with the city of Poznań.

4 R. Jałoszyński: *Więcej dobrych pociągów do stolicy regionu*. "Monitor Wielkopolski" 2010, No. 9, p. 8-9.

intermediate transport services to passengers living in towns and villages located in some distance from the city with no direct connections to the city. Initially, Koleje Wielkopolskie was to start its railway operations in December 2010. It was, however, impossible as the company obtained the safety certificate (required to provide passenger transport services) only on 17.03.2011[5]. The start-up of business operations of the company took place on 1.06.2011 at 4:40am on the route Wolsztyn-Leszno. The scope of transport operations provided by Koleje Wielkopolskie is not impressive, however, as trains operate only on 3 lines connecting Zbąszynek with Leszno, Leszno with Jarocin and Leszno with Ostrów Wielkopolski.

A study conducted by R. Bul in March 2011 shows that on working days at early daytime hours (5:00am – 8:00am – trains and buses, 5:30am – 8:30am – personal cars) over 60k people travel from the surrounding municipalities to Poznań. The majority of them travel by car (ca. 52k people, 40k vehicles), 9k people travel by trains and only a few hundred of them take PKS buses (mainly from the direction of Śrem and Pniewy). According to the study, most travellers got off at the Poznań Główny station (over 7.5k passengers), with nearly 4k passengers arriving from the south (travellers from Leszno, Wolsztyn, Jarocin and Zbąszynek) and 3.5k passengers from the north (travellers from Szamotuły, Oborniki Wielkopolskie, Wągrowiec, Gniezno and Września). Such stops as Poznań Garbary, Poznań Wschód and Poznań Dębiec are also important transport nodes.

As regards the road transport, the largest stream of passengers was observed on the national road no. 92 from the west (from the Tarnowo Podgórne municipality) – almost 3k vehicles, the national road no. 5 from the south (from the Komorniki municipality) – over 2.5k of vehicles and on road S-11 from the south (from the Kórnik municipality) – also over 2.5k of vehicles. These are the directions without railway lines (at least partially) which may be the reason for a more intense use of individual transport. It turns out, however, that a significant volume of personal cars is observed also from the directions serviced by the railway transport system i.e. Gniezno, Swarzędz, Mosina, Luboń and Oborniki Wielkopolskie. It means that the agglomeration railway transport system has a large potential – it only needs to be managed in a proper manner to develop a high quality offer, which would encourage people travelling by cars to change the means of transport.

[5] The company received the A part of the certificate approved by the president of UTK already on 3.03.2011.

Necessary actions – characteristics

The key task aimed at increasing the share of public transport in the passenger stream service is to develop an attractive agglomeration railway transport network. The authors of this study support the proposals prepared by the Marshal Office of the Wielkopolska Region, whereby agglomeration trains were to travel on five routes (fig. 1).

Trains proposed on the above lines are to travel frequently and, what is important, at fixed intervals: on urban routes – even 4 times per hour, on the main routes connecting Poznań with particular municipalities surrounding Poznań – 2-4 times per hour, i.e. every 15-, 20-, 30- or 60-minutes.

Table 1

Agglomeration railway transport system routes

Line no.	Route	Traction and max. speed (km/h)
S1	(Gniezno) – Pobiedziska – Poznań Wschód – Poznań Główny – Luboń – Czempiń – (Kościan)	electrical, 160
S2	(Września) – Kostrzyn – Swarzędz – Poznań Wschód – Poznań Główny – Poznań Górczyn – Opalenica – (Nowy Tomyśl)	electrical, 160
S3	(Wągrowiec) – Murowana Goślina – Poznań Wschód – Luboń – Stęszew – (Grodzisk Wielkopolski)	diesel engine-powered, 120
S4	(Wronki) – Szamotuły – Rokietnica – Poznań Jeżyce – Poznań Główny – Poznań Starołęka – Środa Wielkopolska (Jarocin)	electrical, 120 i 160
S5	(Rogoźno) – Oborniki Wielkopolskie – Poznań Jeżyce – Poznań Główny	electrical, 120

Stops which agglomeration trains are to reach less often are specified in brackets.

Source: Marshal Office of the Wielkopolska Region in Poznań.

It is necessary to coordinate timetables of particular lines properly, so that the waiting period for another train is as short as possible. Some of the existing train stops/stations need redevelopment to become actual multimodal transport nodes. In the first place, the following stops/stations should be redeveloped:

– Poznań Dębiec,
– Poznań Górczyn,
– Poznań Junikowo,
– Poznań Starołęka,
– Poznań Wschód.

