

6th INTERNATIONAL DOCTORAL STUDENTS WORKSHOP ON LOGISTICS

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Prof. Dr.-Ing. habil. Prof. E. h. Dr. h. c. mult. Michael Schenk**

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FOREWORD



Prof. Dr.-Ing. habil. Prof. E. h.
Dr. h. c. mult. Michael Schenk

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Institute of Logistics and Material Handling
Systems, Otto von Guericke University
Magdeburg

Director of Fraunhofer Institute of Factory
Operation and Automation IFF,
Magdeburg, Germany

Photo: Dirk Mahler

Ladies and Gentlemen,
Dear Colleagues and Friends,

This year it is already the Sixth International Doctoral Students Workshop on Logistics in Magdeburg. The workshop provides young researchers an excellent opportunity to present their latest research to an international audience of professors and doctoral students and to have inspiring discussions for their future work.

The increasing complexity of logistics networks has found its way into our current research and the main topics within this year's workshop deal with mobility and transportation systems, logistics networks and manufacturing systems. Risk management in virtual logistics systems, the 4PL approach and logistics outsourcing, mathematical modeling of distribution systems or regional development theories from a logistical perspective are only some of the interesting topics that will be presented and discussed within this workshop. This will generate interesting insights into and support for the workshop participants' dissertations as well as ideas for possible international collaborations.

The workshop is being held in conjunction with the 18th Magdeburg Logistics Conference and the 16th IFF Science Days. This will provide participants an opportunity to benefit from the experience and insights of experts working in both theoretical and practical fields.

The conference proceedings in your hands not only present the participants' research topics. They also furnish insights into the participating international organizations' research and academic work. I am already looking forward to seeing you at the Seventh International Doctoral Students Workshop on Logistics 2014 in Magdeburg.

Sincerely,

Prof. Dr.-Ing. habil. Prof. E. h.
Dr. h. c. mult.
Michael Schenk

GREETINGS



PD Dr. rer. nat. habil. Juri Tolujew

Institute of Logistics and Material Handling
Systems at OVGU, Magdeburg, Germany

Project Manager at Fraunhofer Institute of
Factory Operation and Automation IFF,
Magdeburg, Germany

Professor at Transport and
Telecommunication Institute, Riga, Latvia

Dear Ladies and Gentlemen!
Dear Colleagues and Friends!
Dear Participants!

Please allow me within these greetings to include some facts of my personal scientific and professional career. Exactly 40 years ago, I myself participated on a workshop out of my university for the first time that took place in a “self-contained” research institute near St. Petersburg and two years later I built my first international scientific relationship with Prof. Lorenz, who had come from Magdeburg to Riga for another workshop. After a very long and intense working relationship with colleagues from Magdeburg and Riga – lasting for several years – we decided that I would continue my professional career in Magdeburg.

For already twelve and a half years I have now been working at the Otto-von-Guericke University and at the Fraunhofer IFF. At both institutes I can apply my qualifications that are rooted in the Soviet engineering education system providing me deep and comprehensive knowledge in mechanical and electrical engineering, mathematics and programming.

Nowadays working on projects in the country with the “most intelligent” logistics, I gain practical experiences that I can convey within Russian publications to the country with the “most spacious” logistics. In my home country, Latvia, I directly convey my experiences via lectures at two technical universities in Riga as well in Latvian and Russian language.

Magdeburg has become my “center of the world” with professional and private relationships in two directions of the world – east and west. As a guest I have been welcomed in the families of my colleagues from USA, Ukraine or Russia. Such developments are normal for professional scientists as this profession does not only request an information exchange, but at the same time mental and emotional exchange.

The technical and natural sciences are most definitely international disciplines. There is, if any, just one “theory of logistics” that applies in Germany and Russia in the same way, but the practical logistics in these two countries – like in any other country of the world – are completely different. A successful scientist can only become the one who finds his place in a “real” science that is characterized through an internationally recognizable name and sufficient problems and methods to address them.

I wish all the participants of the 6th International Doctoral Student Workshop on Logistics to find his or her specific scientific field and the own place within it. I am convinced and hope for you that this workshop will be a measure for acceleration to achieve this objective.

Dr. Juri Tolujew
Magdeburg, June 2013

INTRODUCING THE UNIVERSITIES

OTTO VON GUERICKE UNIVERSITY MAGDEBURG



The Otto-von-Guericke University was founded in 1993 from three institutions of higher education: the Technical University Magdeburg, the Teacher Training College and the Medical Academy of Magdeburg. It is named after the famous scientist Otto von Guericke, whose research on the vacuum, especially his hemispheres experiment, earned him fame beyond German borders.

Consisting of 9 Faculties, OvGU offers 72 academic programs. Nearly 13,800 students are enrolled at OvGU; 1,400 of them are international students. OvGU is one of Germany's youngest universities. Its innovative fundamental research contributes to the city's and the country's social and scientific development.

The Institute of Logistics and Material Handling Systems is part of the Faculty of Mechanical Engineering and looks back on more than 50 years of experience in training and research in the field of conveying technologies, logistics and material handling systems.

The fields of research include:

- Mathematical modeling and simulation,
- Development of instruments for analysis and planning,
- The conservation of resources, energy efficiency and sustainable logistics,
- Discrete element method simulation in continuous conveying technology,
- Virtual engineering,
- Ramp-up management and
- The transfer of methodology and know-how in logistics.

www.ilm.ovgu.de

FRAUNHOFER INSTITUTE FOR FACTORY OPERATION AND AUTOMATION



The Fraunhofer Institute for Factory Operation and Automation IFF in Magdeburg carries out research and develops for public sector clients, international industrial enterprises and small- and medium-sized enterprises with a focus on the following topics:

- Logistics and material handling systems,
- Robotic systems, metrology and inspection technologies,
- Process technology and installation engineering,
- Virtual engineering and training.

Digital tools for planning, analysis and assessment of processes in factories, logistic systems and networks are developed for the field of logistics and material handling systems. Another focal point of research at the Fraunhofer IFF is the identification, monitoring and controlling of flows of goods. In the LogMotionLab, applications of RFID technology typical of the logistics sector are developed, tested and certified. In the field of virtual technologies, Fraunhofer IFF devises solutions for all steps in the process chain. The Virtual Development and Training Centre VDTC offers expert's know-how and state-of-the-art equipment, enabling the digital product's passage from the first idea, development, production, distribution all the way to its commissioning and operation.

The Fraunhofer IFF is also a part of national and international networks for research and science. It cooperates closely with the Otto-von-Guericke University Magdeburg, especially with the Institute of Logistics and Material Handling Systems, as well as with other universities and research institutions of the region.

www.iff.fraunhofer.de



UNIVERSIDAD CENTRAL »MARTA ABREU« DE LAS VILLAS

The University »Marta Abreu« of Las Villas (UCLV) was founded in 1948 in Santa Clara. Approximately 6500 students are enrolled at the university, which consists of 13 departments. The green, spacious campus is located on the outskirts and makes up its own small student town that may be reached by car, bus or train. UCLV is the third-biggest university of Cuba. It has ranked on top places in all national evaluations of the quality of teaching and research. UCLV is part of several national and international research networks and maintains scientific cooperation with 130 institutions around the world. Intensive collaboration with the OvGU in Magdeburg focuses on the departments of manufacturing engineering and quality management, mechanics, construction, computer science, automotive technology, process and environmental technologies and especially logistics and material handling systems.

The Department of Mechanical Engineering was founded in December 1959. The Department's most important fields of research pertaining to logistics and material handling systems are:

- Technical logistics,
- Quality management,
- Manufacturing (manufacturing engineering and welding technology),
- Environmental technology.

Furthermore, research is conducted in the fields of biomechanics, mechatronics, development and construction. The training is focused on mechanical engineering.

On February 2nd, 2007, the Department of Industrial Engineering and Tourism was founded. It is divided into two sections (Industrial Engineering and Tourism) and into two institutes: the Center for Tourism Research (CETUR) and Center for Business Management (CEDE). The central fields of research pertaining to logistics and material handling systems at the Department of Industrial Engineering and Tourism are:

- Quality management, quality engineering, metrology, measurement uncertainty,
- Mathematical statistics, operations research, design of experiments, statistical simulation,
- Reliability and safety,
- Logistical networks.

www.uclv.edu.cu



National Aerospace University "KhAI", Kharkiv

The National Aerospace University, Kharkiv, Ukraine (KhAI) was established in 1930. Its history is closely connected with the development of aircraft engineering and science. The University is famous for its creation of the first European high-speed airplane with a retractable landing gear and the creation of the design of the turbojet engine. Nowadays, with 11000 students and 2700 academic staff, KhAI is one of the leading institutions of higher education in Ukraine in the training of specialists for aerospace industry in Ukraine and abroad. The University has trained more than 73000 engineers during its lifetime, 80% of KhAI graduates are among the specialists engaged in aerospace industry of Ukraine.

Many enterprises and institutions in the Ukraine use the scientific developments of the University: in 2004/2005 the University responsible bodies even developed more than 80 bilateral contracts aimed at the design, pilot development, testing and introduction of the products and technologies in 16 areas of aircraft design, machine building and related issues.