It is also important to ensure good quality passenger information, i.e. provide information about a particular line and line structure on the trains as well as at all stops and stations. The information must be updated on a regular basis also during planned renovation works as well as in unexpected events, such as breakdowns, accidents, etc. The staff of Koleje Wielkopolskie has to be properly trained so as to provide passengers with assistance, support and information at all times.

Travel comfort and safety as well as safety at stops and stations are of equal significance. As regards the former, proper investments have already been made by the Marshal Office of the Wielkopolska Region. On 8.02.2011, a contract for the delivery of twenty-two 4-module electric multiple units ELF was signed with PESA from Bydgoszcz (contract value: almost PLN 470m[6]. New, comfortable and fast rolling stock (max. speed: 160 km/h), which is less likely to break down, will enhance the reliability of planned timetables, decrease the number of train sets held as rolling stock reserve and diminish the costs of rolling stock maintenance and its renovation.

Apart from purchasing the rolling, it is also important to modernise railway stops and stations, improve their accessibility and construct P&R (*park & ride*) and B&R (*bike & ride*) parking lots as well as K&R (*kiss & ride*) drop-off zones. It will also be important to increase the number of performed functions to attract more and more passengers. Investors are to be sturdily encouraged to build commercial and retail centres in the vicinity of railway stations. To reach this goal, endeavours are to be taken aimed at the takeover of railway stops and stations by local authority units. Local authority units are to be responsible for shaping the spatial development policy, so that new higher density housing estates are constructed in the surroundings of railway stops and stations (max. within 1 km radius) as well as for taking care of the housing estate planning to ensure safe access to railway stops and stations for both pedestrians and cyclists.

New railway stops and stations are to be constructed, which will make railway transport system more accessible to the largest possible number of people, both in Poznań and in the municipalities within the borders of the Poznań poviat. Investments should be carried out in the following locations:

- Poznań Jeżyce,
- Poznań Golęcin,
- Poznań Podolany,
- Poznań Wilda,

[6] www.umww.pl/urzad/aktualnosci/umowa-na-22-nowe-pociagi-dla-wielkopolski-podpisana.html (27.10.2011).

– Poznań Zawady,
– Poznań Miłostowo
– Poznań Zegrze,
– Poznań Naramowicka
– Poznań Uniwersytet

as well as numerous stops located on the lines within the agglomeration located at the biggest existing and planned housing estate.

For the first time the operations of the agglomeration railway transport system will be supposedly tested in December 2011 when along with the release of a new timetable (although works are to be fully completed in 2013) trains operating on the routes Murowana Goślina – Grodzisk Wielkopolski or Wolsztyn (line S3)[7] will appear on modernised lines 356 and 357 and will start operating more frequently than currently. Decision makers have to remember not to be discouraged by only small successes at the beginning – evident effects of scale will be visible only when the entire agglomeration railway transport system enters into operation. At the same time, in order to integrate the entire public transport in the agglomeration it is necessary to conduct a string of actions in the public transport area both in Poznań and in the surrounding municipalities.

The success of the public transport system integration process will be measured by the number of municipalities within the borders of the Poznań metropolitan area operating as part of ZM "TAP". At first, it is important to attract municipalities generating the largest passenger streams commuting every day to Poznań, i.e. municipalities of the so-called primary transportation ring (directly bordering with Poznań). It is also important not to limit transport services to buses only, but ultimately include also local railway transport services. Związek Międzygminny should also include PKS Poznań, the fleet and potential of which can be used, apart from the existing transport services, to provide transport services to and from railway stops and stations. Such integration of transport services combined with proper arrangement of timetables (bus timetables as complimentary to agglomeration train timetables) would translate into significant positive effects of scale both for passengers and transport system operators cumulating passenger streams and offering them fast and efficient transport services.

To achieve success, it is necessary to implement promotional and educational actions presenting benefits of the integrated public transport system as part of ZM "TAP". The actions should be addressed at both local authority units and citizens. The citizens should be educated in terms of the actual costs of travelling by car, i.e. individual costs (all costs, not only costs of fuel) and external costs

[7] Only initially as ultimately S3 line is to connect Wągrowiec with Grodzisk Wielkopolski.

(social and environmental) known only to a limited group of people, as it impacts daily transport-related decisions. Broadening the knowledge and increasing awareness among the citizens combined with preparing an attractive transport offer would increase the demand for public transport services.

Apart from organisational and promotional & marketing actions, the integration process will also require developing new infrastructure and modernising the old one. The priority for the authorities of Poznań, in line with the intention expressed for many years to ensure sustainable transport development, should be increasing the access to tram transport network. In the densely populated area of medium-sized cities it is the tram that proves highly efficient and competes effectively with individual car transport, contributes to the development of the city and becomes its symbol (as in the case of many French cities).

Until 2020, the currently conducted investments are to be completed (extension of PST (Poznań fast tram) along with the construction of a tram terminus at Dworzec Zachodni (Railway Station West) and construction of a tram route to Franowo along with a tram depot) and the tram transport network in Poznań is to be extended by the following stretches[8] and some infrastructure elements:

- Route to Naramowice district along Garbary street, Szelągowska street and Naramowicka street and its connection with the tram terminus in Wilczak district. The route is to enable the fastest connection between the city centre and Naramowice district which is developing intensively (ca. 6.5 km).
- Extension of the tram route from the tram terminus in Ogrody district in J.H. Dąbrowskiego street to Polska avenue along Nowina street (ca. 1 km) and construction of a new bus and tram station at Polska street and J.H. Dąbrowskiego street.
- Route along F. Ratajczaka street, C. Ratajskiego square and F. Nowowiejskiego street to the junction of K. Pułaskiego street and Wielkopolska avenue (ca. 1.7 km).
- Extension of a tram line from the tram terminus in Zawady to Poznań-Wschód railway station (ca. 1 km) and construction of an interchange station at that place.

In the years 2020-2030 the following tram routes are to be constructed:

- from the tram terminus in Górczyn district along Albańska street, Pogodna street, Grochowska street and Szpitalna street to the tram terminus in Ogrody district;

[8] The order of investments results from the scale of benefits which, according to the authors, they can result in.

– extension of a tram route from the tram terminus in Dębiec district along 28 Czerwca 1956 street to the planned tram terminus at Dębina housing estate;
– extension of the PST (Poznań fast tram) from the tram terminus at Sobieskiego housing estate to Morasko district, which develops intensively.

It is also vital to develop a network of P&R and B&R parking lots at the main tram termini, in particular:
– in Franowo district – currently in construction,
– at Jana III Sobieskiego housing estate, and if PST tram route is extended – at the tram terminus in Morasko district,
– at planned tram terminus at the junction of Polska avenue and J.H. Dąbrowskiego street,
– in Miłostowo district in Warszawska street,
– in Starołęcka street,
– in Naramowicka street at the end of the planned tram route.

Bus transport system will be complimentary to the tram transport system. To improve its currently dysfunctional operations due to congestion issues, in particular during rush hours, dedicated lanes – the so-called bus lanes – will have to be separated or tram & bus lanes will have to be constructed. The latter solution is to be implemented in 2012 along W. Reymonta street and S. Przybyszewskiego street. The existing tram route will be redeveloped and adjusted to bus transport; tram&bus stops will be constructed. Further plans envisage gradual extension of the above route from J. Nowaka-Jeziorańskiego roundabout to J.H. Dąbrowskiego street and construction of a similar route along J.H. Dąbrowskiego street. The authors of this study are of the opinion that such a solution would prove favourable for all traffic participants, yet the effects of tram & bus lanes operation will have to be scrutinised, so that the solution becomes a benchmark for the next stages of such an investment, e.g. on the stretch from Śródka roundabout to Rataje roundabout. Constructing tram & bus lanes is to be accompanied by the development of traditional bus lanes. The biggest problem related to the development of bus lanes is connected with limited number of two-way roads with two or three lanes. Despite the abovementioned difficulties and surely vigorous protests of the remaining infrastructure users opposing limited capacity, the solution is to be implemented in the following locations:
– in J.H. Dąbrowskiego street in the stretch leading to the planned bus & tram station in Polska avenue,
– in Bukowska street from Roosevelta street to Polska avenue and from the airport to Roosevelta street,

- in B. Krzywoustego street in the stretch to Rataje roundabout,
- in A. Baraniaka street in the stretch to Jana Pawła II street,
- majority of streets serviced by buses within the primary transportation ring, in particular along the entire Solna street, Garbary street and Niepodległości avenue.

Similarly as in the case of trams, buses should also have the right of way at junctions before other road users. The tool increasing the attractiveness of bus transport, especially in the outskirts of towns with dispersed developments, will be the so-called "flexible lines" transporting passengers to the nearest tram termini or interchange bus stops and nearest railway stations (within the borders of poviat). In the opinion of the authors of this study, areas to be potentially serviced by the "flexible lines" are to include Smochowice, Strzeszyn, Spławie, Szczepankowo, Krzesiny, Marlewo, Głuszyna, Piotrowo and Sypniewo.

Providing transport services in the areas with dispersed developments requires the use of mini- and midi-buses. Introducing the mini- and midi-buses would improve the access to urban public transport in the outskirts of the city as well as in particular peripheral municipalities, the citizens of which would have a choice and could use other transport means rather than just being forced to use individual road transport.