In 1994 KhAI has signed cooperation agreement with OvGU, which set different joint topics for educational and research collaboration in the sphere of aircraft design, developing the details out of composite materials, technologies and equipment for speed processing of steel construction etc.

www.efc.khai.edu

Transport and Telecommunication Institute, Riga



The Transport and Telecommunication Institute (TTI) is the largest university-type accredited non-state technical higher educational and scientific establishment in Latvia. It was established in 1999 and is situated in Riga. Currently about 3000 students are enrolled in B.Sc., M.Sc. and Ph.D. programmes as well as in higher professional study programmes.

Main directions of academic activities are Electronics and Telecommunications, Information Technologies and Computer Science, Economics, Management and Business Administration as well as Transport and Logistics.

The Transport and Telecommunication Institute has its main research activities in:

- Optimization and modelling of transport systems,
- Logistics,
- Navigation satellite systems,
- Air traffic control systems,
- Telecommunication,
- Transport telematics,
- Applications of information technologies,
- Business re-engineering.

The TTI has also a Telematics and Logistics Institute (TLI) which has been developed with the aim of making productive contributions to the continued progress of the transportation industry in Latvia by conducting applied research and development work in contemporary and future transportation issues.

www.tsi.lv

UNIVERSITY OF MISKOLC



The history of the University of Miskolc refers to Mining and Metallurgy back in 1735. Since those times, the organization of the University changed and was extended several times with new faculties, now being named since 1990 the University of Miskolc. While technical education has the longest tradition at the University of Miskolc, during the recent decades the institution was transformed into a true university. Currently it has eight distinct faculties. At present, faculties have more than 14000 students, who are assisted in their academic advancement by an educational staff of more than 700 and a non-educational staff of more than 800 members.

On most faculties, B.Sc. and M.Sc. programs are both offered for the students. The University of Miskolc started Ph.D. programs on the basis of accredited doctoral programs on October 1, 1993. Currently six Faculties of the University offer doctoral programs and award Ph.D. degrees in seven disciplines: Earth Science, Materials Science and Technologies, Engineering Science, Information Science, Law, Economics and Management Science, Literary Studies.

The University of Miskolc is the largest higher education institution in Northern Hungary. With its highly qualified experts, instrument infrastructure and laboratories, it contributes to scientific research and technical development in Hungary.

The Department of Materials Handling and Logistics is part of the Faculty of Mechanical Engineering and Informatics. The Department has a wide range of educational activities at 3 Faculties of the University of Miskolc in the frame of full time and part time trainings. The focus of research activities of the department lies in the following fields:

- | | |
|--|--|
| – Design of materials handling machines, | – Warehouse logistics, stock management, |
| – Controlling and planning methods for modular materials handling systems, | – Recycling logistics, |
| – Computer integrated logistics, information logistics, | – Maintenance and Quality assurance logistics, |
| – Production and service logistics, | – Global logistics, supply and distribution systems, |
| | – Logistics management. |

www.uni-miskolc.hu



THE MOSCOW STATE AUTOMOBILE & ROAD TECHNICAL UNIVERSITY

The university (formerly an institute) was founded in 1930. On December, 13, 1930 the Council of People's Commissioners of the USSR decided: "To organize the Moscow Automobile - Road Institute on the basis of the road faculty of Moscow Railway Engineering Institute and the Supreme Road School".

When it was originally organized as an institute, MADI consisted only of two faculties (departments): Road-Building and Automotive, each of which worked under one chair of Road Affairs and Automobiles.

The university has been recognized on numerous occasions for its accomplishments since being established over 70 years ago. By the Decree of Presidium of the Supreme Soviet of the USSR issued on December, 8, 1980, MADI was awarded the Labor Red Banner for the preparation of qualified experts for a national economy and the development of a science in this field. In 1988 it received the Friendship of Vietnam award.

MADI earned the status of Technical University in 1992. The formal name of the university was changed in 2001 from Moscow State Automobile and Road Technical University - MADI to State Technical University - MADI. The name change was granted in recognition of the university's maturity, its position as a leading academic institution in the Russian Federation, and its expanding international mission.

State Technical University - MADI is one of the largest post - secondary institutions in Russia, and the leading scientific and methodical center on preparing students for engineering, bachelor's and master's degrees. It also produces highly trained individuals for the design of highways, bridges and airports; operation and maintenance of transport facilities; economic analysis and management of the transport system; and traffic safety.

The focus of research activities of the department lies in the following fields:

- Automation of technological processes and manufacturing
- Automated systems of processing of information and management
- Automobiles and automobile facilities
- Highways and airports
- Hydraulic machines, hydrodrives and hydropneumoautomatics
- Engines of internal combustion
- Engineering protection of the environment
- Multi-purpose caterpillar and wheel machines
- Bridges and transport tunnels
- Equipment and technology of increased wear resistance and restoration of details of machines and devices
- Organization and safety of traffic
- Organization of transportation and management of transport
- Hoisting-and-transport, building, road machines and equipment
- Operation and service of transport and technological machines and equip-ment (service on motor transport)
- Means of ground technical maintenance of aircraft
- Transport complexes of rocket engineering
- Economy and management of transport enterprises
- Economy and management of construction enterprises

www.en.madi.ru/

SCIENTIFIC PAPERS

MANUFACTURING SYSTEMS

The increasing complexity and rising dynamics of manufacturing systems are significant aspects for production companies challenging their competitiveness. An optimization of material flows and logistics tasks within these systems can significantly increase the firm's overall performance. Therefore, the following papers show different measures to decrease manufacturing costs, illustrate the process optimization for the conversion of biomass for energy generation and present applications of modelling and simulation techniques in production systems.

Searching for ways to reduce manufacturing costs by optimizing material flows

Prof. Dr.-Ing. Vitaliy Pavlenko
National Aerospace University "Kharkiv Aviation Institute", Ukraine

Prof. Dr.-Ing. Nataliya Rudenko
National Aerospace University "Kharkiv Aviation Institute", Ukraine

Thermo-economic assessment of the conversion of Cuban sugar cane lignocellulosic residues into liquid biofuels

M.Sc. Lizet Rodríguez-Machín, DrC. Raúl A. Pérez-Bermúdez; DrC. Víctor S. Ocaña-Guevara
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Simulation modelling of Kanban system implementation

M.Sc. Zsolt Harangozó
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Increase of casting yield through optimal riser design in sand casting process using simulation method

M.Sc. Lázaro Humberto Suárez Lisca
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Department of Mechanical Engineering
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SEARCHING FOR WAYS TO REDUCE MANUFACTURING COSTS BY OPTIMIZING MATERIAL FLOWS

Vitaliy Pavlenko
National Aerospace University "Kharkiv Aviation Institute", Ukraine

Nataliya Rudenko
National Aerospace University "Kharkiv Aviation Institute", Ukraine

1 Abstract

Batch production is typical for engineering enterprises connected with aeronautical engineering manufacturing. The characteristic feature of aeronautical engineering manufacturing is the need to periodically change the production pattern due to the instability of products range, changes in volume of series, moral and physical wear of technological equipment.

Such a change is usually carried out in the course of reconstruction and technical re-equipment in order to raise the flexibility of production systems by optimizing material flows.

These changes in the organization of production level up the demands for flexibility both of production itself and of manufacturing sites. In this regard designing the sites is a quite independent task of an utmost importance. It should be considered that each site has specific characteristics, peculiar for it only. Hereby the success of solving production tasks considerably depends on the ability to minimize losses, organize a new production department, and optimize traffic flows.

2 Analysis of the latest research and publications

As shown in the work [1], main characteristics of material flows are determined by spatial component of the flexible production system pattern, set by machine tools arrangement according to the group technological process. The bulk of the cost of final product manufacturing is associated with the arrangement of material flows. In order to reduce manufacturing costs it is necessary to improve the production pattern by applying technologically oriented equipment arrangement. [2] In this case, there arises a need to develop scientific and methodological basis of restructuring the production process. One of the most effective approaches to the design of machine building plants with a batch type of production is the use of a program-target method [3] based on the methodology of choosing the best technological solutions. There exist three principles of manufacturing sites and departments

forming, which determine the form of organization of production:

- Linear: It is characterized by strictly determined sequence of performing technological process operations in every moment of time. This principle is most often implemented in the form of automatic transfer lines;
- Subject: It is applied when there are significant product ranges, units with duplicate parts with raised demands regarding reliability, quality and operability;
- Technological: It is characterized by performing homogenous operations of technological process with application of modular machines.

This is why when designing a new manufacturing site as well as when carrying out technical retooling and reconstruction of existing sites one of the main stages is creation of an optimal structure, which involves scientifically determined selection of its sites components

Modern methodology of batch technologies design is based on the system approach to the analysis and synthesis of the basic structure of the production processes, which allows to apply mathematical simulation.

3 Aim of research

The aim of the present work is to search the ways to reduce manufacturing costs when producing aeronautical engineering by optimizing material flows based on the developed mathematical models.

4 Materials and results of research

Mathematical simulation of the production process entails the need to solve a big amount of logistic problems, including optimization of the machinery composition for each of the manufacturing sites, optimization of details production startup, calculating the production lead time during machining the batch of details, optimizing batch size, organization of just-in-time flow of cargo.