The management board of ZM "TAP" should be open to demands reported by citizens as regards the development of new lines, modification of the existing ones, introduction of the "flexible lines" or change of timetables. The effects of introduced changes and the existing solutions should be monitored on an on-going basis to eliminate the least effective solutions and at the same time to adjust supply to demand through tailoring the frequency of transport services and their capacity.

The introduction of the Poznań Electronic Agglomeration Card (Poznańska Elektroniczna Karta Aglomeracyjna – PEKA) will support, as a quasi bottom-up initiative, the integration of transport in the metropolitan area and its growing popularity will become one of the drivers accelerating the process. PEKA is not only useful and comfortable for the agglomeration citizens using public transport system as it has potentially numerous functions but also for the transport system operators as it allows them to make detailed calculations and will become a perfect tool for measuring passenger streams.

Integration actions have to include the unification of the passenger information system (which has been partially delivered by means of introducing unified line numbering), coordination of particular timetables, especially in key agglomeration transport nodes, as well as coordination of transport routes serviced by various transport operators.

The planned initiative of creating a 30km/h restricted speed zone ("Tempo 30") is to cover the city centre area between Niepodległości avenue, Święty Marcin street, Solna street and K. Marcinkowskiego avenue. The plans include the introduction of cycling contra-lanes, among others, in T. Kościuszki street, F. Nowowiejskiego street or 27 Grudnia street, as well as engineering elements and small architecture elements, which are to prevent drivers from exceeding the permissible speed of 30 km/h.

Although many individual drivers are against the establishment of the restricted speed zone "Tempo 30" and are in general against reducing the maximum speed limit, they tend to forget that during rush hours the average speed in the centre of Poznań and even in many streets outside the city centre oscillates around a dozen or so kilometres per hour, while at times in-between the rush hours it is only slightly higher. Paradoxically, as evidenced in multiple Scandinavian or German cities where such solutions have been applied for years, the maximum speed limit of 30 km/h not only contributes to increased safety of pedestrians and cyclists (and drivers themselves), but also increases the average speed of vehicles even up to 25 km/h (owing to smoother traffic flow). The solution will also reduce the level of noise and vibrations. A smaller number of cars in the zone and attractive small architecture elements should encourage people to strolling and contribute to the revitalisation of the entire area. Similarly as in the case of the shared bus&tram lanes, the restricted speed zone "Tempo 30" is also a pilot project and its successful implementation, good quality and satisfactory effects can convince the citizens to such projects and thus trigger the establishment of further similar zones. The authors of the study have no doubts that such zones should be created, in particular in the Jeżyce district (between the following streets: S. Przybyszewskiego, J.H. Dąbrowskiego, F. Roosevelta and Bukowska), Łazarz district (between the following streets: Głogowska, Hetmańska and Kolejowa) and in Wilda district.

Conclusion

The integration of particular systems and increased functionality of public transport following many years of divisions, negligence and chronic under--financing combined with dynamic increase of personal vehicle traffic is a very demanding task, yet it needs to be taken. The strongest driver towards further integration of public transport system in Poznań and peripheral municipalities will be positive experiences and benefits for transport users and operators in Poznań and Luboń. Their example will prove stimulating, if not directly for local politicians, then certainly for citizens who will force the politicians representing them to accede to the integration process.

Paradoxically, the factors favourable to the development of the public transport will also include the increasing level of transport congestion, growing fuel prices on global markets as well as higher excise duty – PLN 0.15 per litre of diesel fuel as of 1.01.2012. The costs of personal car use will go up and it will be accompanied by more and more intensive actions taken by the European Commission aimed at the reduction of external transport costs by means of introducing the principles ”polluter pays” and ”user pays”. Therefore, some drivers will resign from travelling by car, because they will not be able to afford that or they will come to a conclusion that they spend too much time in traffic jams and will choose alternative means of transport.

Environmental awareness supported by relevant informational and educational campaigns (including also transport education classes at schools) should trigger a change in the transport-related behaviour and contribute to a greater demand for mass transport services, popularity of travelling by bikes and to rationalisation of car use, e.g. through *car-sharing* and *car-pooling*.

The implementation of a plethora of actions aiming at restricting car traffic in Poznań, especially within the secondary transportation ring, will have a great impact on the successful delivery of the plan aimed at increasing the share of public transport services. The key action should cover the implementation of a comprehensive parking policy in the city with the following main elements: extension of the existing Paid Parking Zone (Strefa Płatnego Parkowania – SPP); higher parking charges, introduction of parking charges within SPP also on Saturdays; construction of parking lots in the *park & ride* formula; construction of multi-storey parking lots which would contribute to the liquidation of parking places along the streets, stopping the establishment of illegal parking lots; implementation of intelligent transport systems informing about the location of parking lots and number of vacant parking places[9]. The above actions should be accompanied by marking special places for vehicles providing deliveries to business entities and institutions located within the SPP zone[10]. These places are to ensure safe and smooth loading of goods and should not interrupt other road users and pedestrians. Above all, deliveries and waste collection are to be conducted outside rush hours. These rules should also apply to vehicles owned by courier and post companies. In the longer time horizon (after 2020), provided the above actions do not bring the assumed effects, the possibility of introducing congestion charges for vehicles entering the centre of Poznań, as in Stockholm or London should also be considered.

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[9] H. Igliński, *Polityka parkingowa a ograniczanie kongestii transportowej w miastach*. „LOGISTYKA” 2010, No. 5, p. 21-23.

[10] The need is proved by research results. See: M. Szymczak: *Solving Road Cargo Traffic Problems in Cities – A Logistics Approach*. In: *Zarządzanie projektami logistycznymi*. Ed. by J. Witkowski, A. Skowrońska. “Prace Naukowe” No. 11, Uniwersytet Ekonomiczny we Wrocławiu, Wrocław 2008, p. 199-208.

The majority of the proposed actions would translate into transferring capital expenditure from road transport to mass and bicycle transport, which combined with the implementation of a number of actions characterised by different persuasion power will result in a natural resistance on the part of car users. Protests of drivers reluctant to the change in the existing policy focused mainly on the development and modernisation of road infrastructure may discourage local authority units, in particular the authorities of Poznań, from determined delivery of the assumptions specified in the *Development Strategy for the City of Poznań by 2030* for fear of not being re-elected. Such fears are justified – therefore, introducing informational and educational programmes and the dedication of the authorities are crucial. Withdrawal from the policy of sustained development will result in a further decrease in the population of Poznań, higher congestion and relevant costs, intensification of transport problems and many more.

The barrier in the integration of public transport and investments carried out to improve its operations could also be hardships in reaching an agreement between local authority units at different levels. The most important issue and at the same time the most difficult one is the share in financing of particular investment plans as well as a division of costs related to the maintenance and operation of a given infrastructure element. Hardships may also occur when specifying the schedule of implementing actions and delivering investments due to the fact that their significance is different for every municipality.

The biggest obstacle in the execution of the tasks described in this paper will be funds. It will be even more difficult to obtain the funds as the European Union subsidies will be certainly much lower than presently, the city of Poznań is already deeply in debt and the tax base is diminishing due to gradual outflow of citizens from the city.

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MOBILITY – A PUBLIC ISSUE

Introduction

Mobility is one of the basic human needs, a prerequisite to work allotment in society and economic growth. Mobility is natural. Everyone travels, be it by car – to work and to shop or on an airplane – to remote countries of the world. Lorries deliver fresh products to shops every day and production process is realized in accordance with the Just in Time rule.

Unfortunately, this movement is not without interference. Blockages and infrastructure overload occur often and transport connections in the rural areas are being closed. The number of traffic flow is constantly growing and investments in infrastructure are still insufficient. Mostly it is caused by financial deficiencies, planning difficulties or social resistance. And mobility is inherently connected with economic growth. It has a deciding role in the future of the contemporary world.

Shipper as an 'architect' of road traffic

Shippers are generally perceived negatively by the society: lorries cause great traffic in cities and pollute natural environment, slow down traffic and tired drivers constitute a serious threat to other drivers and pedestrians. Yet it is difficult to imagine functional economy without spedition. Even the most efficient companies would be unable to generate profits without delivering their products to consumers or users.

Shipper as a transport intermediary is an architect of traffic, of sorts. Their responsibility is to choose means of transport by which the product will be delivered to the recipients[1]. Currently shippers are struggling against more and more problems, pertaining to, for example, environmental protection requirements, highway fees or constantly growing fuel prices. They must also take into consideration strict safety measures and rules governing working hours of

[1] J.J. Coyle, E.J. Bardi, C.J. Langley: *Zarządzanie logistyczne.* PWE, Warszawa 2007, p. 403.

drivers and entering city centers, for example. Not without meaning is the pressure of delivering the products to recipients in prompt time, amount and quality. A good shipper is able to organise the logistics of the process of transport in such a way that balances the relation between time and cost of delivery.

The greatest challenge seems to be the requirement of realisation of transport objectives in accordance with the rule of balanced development. Consequently logistic operators choose pro-ecologic transporting alternatives where possible. In practice it means preference towards railway transport. However, lacking railway infrastructure[2] and restricted capacity of the train, not only in Poland, but also in Europe often prevent realization of this mean of transport, including short distance deliveries. Then the claiming of the cargo itself and the trans-shipment may take longer than it would in case of shipment via the direct road transport. (bezpośredniego transportu kołowego). That is why a significant share of transport will be conducted via the means of road transport.