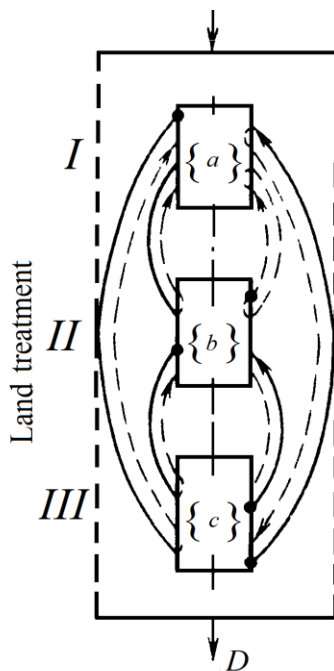
When using the system approach to analyze production systems and their components, the following subsystems can be distinguished: functional, organizational and element. They cannot be separated, since they represent three sides of a unified whole: relationship, unity and interaction.

The functional aspect of the flexible production system (workshop) and its subsystems (manufacturing sites) is determined by their technological purpose.

The element aspect is defined by the equipment in these sites.

The organizational aspect of the system establishes system pattern and objectives for each of its components and provides their achievement in accordance with the functional purpose.

When applying the traditional approach for determining the pattern and workshop and manufacturing sites management type, special emphasis is placed on breaking down the total volume of works into individual production operations on different parts and joints. The operations mentioned, especially under batch production conditions, are concentrated in the corresponding manufacturing sites formed on the functional principle. In this case the recommendations for the structure are made primarily on the basis of the production process bulk analysis and do not interfere with the interaction of operations. The structural scheme of the production process and the relations entailed is shown in Figure 1.



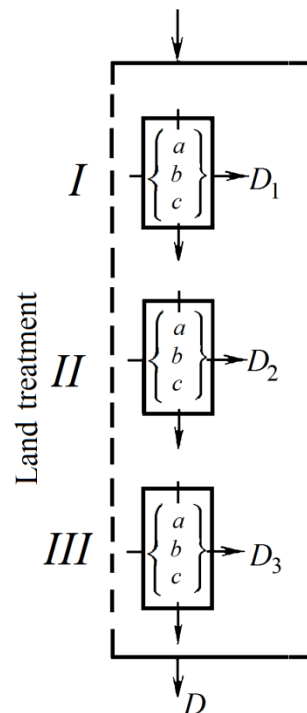
I, II, III – manufacturing sites *a, b, c* – a group of machines of the same technological purpose

Figure 1: Schematic structure of the production process, under the traditional approach

The diagram shows three manufacturing sites, each formed out of the machines of the same technological purpose. The machine tools mentioned can belong to the same technological group, but to different size groups. Such structure entails numerous direct and inverse external relations between sites intended for production the set *D* of parts.

Interrelationship, unity and efficiency of work of different manufacturing sites (subsystems) as well as of manufacturing workshop (system) as a whole are most crucial under the system approach. The choice of the manufacturing pattern as an integrated object with qualitatively new characteristics is made in accordance with the results of the analysis and synthesis of its components.

Therefore, under the system approach the structure of production process is based on the use of detailed or subject specialization of the manufacturing sites and workshops. Figure 2 shows the structural scheme of the production process under the system approach.



I, II, III – manufacturing sites *a, b, c* – a group of machines of the same technological purpose

Figure 2: Structural scheme of the production process under the system approach

In this case, the site consists of three sections, built on the principle of detailed specialization, external vertical and internal horizontal relations being crossed. Here, the ultimate goals of the production system (site) are composed of the private goals of separate divisions (manufacturing sites), producing the finished parts subsets $\{D_1, D_2, D_3\} \subset D$.

The orientation of each of the sites on the end result leads to a substantial reduction of manufacturing costs, which significantly simplifies solving problems of division and coordination of labor on the principles of self-organization and self-regulation.

Three basic structure-forming principles are realized when applying manufacturing management method based on the system approach:

- specialization of manufacturing workshops and their sites according to our goals entailing spatial concentration of production of homogeneous parts or assembly units;
- standardization of technological processes of homogeneous parts or assembly units manufacturing entailing a certain specialization and completeness of equipment and tools required;
- centralization of target program distribution among workshops and sites by operation administration for manufacturing of parts, necessary to reduce the manufacturing cycle and costs.

Selection of the way of manufacturing sites organization forming is carried out on the principle of cooperation. The index of cooperation is determined according to the formula:

$$X = \sum k_i / N, \quad (1)$$

where k_i – is the number of material connections which connect the i equipment with the rest of the equipment; N – is the quantity of technological equipment in the organization department.

The areas of implementation of different ways of manufacturing sites organization forming are shown in the Figure 3. Lines, limiting each area are built based on the relations presented in [3, 4].

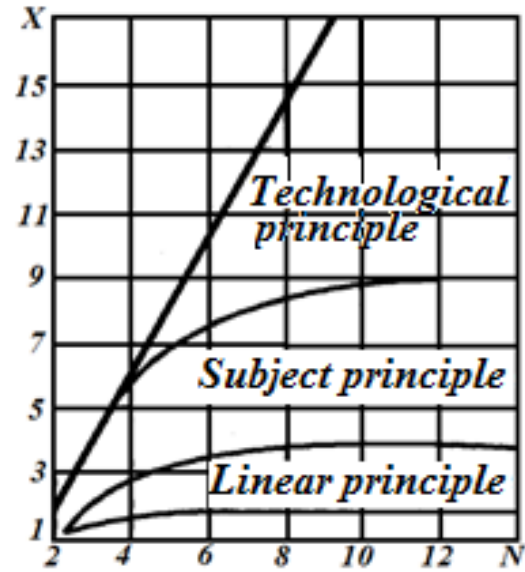


Figure 3: Areas of implementation of different ways of manufacturing sites organization forming

The proposed mathematical model of manufacturing costs optimization is designed in accordance with all the aforementioned principles. The problem being solved is multi-objective, thus the mathematical model has several target functions.

Let's consider two goal functions

$$\begin{cases} S_1 = \sum_{j=1}^n k_j x_j \rightarrow \max, \\ S_2 = \sum_{j=1}^n m_j x_j \rightarrow \min, \end{cases} \quad (2)$$

with the following constraints

$$\sum_{j=1}^n \sum_{i=1}^m p_{ij} x_j \leq q_i, \quad x_j \geq 0. \quad (3)$$

The problem is solved separately for each value, and the criteria $S_{1\max}$ (machine work load) и $S_{2\min}$ (cargo flow capacity) are determined. Then the constraints are formulated as following

$$\begin{cases} \sum_{j=1}^n k_j x_j + S_{1\max} x_{n+1} \geq S_{1\max} \\ \sum_{j=1}^n m_j x_j - S_{2\min} x_{n+1} \geq S_{2\min} \\ \sum_{j=1}^n p_{ij} x_j \leq q_i, \quad i = \overline{1, m} \quad j = \overline{1, n} \end{cases} \quad (4)$$

and the new goal function (manufacturing costs) is written as:

$$W = x_{n+1} \rightarrow \min. \quad (5)$$

The model can be applied in organizing the aeronautical engineering production, which requires effective remounting during the change of product range thus ensuring the required flexibility of production.

A way of selection of manufacturing sites forming is provided as an example. The main initial data are technological processes of details (articles) production shown in the Table 1.

Article (code)	Manufacturing route (machine №)	Traffic, t
A	3-6-1-4-5	4
B	4-2-6-5	2
B	2-5-4	6
Г	1-3-2	3

Table 1: Manufacturing routes of details processing

Manufacturing routes of A, B, C, D details (articles) manufacturing are viewed consequently in order to determine material connections with each machine. This overview allows to determine that the № 1 machine has the following connections: in the manufacturing route of the A detail production – with the № 4 и № 6 machines, in the manufacturing route of the D detail production – with the № 3 machine. The connections determined this way are tabulated to the table 2. Duplicated connections are considered once.

Machine №	Material connection with other machines	Number of connections – $\sum k_i$	Number of machines – N, p.
1	6, 4, 3	3	1
2	4, 6, 5, 3	4	1
3	6, 1, 2	3	1
4	1, 5, 2	3	1
5	4, 6, 2	3	1
6	3, 1, 2, 5	4	1
Total		20	6

Table 2: Results of calculations for selecting the manufacturing site forming principle according to the index of cooperation

After having calculated the number of connections for each machine and summing them up for all the equipment items, we determine the index of cooperation according to the formula (1): $X = 20 / 6 = 3,33$. According to the Figure 3 according to the value of X and the number of machines N we determine the manufacturing site forming principle (in the example considered it is the subject principle).

For the achieved principle of manufacturing site structure we build the graph of material bonds between the material equipment (Figure 4). Graph ribs reflect the value of traffic between the separate items of equipment. The construction of the matrix is considered when manufacturing site enter and exit coincide. In this case the number of interplant transport dead runs is reduced.