A positive effect is usage of combined transport and cooperation between countries in transnational arrangements. New transportation channels through eastern Europe countries have a fundamental role in attempts to restrict arduous traffic. Modernization and extension of trans-shipment areas and logistics centers[3] play major roles as well. In Poland, however, these centers do not cooperate and do not undertake initiative towards creating common intermodal logistic network[4].

Technological advancement poses a great challenge for traffic participants. European exhaust fumes standards growing in strictness certainly partake in reduction of environmental pollution. Nonetheless, carriers are forced to make more ecological transport choices to avoid road tolls. This decision is hard because in 2014 another Euro 6 norm[5] is supposed to go into effect. This fact causes cars meeting norm 3 to be practically worthless. And this in turn causes financial losses. The cars with newer and newer emission exhaustion norms generate higher service costs due to more complex power train, among others.

Another widely discussed technical innovation are Giga-liners, 25 meter long lorries being used in road transport[6]. Majority of European countries are against allowing them to enter the traffic[7]. This disapproval is caused mostly by the fear of overloading bridges and some roads. It also seems unreal to expect such long vehicles to efficiently navigate through narrow and busy roads. This

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[2] Extension of infrastructure repeatedly is not possible from economic and geographic point of view.

[3] I. Fechner: Miejsce centrum logistycznego w warstwie pojęciowej infrastruktury logistycznej. „Logistyka" 2008, nr 3.

[4] M. Foltyński: *Centra logistyczno-dystrybucyjne a rozwój regionalny*. ILiM 2011.

[5] Directive 2007/715/EC[13] for heavy cars.

[6] Their introduction to the traffic is still in testing phase.

[7] Introducing the giga liners to the traffic is currently discussed nly in Germany, Netherland and France.

reason is countered by the fact these lorries are designed to transport cargo only between trans-shipment points. That would not necessitate participating in local and city traffic. Those favoring train transport are afraid of decrease in amount of cargo transported via trains.

Answering the market needs, shippers widened the range of their services. Nowadays, the shipper who wants to stay in business in long term is not only the organizer of cargo shipments, but offers a whole package of services. Big companies relay more and more tasks to outside subcontractors (e.g. storage maintenance). Those agents are dubbed logistic operators[8]. Having their own, well-trained personnel, they take over the overall logistic process organizer, from accepting the order to commissioning, packing, delivery to the recipient and the final assembly. Often the final production operations take place on their sites. Consumer does not even notice that by calling to the manufacturer he speaks to the logistic operator representant. Their employees are trained so well they can solve the customer complaints, make decisions pertaining to repairing or exchanging the product. Often they undertake the consumer satisfaction polls as well.

Appearance of logistic operators is a beneficent influence on the economy. It takes part in process implementation, shortens the transport path between companies and customers, protects the natural environment. This positive effect should be appreciated, however, it would be prudent to keep in mind that the logistic operators are unable to take over all of the external costs, such as those related to the highway fees or environmental investments, by themselves. Some of those responsibilities have to be taken by the employer and, consequently, by the ultimate consumer. This is why instead of imposing new, more strict regulations on the operators, relative balance between protecting the environment and growing social cost should be strived for.

Cargo mobility. Availability versus balanced development

The product achieves its value only when it becomes available to the recipient in terms of time, place and quantity. Availability is easily identified by the consumers: the product either is or is not available on the store shelves. Similiarily, the product orders (e.g. on the Internet) are either delivered promptly or not. Lack of product is equal to stockout. Data presented in FMCG industry report for 2009[9] shows that the average western Europe products deficiency marker is estimated at 8% and has not improved over the last few years. Short-

[8] S. Kwaśniowski, T. Nowakowski, M. Zając: *Transport intermodalny w sieciach logistycznych.* Politechnika Wrocławska, Wrocław 2008, p. 30 and next.

[9] Branchenbericht "FMCG 2009", Marktanalyse. Springer Verlag, Berlin 2009, p. 89.

ages mean lost benefits for manufacturers and traders. This in turn depends on the consumer behavior. If they decide to buy the rival product, manufacturer suffers loses. In the event of changing of place of transaction or cancelling of an order, the retailer is the one to suffer loses. Consequently, the attempts of guaranteeing high availability (high standard of delivery service) depend on the type of product.