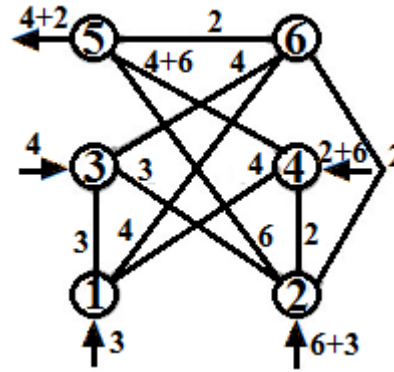


Figure 4: Graph of material connections between technological equipment

Concentration of the machine groups processing similar list of details, carried out by optimizing the options of machines location according to the criteria of the traffic power minimum (S_{2min}). on the given stage the technique is applied – all the machines are nominally placed in one line. Total traffic power is calculated as the sum of products of raw stocks (m) on their relocations according to the following scheme. The raw stock is transferred to the first machine given it this sequence, involved in any operation of the technological process of the given detail production and follows through all the machines up to the last similar one. Geometrical sizes of the manufacturing equipment are not considered hereby and it is supposed that that the distance between the neighboring equipment items equals to the unit length. Thus optimization of the linear machine sequence leads to approximation of those of them on which the technologically similar details are manufactured. Moreover, machine groups form in the linear sequence, which are intended to manufacture the details of the defined assortment.

In order to solve the given problem Ant algorithms were selected, which are based on using the manifold of potential solutions and developed to solve the combinational organization problems, first and foremost of searching different ways on graphs. Algorithm operation time is in direct ratio to the number of equipment items. During its operation the following is carried out for each detail: the first and the last machine tool, involved in raw stock processing are determined, the last machine tool switched with the machine tools located between the end machines, but not the ones processing the given raw stock, the target

function for achieved options is calculated, the options are compared with each other and with the initial linear sequence, the best option is selected and accepted as the initial for the following iteration.

The result of Ant algorithm solution is an optimal linear sequence of the machine tools arrangement and the traffic power corresponding to it.

5 Conclusions

The Ant algorithm body of mathematics is capable of satisfying all the demands, set by the modern manufacturing, since it represents the behavior of actual ants, whose ability to adapt to any conditions has been sharpened by the nature for centuries. Due to their simplicity, scalability and vibrancy Ant algorithms are reasonable to be implicated to solve the problems of forming technologically oriented structures of the serial manufacturing departments and optimizing the options of planning concepts.

Development of production processes optimization methods, conducted in our department of Theoretical Mechanics, Engineering and Robotic Systems at the National Aerospace University "Kharkiv Aviation Institute" is carried out to design flexible manufacturing systems for aeronautical industry.

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THERMO-ECONOMIC ASSESSMENT OF THE CONVERSION OF CUBAN SUGAR CANE LIGNOCELLULOSIC RESIDUES INTO LIQUID BIOFUELS

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1 Abstract

It is estimated that world's supply of fuel will increase globally so its production will help address the growth in consumption. Cuba is not an exception in this world trend. The present work has the general objective to introduce the projection of the research to perform a thermo-economic assessment of the conversion of Cuban sugar cane lignocellulosic residues by pyrolysis processes to obtain maximum yields of liquid fuels with low cost. In Cuba, the main renewable energy sources are concentrated in biomass with 2,027,530 toe (99.3%). Biomass fuels and residues can be converted to more valuable energy forms via a number of processes including thermal, biological, and mechanical or physical processes. There are some relevant comments to be considered in thermo-chemical conversion of biomass to obtain liquid biofuels: investors need to know the most appropriate conversion method for each feedstock in particular; it is essential to improve the understanding of the process, leading them towards the optimization and explaining the variation in performance between feedstock, process parameters and operating scale, also there are technical barriers in the environmental performance; sometimes it is even confusing and frustrating to comprehend the details and validity of the techniques and to make a decision on a method to use for a certain type of biomass or a combination of different biomass types. The authors add that the selection of these alternatives is based mainly in the analysis of the

type of energy, process optimization or economic studies without the integration of them, making the right choice are hard to get. Availability, dedicated fuel handling and logistic systems are needed to take them into account in the process of selection. To achieve the proposed objective will be obtained the kinetic model for the pyrolysis of sugar cane lignocellulosic residues, develop processes for the production of bio-oil with lignocellulosic materials derived from sugar cane, test the bio-oil derived from the pyrolysis of sugar cane lignocellulosic residues as fuel for internal combustion engines, develop a plant model of fast pyrolysis of sugar cane lignocellulosic residues, and develop a procedure of thermo-economic assessment.

2 Introduction

Biomass is a diffuse resource, requiring large areas of land with substantial logistical problems in collection and transport as well as high costs. It is estimated that the world's supply of fuel will increase globally so its production will help address the growth in consumption. Cuba is not an exception in this world trend. This expected expansion in biofuel production is due to the benefits they offer as its contribution to climate change mitigation and relieves world dependence on scarce and uncertain supplies of oil and additionally favor the reduction of oil prices (Figure 1). In this context, in the last five decades in the country, a lot of activities in the field of renewable energy have been done and needed to

be encouraged and continued, playing an important role in social development.

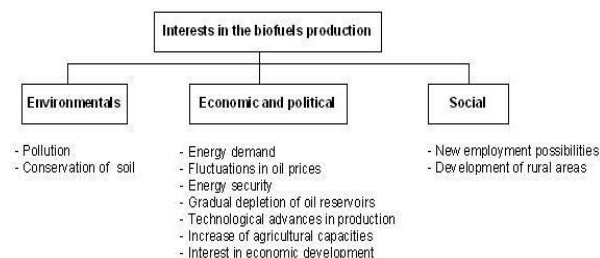


Figure 1: Modern drivers of biofuels development

At present, renewable energy in exploitation is around 2,042,000 tons of oil equivalents (toe), which is around 54.5% of Cuban annual crude oil production in 2009, and a total installed capacity of 400 MW, contributing about 4.0% of the national electricity generation. The main renewable energy sources are concentrated in biomass with 2,027,530 toe (99.3%). [23] The current world energy policy addresses among others has the following needs: meet demand using domestic energy resources as the highest priority, develop existing sources while acceleration the penetration of new and renewable sources, diversify energy sources, avoid dependence on energy imports from a single source or country, and protect the environment and public health.

There are some relevant comments to be considered in thermo-chemical conversion of biomass to obtain liquid biofuels: investors need credible information to support both short and long term alternatives and need know the most appropriate conversion method for each feedstock in particular; it is essential to improve the understanding of the process, leading them towards the optimization and explaining the variation in performance between feedstock, process parameters and operating scale, also there are technical barriers in the environmental performance and point out that such systems will always be relatively small and therefore should be technically and economically competitive; sometimes it is even confusing and frustrating to comprehend the details and validity of the techniques and to make a decision on a method to use for a certain type of biomass or a combination of different biomass types. [9]

The authors add that the selection of these alternatives is based mainly in the analysis of the type of energy, process optimization or economic studies without the integration of them, making the right choice are hard to get. Availability, dedicated fuel handling and logistic systems are needed to take them into account in the process of selection. The present research has the overall aim to

introduce the projection of the research to perform a thermo-economic assessment of the conversion of Cuban sugar cane lignocellulosic residues by pyrolysis processes to obtain maximum yields of liquid fuels with low cost.

3 Research background

3.1 Overview of the energy balance in Cuba

During the crisis of 1990s, industrial and agricultural production decreased abruptly and drastically, as did per capita energy use. Economic recovery began in 1994. The sugarcane industry, however, has still not fully recovered. The decrease in biomass was result of the closure of nearly the half of sugarcane production facilities and a reduction in harvesting areas during the crisis, referred to as the Special Period in Peacetime, which limited the availability of the corresponding sugarcane bagasse. [13] Up to 1998, the total primary energy supply in Cuba had been dominated essentially by two fuels: oil and biomass (Table 1).

Primary energy	Value (thousand toe)
Petroleum	2,995 ^(a)
Natural gas	946.25
Fuelwood	161.34
Sugarcane products	837.12
Sugarcane bagasse	726.48

Table 1: Domestic production of primary energy 2010
Source: Adapted from Statistical Yearbook of Cuba [23]

(a) Including mixtures of other derivatives that are added to oil to decrease its viscosity.

3.2 Potential contribution of biomass as fuel

Annual sugarcane production in Cuba is at present about 25 million metric tons a year. Sugarcane bagasse is the fibrous material that remains after recovering the sugar containing juice after crushing and extraction. It is constituted approximately of 50% of solids and 50% of water. On the other hand, the use of mechanical harvesting also generates significant amount of plant residues (i.e. leafs), [1] 75% of the sugarcane is cut with machines and nearly all is processed in cleaning stations and 25% remaining is cut by hand. [21] Typically, each metric ton of processed sugarcane yields 0.11 metric tons of sugar, while also generating 0.27 metric tons of bagasse and 0.25 metric tons of agricultural residues. In Table 2 is shown the main residues from sugarcane processing including bagasse and sugarcane trash 'SCT'. [1, 2]

Biomass	ton /ton crushed cane
Bagasse + SCT in sugar mill	31.9%
SCT left in field	16.7%
SCT separated in cane cleaning stations	11.0%

Table 2: Indicators for the calculation of sugarcane biomass [6]

Sugarcane bagasse as well as SCT, has a higher heating value of approx. 20 MJ/kg (on a dry basis). Composition-wise of Cuban bagasse is mainly constituted of cellulose (45-60%), hemicellulose (20-25%) and lignin (20-25%) (on a dry basis). [21] Considering a global annual production of bagasse about 1.3 billion metric tons [6], it is considered to be the most considerable lignocellulosic agricultural residue available worldwide.

Today, a subject of research is to find a solution to sugarcane residues as energy sources. Current day practices in Cuba include burning the majority of the sugarcane bagasse in low efficiency (< 20 %) boilers for steam generation in order to meet the demands of local sugar production and at the same time burning provides a means for waste disposal of any excess bagasse. Around 54 sugarcane bagasse fired power plants generated 2.9% of total power generation. [22] Some sugar mills stop process due to surplus bagasse either by low storage capacity or insufficient power generation capacity.

Although the potential exists for the agricultural residues resulting from harvesting to be used in cattle feed or as a solid fuel, in current day practices in Cuba, these are most often burnt, resulting in environmental burden. [1]

4 Methods

Recent advances in boiler technology, with the possibility of cogeneration and the use of high temperature/high pressure steam boilers, has led to higher efficiencies. As a consequence, lower amounts of bagasse and residues are required to be burnt in order to cover the sugarcane processing plant's energy needs. [2, 15] In the absence of a proper infrastructure to export electrical as well as thermal energy, the surplus bagasse and other agricultural residues become available for alternative processing which can amount up to 50 wt% of the originally generated sugarcane processing byproducts.

4.1 Alternative technology to process the bagasse and other SCT

Biomass fuels and residues can be converted to more valuable energy forms via a number of processes including thermal, biological, and mechanical or physical processes.

Fast pyrolysis is one of the more attractive alternative technologies to process the bagasse and other SCT. [19] This thermo-conversion process is the rapid thermal decomposition of biomass in the absence of oxygen. During this process, the natural polymeric constituents (including lignin, cellulose, fats and starches) are thermally broken into numerous smaller components, which are traditionally classified among the following three categories: bio-oil (the condensed vapors), char (solid fraction) and non-condensable gases. [17]

Depending on the heating rate and temperature, different distributions of the aforementioned products can be obtained. In fast pyrolysis, process conditions are selected with the aim of maximizing the bio-oil yield. These process conditions characteristic of fast pyrolysis include [16]: moderate temperatures (400 – 600°C), rapid heating rates (>100°C/min) combined with short residence times of the biomass particles (0.5 – 2 s), small particle size to support high heating rates (typically less than a few millimeters) and rapid cooling or quenching of the pyrolysis vapors into bio-oil. Under these conditions, bio-oil yields up to 70-80% could be obtained. [3, 7]

The bio-oil is a dense energy liquid (21 MJ/kg, 1,100 kg/m³, [3][4] and as such, can be stored for later use or exported to remote application sites, using existing fuel transportation infrastructure. The char, being a byproduct from biomass fast pyrolysis can be used as a solid fuel with Higher Heating Value (HHV) up to 35 MJ/kg [20] or as a soil amendment to improve fertility and plant productivity. [14, 24] Consequently, the flexibility offered by fast pyrolysis to transform biomass into energy-dense liquid (and solid) biofuels could significantly improve the profitability of sugarcane plantations. [10]

The major benefit of fast pyrolysis technology over combustion or gasification technologies is that it effectively decouples fuel production from its application, both in time and in space (Figure 2). It offers also the benefits of a liquid fuel with concomitant advantages of easy storage and transport as well as comparable higher power generation efficiencies at the smaller scales of operation that are likely to be achieved from bio-energy systems compared to fossil-fuelled systems.

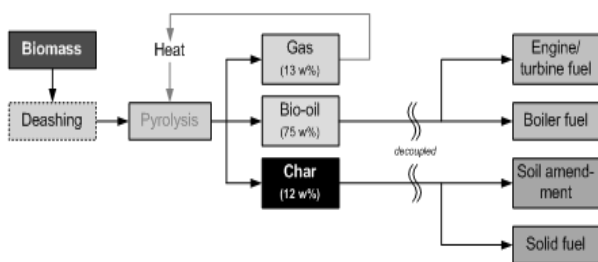


Figure 2: Biomass fast pyrolysis platform for bagasse and sugarcane trash

With respect to bagasse, it is known from literature that this feedstock is well suited for fast pyrolysis from which a single phase bio-oil can be obtained with yields up to 70 wt% based on feedstock weight. [18]

However, fast pyrolysis also faces technological challenges. The major drawback of fast pyrolysis bio-oil is its highly oxygenated nature resulting in less beneficial properties such as low stability, corrosiveness and a lower heating value than that of fossil fuels. [16] Specifically with respect to fast pyrolysis of sugarcane bagasse and agricultural residues, lower stability is further promoted by the rather high ash (mineral) content of bagasse and its tendency to induce fine particle carry-over or entrainment into the bio-oil during fluidized bed pyrolysis. [8, 11] Chemically, the pyrolysis oil (or bio-oil) constitutes several 100's of oxygenated species (aldehydes, ketones, acid, etc.) which during storage can react and polymerize thereby resulting in a deterioration of the fuel properties of the bio-oil, a process also known as 'bio-oil ageing'. Bagasse has a rather high ash content (esp. compared to wood), reported between 1.9 to 3.5 wt% dry basis [5, 11] of which up to 39% are alkaline or earth-alkali metals [8] which are known to catalyze the polymerization reactions during bio-oil ageing. Carry-over of ash particles could also prove detrimental to internal combustion engines or turbines if the bio-oil is used as a fuel.

With the purpose of overcome problems associated with bagasse fast pyrolysis, potential solutions exist: on the one hand alternative pyrolysis reactor configurations can be employed which do not rely upon high fluidization gas flow rates, such as vacuum pyrolysis reactors [5] and rotating screw or rotating cone reactors. On the other hand, the bagasse feedstock could be pretreated prior to pyrolysis to reduce its ash content. Washing the bagasse with water or dilute acids has been demonstrated to reduce its mineral content and improve the yield and the composition of the resulting bio-oil. [8, 18]

In order to develop a plant model for techno-economic analysis, this project mashes a series of

experimental designs and modeling techniques including,

- For plant performance models, computational models for energy and mass balances, as well as for reaction kinetics of the fast pyrolysis process of bagasse and other SCT, and for bio-oil application in internal combustion engines (or turbines) as employed in cogeneration units will have to be developed. Building these computational models mostly relies on mass and energy balance data gathered from pyrolysis experiments which will be conducted on the continuous auger-based (0.5 kg/h) fast pyrolysis reactor.
- Prior to bench-scale continuous fast pyrolysis experiments, feedstock suitability will be tested using analytical pyrolysis (pyGCMS) and reaction kinetic data will be gathered from thermogravimetric analysis as well. Untreated feedstocks from sugarcane processing as well as demineralised feedstocks (through water and dilute acid washing) will be used throughout this study. Different demineralization strategies (temperature, type of acid, acid concentration, etc.) will be evaluated as well.
- The continuous bench-scale pyrolysis unit will be used to generate sufficient quantities of bio-oil samples from the different sugarcane trash feedstocks (in both untreated and demineralised form) in order to test their potential as fuel in boilers or internal combustion engines. These include bio-oil HHV, elemental composition, chemical composition (GCMS) and acid number. Further tests include boiler and/or engine test runs. Storability and ageing of said bio-oils will be included in the assessment as well.
- Fast pyrolysis also results the formation of char as a byproduct. Also this char product will be evaluated in terms of solid fuel properties.
- Once computational models describing heat and mass balances for the fast pyrolysis process, storage and application in engines and boilers have been built based on the gathered experimental data, a combined thermodynamic and economic plant model for an integrated sugarcane processing/residue pyrolysis plant will be developed. The plant model will be used to analyze the overall plant performance by employing software e.g. Aspen Plus. The plant model will be used to identify the optimum operating conditions regarding efficiency, scale-of-operation and cost.
- Finally, next to the techno-economic analysis, an environmental impact study will be performed using life cycle analysis (LCA)

methodology and comparison will be made with current-day practices of sugarcane residue processing in Cuba.

5 Expected results & significance

The results of this research will have significant impact on future development of Cuban sugarcane waste processing and its energetic valorization. It will contribute to the necessary knowledge for decision and policy making regarding alternative methods to process agricultural and biorefinery waste streams that reduce environmental impact and dependency on fossil fuels. It will also make significant progress in developing and adapting techno-economic methodologies for the evaluation of advanced biomass thermo-chemical conversion techniques.

6 Conclusions

Bagasse is considered to be the most considerable lignocellulosic agricultural residue available worldwide. It is well suited as a feedstock for fast pyrolysis from which a single phase bio-oil can be obtained with yields up to 70% based on feedstock weight. The major benefit of fast pyrolysis technology over combustion or gasification technologies is that it effectively decouples fuel production from its application, both in time and in space. Problems associated with bagasse fast pyrolysis could be potentially overcome employing alternative pyrolysis reactor configurations which do not rely upon high fluidization gas flow rates, such as vacuum pyrolysis reactors and rotating screw or rotating cone reactors. Another solution could be making pretreatment to bagasse feedstock (washing with water or dilute acids) prior to pyrolysis to reduce its ash content. This research will contribute to the necessary knowledge for decision and policy making regarding alternative methods to process agricultural and biorefinery waste streams. Significant progress will be done in developing and adapting techno-economic methodologies for the evaluation of advanced biomass thermo-chemical conversion techniques.