As a branch of logistics, product distribution is faced with a dilemma. Adhering to the constantly rising recipients expectations, who expect wide assortment and fresh products from the quickly spoiling products. Aiming to comply, companies try to diversify the offer from the competition by means of offering wide spectrum of ultra fresh products, such as sandwiches or salads. Those necessitate up to few deliveries a day. Besides that, trading companies and manufacturers organise promoting actions, during which the number of sold products rises, leading to shortages on a regular basis. In spite of those difficulties, the deliverers strive to ensure the customers find the products easily available. From this point of view, the product mobility is regarded by the recipients as a gain, pleasure and variety during shopping.

This availability, however, impllicates surge in the amount of product shipped, causing the overload of communication infrastructure and environment pollution. The situation is illustrated by this example: the broadening the assortment offer while having limited shelf surface in the retail point is synonymous with the decrease in stock of each product. Less stock means greater probability of shortages. To avoid that, the products are delivered more often. Minimising the inconvenience requires balanced distribution – in accordance to the balanced development rule. Currently, however, the pursuit of quality service is set above the balanced development.

The matter of balanced development gains more and more meaning. Often it becomes the priority during choosing the strategy[10]. We understand the balanced development as ecological effectiveness, measured by the severity of damage dealt while realisation of the desired product availability. The term 'damage' is a wide term, ensued by the fact that logistics influences both the society and the environment. It includes mainly the strain on communication infractructure, energy and materials consumption and pollution.

The problem of balanced development in food companies branch is widely discussed. In this matter, the general merchandise retailer TESCO can be considered a forerunner, since it was the first one to document CO_2 consumption of their products' manufacturing[11]. Reports of the CO_2 emission are being made

[10] A. Chmielak: *Wybrane problemy kształtowania infrastruktury rozwoju zrównoważonego*. Politechnika Białostocka, Białystok 2001, p. 76.

[11] A. Otto, R. Obermeier: *Logistikmanagement – Analyse, Bewertung und Gestaltunglogistische Systeme*. DÜV, Wiesbaden 2007, p. 128.

by other companies as well. What will be the result of that, regardless of marketing effects, only time will show.

In logistics, there are close conections between costs, material utilisation and balanced development in terms of ecological productivity. It is prudent to expect that in the near future the companies will make every effort to guarantee the biggest availability of their products while at the same time lessening the strain on the environment, regardless of customers' cyclical readiness to pay for ecological products.

City-logistics – less traffic, better quality of life

Lessening of the traffic causing better city life quality is an irrefutable fact. The only problem is the constant rise in internal transport services demand[12], causing the decreace in its attractiveness. This effect is a result of not only the economic growth, but the aforementioned increase in availability demand as well. Some local governments notice this problem and seek solutions to reduce the traffic, especially the cargo vans[13] in the city area. They also look for models briging profits to both the city and the logistic operators.

A kind of remedy to the city traffic patology is city logistics, formed on the basis of distribution logistics, which deals with delivering the products to retail points located withing the city. City logistics consolidates product streams, enabling lessening the road traffic without decrease in the amount of transported goods or necessitating any changes in city functioning. It also allows for the cost structures and logistic operators benefits[14] to be improved and for such an optimalistation of product stram that could not have been achieved by the operators themselves. Which, in turn, leads to decrease in road traffic.

German city of Regensburg[15] is a great example of efficient city logistics. In this city, in 1998 logistic project RegLog® was initiated, with its motto: 'lower intensity of city's road traffic, better life quality of its citizens'. To this day, reduction of 50,000 car-kilometres[16] was possible. 9,000 litres of saved fuel decreased the CO_2 emission by 15 tones and caused major decrease in microdust emission. This reduction was possible thanks to the consolidation of six

[12] Production growth caused transport flow to rise 95% between 1992 and 2010.

[13] These, for example, stop in the 'second row' on the street because of a lack of available unloading space, causing blockages and disrupting the traffic.

[14] Positive effects of aforementioned cooperation have been visible for a long time in regional and international transport. Which is why, analogically, it can be assumed that cooperation of shippers in the city would also be greatly beneficial to the rationalisation.

[15] See: S. Kauf, S. Kauf: *Logistyka jako narzędzie redukcji kongestii transportowej w miastach*. LogForum, Poznań 2010, nr 1, pp. 37-45.

[16] www.reg.log.de

extra-regional spedition companies, which delegated its deliveries to the transport company appointed within the RegLog® project.

As in many big city agglomerations, considerable part of the traffic in Regensburg[17] is comprised of shipping. Its particular burdensomeness was caused by the concentration of enterprise in the city centre built with medieval urban premises. It is characterised by a system of numerous narrow streets and alleys. They constitute communication channels for the shipment cars, citizens and tourists.