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SIMULATION MODELLING OF KANBAN SYSTEM IMPLEMENTATION

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1 Introduction

The literature does not mention too much about how a general system can convert into a lean system. Most of the books which deal with the lean in the best case are “anecdotic” and basically deal with the management of cultural change. Until now, only a few scientific studies have written about the accurate mechanism of already existing manufacturing systems’ lean transition and its effects. The transient behaviour of production systems is rarely examined. Most of the researchers pay a lot of attention to equilibrium state behaviour. Analysis of the transient behaviour of queuing systems often remains difficult and very special. The simulation studies often intentionally ignore the transient behaviour, because they allow to the simulation-running to complete a warm-up period before it makes statistics.

2 Transition to Pull Production

One essential element of the lean transition is the transition from “traditional” push-type production to the more efficient pull type. Those companies which implement the lean principles generally adapt the pull-type production management techniques and its “objectified” appearance: the Kanban card. The cards coordinate the production activity by limiting the number of working processes in the progress.

At the same time, the sales order interface is shifted from the beginning of production line to the end of the production line. This interface is sometimes known as “push-pull interface” or “inventory/order interface”.

The Kanban system can be used in those production lines, where the production volume is between the batch production’s lower limit and mass production.

Kanban is a pull-type production control system. This means that a request for production of given product appears first at production line’s last tool unit, then it running through the previous production workplace, reaches the first where first operation of the given product’s production starts. The satisfaction of needs then runs through the production line in natural order, and after the last workplace’s operation the given ordered quantity will be delivered or placed into the warehouse.

The order is based on the medium-term schedule (Master Production Schedule – MPS) in the last machining place.

The detailed operation: the claim for the product appears on the final tool unit. The product manufactures or transmits the request to the preceding station; it depends on whether the required quantities of pre-forms or raw materials are available for the production of the given quantity of product. The claim runs through the stages thus, including the raw materials orders of the storages. As the release of claims always depends on the situation and if it necessary, it spreads automatically, the introduction of the system requires high discipline and fast response time from the production line and from the warehouse-suppliers too. However, this mode of production results in short lead times and small stocks, which is the most important cost component in today’s production. At the same time, this change could reduce the average time that customers have to wait for the fulfilment of their orders.

3 Theoretical Background

This shift’s basic element is the transition from push-type to a pull processing type: the production is based on the next operation’s status and it uses the Kanban cards as signal mechanism. So the device that is used for controlling is a card, which Japanese name is: Kanban. The cards are circulating between two adjacent stations, providing the required quantity to the previous station and the manufactured quantity to the next station. Cards are moving between two adjacent stations back and forth and thereby they control the production line.

During the transition, the production phase is detecting load running-up and at the same time it the orders of the Kanban card and simultaneously the regular customers’ orders are processed. This can overload the capacity of the workstation, which causes lag, which reduces the processing time of the order.

To prevent this, two temporary mitigation techniques are recommended: initiation of more resources or the delay of customer needs.

The research purpose is dual: on the one hand it is to model this transition process; on the other hand the created model is used to define what

kind of directives can be formulated to reduce the cost of the lean transition.

The literature of the lean unanimously recommends the shift from push to pull production, wherever it is possible, but very few sources are about the mechanism of the transition process, or the system's behaviour.

The significant Anglo-Saxon researchers of production management, Hopp and Spearman also discuss the push and pull control mechanisms and their roles in the transition to the lean but unfortunately their analysis is limited to only for the "before" and "after" equilibrium state.

[2.] According to my previous researches there are only a few studies which are about the details of the lean production management's transition. Although the literature which deal with spool is dealing with non-constant arrival rates of the production system but most of all Hall describes the system modelling with non-constant arrival rates. [3.] He states that rate of change of the arrival rate compared to the capacity determine the modelling technique. In those systems where the arrival rates are always much lower than the capacity, the equilibrium approach should be used. But in those systems where it is higher, there the flow type of approach is more appropriate. In those systems where the arrival rate and capacity are nearly equal, only simulation is able to accurately model the efficiency of the system. [3.]

4 The Features of the analyzed System

The process gets customer orders (one product per order) in λ_j proportion within a time unit, but orders can be delayed. The order postponement rate is a decision variable, λ_h time unit order.

Assume that the supply of the raw materials is unlimited. The process requires e resources for the production, but more that can be order to the process. The additionally useable resource – the second decision variable – is denoted by the e_+ . From the given stock, μ_e product can be prepared within a time unit. Products will only be prepared if there are orders or Kanban cards that have been received but not yet been completed. The processing rate of the whole process is the $e\mu_e$ product, within a time unit.

Therefore, the process can be modelled as a G/G/m queuing system. [2.] Due to the notation system, the arrival time interval and service time is general, G/G, and the system has m servers. The push-pull transition can be characterized by three events.

The first event is the arrival of the Kanban card at $t=t_0$ time.

Assume that the number of Kanban cards is n_k , and it is predetermined. The Kanban arrival rate is $1/\lambda_k$ per time unit.

The last Kanban card arrives at $t_1=t_0+(n_k-1)/\lambda_k$ time. The final conversion event occurs at t_2 time, when the last product of the Kanban card is finished. Then the process can be converted into pull production management, because each customer order can be satisfied from the accumulation-buffer.

The subject of my investigations is how the system behaves during this temporary phase and how the three decision variables affect on the system's performance.

4.1 Decision Variables

The transition process is characterized by three decision variables. As the number of the Kanban cards is fixed and constant, the first decision variable is the implementation rate. The second decision variable, the additional supplies amount is the k_+ . The third decision variable is the delayed orders' number: λ_h .

4.2 The cases of the conversion

Three separate conditions can be identified when the transition can occur which is based on the arrival and processing rates. This ratio, which is also called turnover intensity, is the centre of my work, so I denote turnover intensity with ρ , where:

$$\rho = \frac{\lambda_k + \lambda_j - \lambda_h}{(e + e_+) \mu_e} \quad (1.)$$

Then the shift's cases can be defined for the turnover intensity, because it has a direct effect on how long the changeover time is.

- CASE 1: The arrival rate is lower than the processing rate: $0 < \rho < 1$
In this case, the raised arrival rate does not completely use up the available capacity; waiting list will not form during the conversion. The Kanban cards will be processed when they arrive and the transition take place quickly, minimizing t_2 .
- CASE 2: The arrival rate is higher than the processing rate: $\rho > 1$
In this case, the raised arrival rate completely utilizes the available capacity, order waiting list and Kanban card will form during the conversion.
- CASE 3: The arrival rate is equal to the processing rate: $\rho \approx 1$
In this case, the raised arrival rate is almost equal to the available capacity. It is possible that Kanban cards and ordering waiting list will form. When the arrival and capacity are balanced, then the waiting list much more depends on the changes of processing time.

4.3 Transition targets

Keeping customer orders and Kanban cards on waiting lists, keeping the finished products in the inventory, supplying the resources and delaying the orders are all cause costs. My aim is to find that value of the decision variables that minimize the total cost of C_{tot} :

$$C_{tot} = C_h + C_e + C_i + C_v \quad (2.)$$

- where C_h is the cost of the orders delay,
- C_e is the resource supply cost,
- C_i is the products and their Kanban card's accumulation cost,
- C_v the expectation cost of sales orders and Kanban cards.

The composition of these costs can be determined after the system's variables:

$$C_h = \lambda_h (t_2 - t_0) c_h \quad (3.)$$

$$C_e = e_+ (t_2 - t_0) c_e \quad (4.)$$

$$C_i = (n_k/2) (t_2 - t_0) c_i \quad (5.)$$

$$C_v = c_v \int_{t_0}^{t_2} Q(t) dt \quad (6.)$$

In the above equations, c_h is the cost of the delayed order, c_e is the cost of the additional resources which are used per unit of time, c_i is the unit cost that an already-processed item have to be held back, c_v is unit cost per unit of time that an order (Kanban card) should be on hold for a machining process.

$Q(t)$ is the backlog, which expresses the sales order numbers that are waiting for the machining process and the number of Kanban cards at a time t during the transition period.

As the λ_h deferral extent is increasing, deferral cost are increasing, but the other costs are decreasing due to the decreasing backlog and the shortening transition time. Similarly, as e_+ increases, the raw material costs will reduce and other costs also will reduce due to the decreasing backlog and the shortening transition time. The increase of λ_k Kanban implementation rate may reduce changeover time, unless it is too large, in which case the significant increase in demand will increase the backlog.

5 Characteristics of a more-step Changing

After having looked at the simple systems and how to change from push to pull in one step we can define the regularities of restructuring of the all system. At first it is worth modelling the changing of a two-step-manufacturing system from push to pull by using the results of simulating

models of one-step system. The behaviour characteristics, which were revealed in this way, can help characterise the changing of N-step system. [1]

To build a model, at first we need to define the more-step changing's events. Earlier I have defined the one-step changing's events. Now we can say that more-step changing consists of the same events. The principal of more-step changing determines the time of the events regarding their presence in the system's other parts.

In N-step manufacturing system which is a series, I examined the arrival of orders in each section.

The orders can be asked by clients depending on the effect of the trade checking politics. It will be the starter of the goods product. Or it can be a precedent from the other section which leads to some kind of assemble tasks – it is the assembly of semi-prepared goods. The arrival range of the order was marked by λ_a at one-step changing.

When we examine more-step changing we need to differentiate this indicator in each section. At this parameter and at each parameter that we defined in one-step situation is good to identify the given section with a lower index. For example order's arrival range at stage i is: λ_{ai}

The balance status' parameters and their marks are the following:

- order arrival range: λ_{ai}
- substance arrival range: λ_{mi}
- number of resources: r_{0i}
- source of energy process range: μ_{0i} .

Similarly to the parameters at stage i – where $1 \leq i \leq N$ – are the following:

- number of Kanban cards: n_{ki} ,
- measure of order delay: λD_i ,
- arrival range of Kanban card: λ_{ki} ,
- further resource: r_{+i} .

We need to establish a new parameter. It is called substance arrival index, marked by λ_{mi} . I supposed at one-step situation there is substance in infinite quantity to meet clients' requirements. This fact at more-step system is true only at the first section. But from the second section to N^{th} section the output of previous section ($i-1$) is the condition to satisfy the next section's substance demands.

In the course of earlier research 3 different time events could be identified in each section [2.]: The start of Kanban card's introduction, the end of Kanban card's introduction, and the process of the last Kanban card.

I call the first two events t_{0i} and t_{1i} regarding to those sections which link to events. The third event is not important in more-step system. In section changing we need to define two new

periodic events. The system goes from push to pull. Every section goes from push control to push-pull interface. In the push section clients order are directed towards the first section of the system. In every further section, the previous section's substance process is definite. Clients' demands are directed towards a section of the system in hybrid manufacturing. [3] They appear there. We call this section push-pull interface, which handles substance only if there is a client order. Every previous section works with pull control, which means, they operate as if there was free space in the next line as they work with push management. I presume the stream being one-way toward the client in lean changing into push-pull interface. [4, 5] As a result, manufacturing control of the given section always goes from push to push-pull interface, then to pull control. We need to establish two new periodic cases:

- time of changing to interface: t_{xi} ,
- time of changing to pull: t_{pi} .

Further parameters of N-step manufacturing system „ith“ section's periodic events:

- arrival of the first Kanban card: t_{0i} ,
- arrival of the last Kanban card: t_{1i} .

To establish a coherent changing strategy, we need to identify the condition of events. [6]

1. First of all we define the arrival time of the first and last Kanban card: $t_{0i} < t_{1i}$.
It is obvious that we cannot complete the introduction of Kanban cards if we don't start the changing progress. The introduction of Kanban card cannot be a moment. It is an essential frequent restriction that doesn't let infinite ranges. After this we introduce Kanban cards from section to section.
2. It means, we cannot establish the Kanban card in the second section before the first section: $t_{0i} \leq t_{0(i+1)}$.
But it is also possible to establish it into all the sections at the same time.
3. I can restrict the introduction of Kanban cards if I don't let them finish in the second section earlier before completing in the first section: $t_{1i} \leq t_{1(i+1)}$.
It is still possible to establish them into all the sections at the same time.
4. We can restrict the order of manufacturing control changing from section to section. The right order is the following: we control it from push to push-pull interface then to pull: $t_{xi} \leq t_{pi}$.
5. There is a push-pull interface in every system, even in push systems. The first section never works in push manufacturing

control, just in pull or push-pull interface. So, in the first section it is: $t_{x1} < t_{01}$.

I defined t_2 as a time in one-step model, which I help Kanban card be ready in the given section, this is the end of changing from push to pull. The model supposes that we do not use Kanban cards later but in time. It is not true in more-step system, so the definition of t_2 is more complex in every section as Kanban cards circle among sections during changing. We need to identify a new definition for t_2 . [7,8]

Although these events are restricted in time, it doesn't mean that punctual time of these events is known. It is better to handle them as output instead of using them as a parameter of changing input.

The definition of all systems helps to be able to examine the expenses of more-step changing.

6 Definition of Expense of more-step Changing

When I examined one-step changing I realised two changing expenses: reserve and stock, where the difference depended on the line which stood one side of the system. In more-step system there is no difference. There is an upstream line for order in each section, and there is a downstream line for completed orders (stockline). There is a third resource line where the orders and the substance can meet and wait for completion. I supposed infinite quantity of raw material to meet clients' requirement in one-step model. I do it in the first section of more-step system, too. In further sections I need an order in reserve line and material in stockline of the previous section before processing. So sections connect in this way.

The expense of C_i one-step stock was defined earlier:

$$C_i = \frac{n_k}{2} (t_2 - t_0) c_i \quad (7.)$$

This stockline was based on simplification the volume of the average line. Quantity increased linearly in the defined time period. But it is not unambiguous in more-step system. Therefore I rewrote the definition:

$$C_I = \sum_{i=1}^N c_{Ii} \int_T Q_{Ii}(t) dt \quad (8.)$$

I marked C_i the expense of all system's stock, where „I“ means stock in lower index, „i“ lower index means the number of the section.

As there is no clear definition for a completed event, it is worth substituting with t_1 and t_2 in changing time period. I introduce $Q_{ji}(t)$, too, which means order number of stockline in „ith“ section at t time. This equation is similar to the previous one where I defined reserve expense:

$$C_B = \sum_{i=1}^N c_{Bi} \int_T Q_{Bi}(t) dt \quad (9.)$$

We can define the resource expense like this:

$$C_R = \sum_{i=1}^N c_{Ri} \int_T r_{+i}(t) dt \quad (10.)$$

The index with capital letters means the expenses of all systems.

The expenses of cancel and delay seemed independent before, but we can see in the more-step model that they have a strong connection with the income of client's order. Consumer's order shows demand for finished products. There is no segment, so we cannot postpone the progress of client's order based on a section. As a result of it, the definition of order delay cost is:

$$C_D = c_D \int_T \lambda_d(t) dt \quad (11.)$$

There is no summary by sections from the earlier expenses point of view. Reserve costs connect to client's orders that wait for completion.

These expense equations make it possible to reduce the number of delay and supplementary resources.

To summarise the expense condition, we can define the changing expense of more-step model:

$$C_T = C_I + C_B + C_R + C_D \quad (12.)$$

Now we can give the changing aim successfully that we want to minimize. Then we will need to check changing strategies.

7 Strategies for more-step Changing

We can define infinite changing strategies with the use of restriction – made earlier – [9], [10] for simple systems. Survey is good starting with two useful and special events: „Everything at once“ and „step by step“.

7.1 „Everything at once“ changing strategy

Lean gives simple advice in connection with manufacturing control: you must do it as fast as possible. The cheapest, so called simple changing

principal is when you establish every Kanban card in the system at the same time. If you follow it, you can have a cheap and simple changing strategy. We call it „everything at once“ strategy, which we can define like this: $t_{0i}=0$, where $1 \leq i \leq N$ and $t_{1i} \rightarrow 0$, where $1 \leq i \leq N$.

It means, Kanban cards enter in every section nearly at once.

Changing time can be defined: $t_{x1} < 0$. It means, push-pull interface has to start. First section has to become push-pull interface, so it begins before the start of Lean changing.

During changing, stock lines will be filled, started with N sections going back to the first section, so changing event happens in the first section's line. Push-pull interface appears in the third section when all the Kanban cards have been processed and they are already in the first section's line.

In the „everything at once“ strategy, Kanban cards enter at the same time. When they completed the stock, changing events happen also at once.

7.2 „Step by step“ changing strategy

In this strategy I transfer all sections of the system, but I do the same, as in a one-section examination. Push-pull interface goes in downstream as every Kanban line is filling. It is called „step by step“.

If we choose the suitable strategy, we can reduce changing expenses. There are different changing restrictions in different strategies. As a result we will have different changing principals. In a more-step system we won't probably have less expense, because there are more progress.

We can see when I transfer each section of the system, I will optimise changing politics of each transfer, completing each section, before going on.

In this situation we can use end changing variable of the one-step model, but we also need to add an index regarding the given section.

The t_{2i} is the time, when „ith“ section's changing is finished, every Kanban card processed and waiting in stock. We can define it like this: $t_{0i}=0$ and $t_{0(i+1)}=t_{2i}$, where $1 \leq i \leq N-1$.

Changing starts in each section when previous sections are completed. Changing of each section is ready if the stockline of the section contains every Kanban card.

So, every section becomes push-pull interface when changing starts. It will be pull when changing is finished.

It means Kanban cards are entered into the first section at first, it will be possible to process all of them. When every Kanban card is ready in first section, they go into the second section. At the same time push-pull interface goes from the first section into the second one. The first section starts to operate in pull manufacturing control.

8 Conclusion

A production system's transition from push to pull control and stock/order moving interface are very important, but a minor understood part of the lean production.

The simulation modelling provides a useful tool to explore the transition costs and we can analyze the mechanism for their leadership with its help. However, the simulation models are typically used to study the equilibrium-state systems. In fact, the simulation literature deals with the transient behaviour as a factor which has to be eliminated. The aim of the research is therefore a new simulation technique that is needed to study such a system that shows only transient behaviour. It is worth to run the simulation models in those systems which go through rule changes of production management in relation with the introduction of lean. The simulations efforts are to mitigate the costs, and simulation based optimization use in order to find the least expensive strategy change.