Serving as a kind of mobility centre[18], BMW company took over the operation coordination within the RegLog® project. It prepared and formulated the project and also took over the implementation management. Realisation of logistics goals was supposed to be achieved by creating an effective unloading and garbage disposal systems, among others. This required suitable circulation management, especially creating and integrating transfers, adequate choice of the method of transport or garbage storage places. The oprimalisation of transcirculation was important as well. The goals set by the RegLog were to[19]:

- decrease the number of cars in the city centre;
- minimise the harmful substances emission, particularly CO_2;
- consolidate product batches delivered to the centre;
- improve the product transfers and to optimise the routes;
- increase the effectiveness of car capacity utilisation;
- reduce the number of 'empty transfers'.

Currently, the RegLog® project is economically independent, protects the natural environment significantly, supports economic growth of the city and adjacent areas. Great interest in this innovative project, unique in Germany and Europe, is caused by the creation of common cooperation platform of many partners and shippers, allowing for consolidated centre service.Project co-operators managed to significantly improve the transport in the city, consolidated the deliveries and utilise the delivery cars' capacity better. Among the basic effects of the RegLog® project are:

- the concentration of transport routes – one shipper delivers to bigger number of recipients in the centre, which causes their greater concentration;
- delivery consolidation – different shippers deliver products to the same recipients – these packages are consolidated at one carrier, which leads to the single unloading and prevents unloading stoppages;

[17] Population of Regensburg is 150,000 people.

[18] According to J. Szołtysek, mobility centre should adhere to philosophy of multimodal approach to service, gather all mobility-related services and serve as a platform of cooperation between all engaged in transport processes in the city.

[19] B. Tundys: *Logistyka miejska.* Difin, Warszawa 2008, p. 249.

– reduction of the number of cars in the city centre – currently only one or two cars are necessary, as opposed to the seven to eight before the project initiation.

Thanks to the RegLog® project, this medieval city is still attractive to the citizens, tourists and businessmen. The positive example of Regensburg shows how urban logistics can contribute to congestion reduction and the increase in the quality of life in the city.

Instead of a summary — a mobile world of tomorrow

When considering the future of mobility, one should remember that it is the basic, and maybe even the most important MOTOR of the civilisation growth. In the last century the mobility growth was synonymous with economic life and changes.

In the future, the tendencies growth is to be expected. However, the climat change forces us to face new, exciting challenges. The conception, which will enable the CO_2 reduction and the creation of global network of all social processes.

An answer to this question can be found in the A.D. Little Institute[20] 'The future of mobility 2020' report. Authors think that the solution is simple – saying farewell to the classic car mobility and using new technologies and communication techniques. Understanding that mobility is a basic 21 century human need is the first step. However, negative climate changes mean mobility is not an infinite economic growth and individual welfare reservoir. Although it does not change the fact that even in the 21 century mobility will be the driving force behind the trade and advancement, the notable changes can not be expected to happen until 2020. Report by A.D. Little[21] claims that in the future we will still favour individual communication, however, in the next few years we will observe an increase in pro-ecological innovation in the motor industry.

The necessity to care about balanced development has been already noticed by the society. Carsharing, a concept of using one car, is a proof of that. Carsharing Bundesverband[22], national association of car users, postulated in its report that in Germany only, in 2010 the number of users of this commuting method rose 20% since the previous year. This growth places Germany in the

[20] M. Winterhoff, C. Kahner, Ch. Ulrich, P. Sayler, E. Wenzel: *Zukunft der Mobilität 2020.* Hrsg. A.D. Little, Wien 2009.

[21] Ibid.

[22] *Veränderungen fordern die Branche – wir gestalten den Wandel*. Jahresbericht 2010, Hrsg. Bundesverband CarSharing e.V, p. 2, www.carsharing.de/images/stories/pdf_dateien /jahres bericht_2010_endversion.pdf (21.10.2011).

top of European countries. In the early 2011 the number of carsharing organisations members reached 190,000, whereas in 2008 it barely reached 116,000. The number of cars available for carsharing rose as well, almost 30% since 2008.

The market of e-bikes, bikes with electric power source, is dynamically growing. Analysis presented in Electric Bikes Worldwide Reports show that in 2010 the number of its users in Europe reached million, whilst in 2008 it was estimated at 4000,000[23].

In the future, big agglomerations will be the advancement centres. In 2007 ten world's greatest agglomerations' GDI surpassed those of 162 countries[24]. Those agglomerations also had the biggest traffic and the were most densely crowded. Which is why their marketing concepts allude to necessity of protecting the enviroment and CO_2 reduction. In the future it is most likely that the bigger offerors will minimise road transport. For example, IKEA, profitting from consumer mobility, today transfers its stores from suburbs to city centres, for example in London. Until 2020 communicating behaviour will be subject to change, and car will become just one of the transporting possibilities.

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