To achieve this, new simulation models should be developed. A discrete event simulation can cover a wide range of the production management techniques, including the lean oriented production management. The development of simulation methodology provides an opportunity to eliminate the transient behaviour, while techniques could develop in order to model and measure the manufacturing systems in the transition. In the course of these researches I didn't modify the introduction range of Kanban cards. In the next stage I will examine it in more detail. In the present research I used the „step by step” strategy. Of course, there are many other conditions which help to cause this strategy. We need to examine these criteria to be able to improve the strategy. We also need more examination to evaluate other manufacturing system's changing strategy. I paid less attention to the event when changing or their criterion finished. This topic also needs further research to be able to compare different strategies.

To summarise it, I can say that the optimising system, which is good for a one-step system, can also be suitable for more-step system to optimise the changing expenses.

In addition, using the new, transient ranges simulation modelling techniques and with an objective function, the efficiency of the different transition strategies cost reduction techniques can be evaluated.

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INCREASE OF CASTING YIELD THROUGH OPTIMAL RISER DESIGN IN SAND CASTING PROCESS USING SIMULATION METHOD

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Abstract

The pieces obtained by foundry is the most direct and economic way to transform a metal or an alloy into a wanted form; furthermore, the pouring process allows to the casting designer, to locate the metal in the required quantity, in the appropriate place, in the appropriate moment to complete the conditions service of the piece to be manufactured. In principle, it seems an easy task but there are many metallurgical, chemical and human variables involved in a process that should be considered. To achieve a piece with the required quality, as well as to fulfill the procurement time, without defects and with the properties demanded by the client it is the main task of the specialists in foundry in the whole world per years. In previous paper the processes that affect the quality of the final product in the foundry industry was determined, the geometry of the riser. In this case it was necessary to determine which it is among different methods the best or the most efficient. Several experiments and simulations to reach a conclusion were carried out. It was demonstrate that the method proposed by Beckermann offers the best values of efficiency. Several simulations, using the software ProCAST, were carried out to make comparisons between the results of the experiments and the virtual reality.

Introduction

The gating and risering systems as one of the main factors for their effect in the quality of the casting is identified, a brief study is pointed out on the same ones and it is determined for wheel of AISI 1045 which is the effective feeding distance depending on the geometric characteristics of the cast.

Maximizing casting yield, which is defined as the weight of a casting divided by the weight of the metal poured to produce the casting (*i.e.*, including metal that solidifies in the risers, gating, downsprue, *etc.*), is an important consideration in

the steel casting industry [1]. An increase in casting yield decreases production costs; with increased yield, production of the same number of castings requires less melted metal and fewer heats, as well as reduced labor and material costs required for production. Also, higher yield usually has the side benefit of lower casting cleaning costs. One effective way to improve casting yield is through riser optimization, where "optimized" means (a) the riser has the minimum possible volume to provide sufficient feed metal to the casting, without the riser pipe extending into the casting; and (b) the smallest number of risers are used, while still ensuring that the risers are close enough to each other to produce a sufficiently sound casting.

Computer simulation of the casting process is becoming an indispensable tool in the effort to increase casting yield. Through the use of simulation, foundries are able to evaluate modifications to casting designs without having to actually produce the casting, thus saving time, material resources, and manpower. However, computer simulation must be applied on a case-by-case basis, and its effective use requires expertise as well as accurate data for many process variables [2].

Due to these limitations, risering rules are still widely used in the steel casting industry. Risering rules dictate riser size and placement by determining (a) the riser size necessary to supply adequate feed metal to a casting section, and (b) the feeding distance (FD), which is the maximum distance over which a riser can supply feed metal to produce a sound casting. According to Beckermann [1] different survey indicates that simulation is used for less than 10 pct of the tonnage of steel castings produced, and that risering rules (or rules-based software) are used to rig about 80 pct of the tonnage produced [2]. Due to the prevalence of rules-based rigging in the steel casting industry, any attempt to increase casting yield in a general sense must begin with

these rules. Even if simulation is used, risering rules are still useful to develop a reasonable starting point for simulation, which will shorten the iterative optimization cycle.

1 Different ways to calculate the geometry of the riser

Casting is an important industrial process for manufacturing near net-shaped products such as engine blocks, crankshafts, and turbine blades. Among various shape casting methods, sand casting is very common, and more than 80% of casting parts is produced by this method [3]. Generally, production of cast parts has two design stages: product design and process design. The product design is performed by design engineers based on the expected service requirements. In this context, topology optimization is common to achieve the optimal design. The process design stage then is performed by manufacturing engineers to produce sound castings that satisfy the a priori defined criteria for filling and solidification defects, mechanical properties, dimensional tolerance, residual stresses, and production cost. Riser design is one of the main parts of the casting process design. When molten metal enters into the mold cavity, its heat is transferred through the mold wall. In the case of pure metals and eutectics (narrow bound solidifications), the solidification proceeds layer by layer (like onion shells) starting from the mold wall and proceeding inward. The moving isothermal interface between the liquid and the solid region is called the solidification front. As the front solidifies, it contracts in volume (density of solid is usually larger than the liquid) and draws molten metal from the adjacent liquid layer. When the solidification front reaches the central hot spot, there is no more liquid metal left, and a void—shrinkage cavity—is formed. This is avoided by attaching an additional part to the casting, which is called riser or feeder. The riser should be designed so that the controlled progressive directional solidification is established and the volumetric shrinkage is compensated. Therefore, the optimal design of feeding system is a key to produce sound castings. The riser design not only controls remained defects in the casting, but also affects the cooling rate and so mechanical properties and thermal stresses. Furthermore, it has a considerable effect on the production cost. As mechanical properties of castings are considerably affected by process conditions, particularly riser design.

1.1 Determination of the FD

A great deal of effort has been expended to develop rules for determining riser FDs in steel castings. Many researchers have developed

empirical relations for determining feeding distances in carbon and low-alloy (C&LA) steels. These rules are typically based on experimental casting trials performed in the 1950s by Bishop, Myskowski, and Pellini at the Naval Research Laboratory (NRL), as well as on similar casting trials conducted by the Steel Founders' Society of America (SFSA). An extensive review of empirical FD relations for C&LA steels is provided in previous work by Beckermann [4].

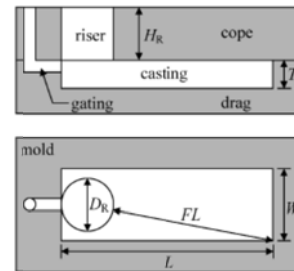


Figure 1: General configuration and nomenclature for horizontal plate casting trials.

1.2 Simulation in casting process

The replacement of physical experiments with software simulations is increasingly common in many sections of the industry today. Some numerical experiments are carried out in order that optimal tooling and process parameters are selected to get products right first time-avoiding time-consuming and costly physical experimentation. Other studies aim to obtain a deeper understanding of the effect of varying process parameters (sensitivity studies) towards optimizing a process [5]. However, numerical experiments that were based on the DOE method are rare in the open literature. The fact that workers are only just starting to consider such a combination for casting related simulations is apparent from a recent paper [6] where the DOE method is applied to numerical simulations of aluminum permanent mold casting. The aim of their investigation was determine what is the best method for optimal riser design in sand casting process. In summary, whilst DOE methods and the use of computer simulations are no longer new to the manufacturing industry, instances of combining the two for achieving significant increases in productivity during a problem solving exercise are relatively scarce and the effectiveness of this strategy therefore remains to be investigated.

Simulation studies, when used in several areas of investigation, are quite useful to study the behavior of some phenomena in which different virtual situations are generated by the researcher using some specialized software. Robustness studies are rather common in statistic research; many of them are used to observe the behavior of

an estimator under several hypothetical situations that could happen in practice [7].

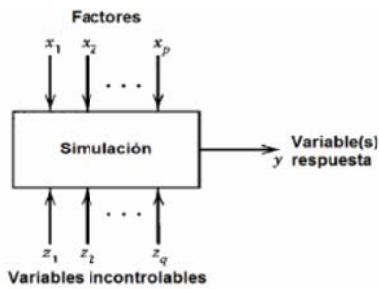


Figure 2: General scheme of a simulation study. Adapted from a scheme presented in [7]

Simulation studies, when used in several areas of investigation, are quite useful to study the behavior of some phenomena in which different virtual situations are generated by the researcher using some specialized software. Robustness studies are rather common in statistic research; many of them are used to observe the behavior of an estimator under several hypothetical situations that could happen in practice.

As computer technology continues to advance, computer simulation of the metal casting process is becoming an increasingly popular tool. Through the use of simulation, foundries are able to evaluate modifications to casting designs without having to actually produce the casting, thus saving time, material resources, and manpower. However, computer simulation must be applied on a case-by-case basis and its effective use requires expertise as well as accurate data for many process variables. Furthermore, casting simulation does not provide the initial riser design for a casting nor does it automatically optimize the risering. Due to these limitations, feeding rules are still widely used in the steel casting industry to determine the size and placement of risers. The success of casting, particularly sand casting, depends on a large number of parameters, many of which are only controlled to loose tolerances within many foundries [8]. This has led to casting being something of a 'black-art' rather than a science, with experience being the most desirable possession. However, the foundry industry has come under increased commercial pressure from other metal forming processes such that a more scientific approach to casting design is being introduced into many foundries. This has also coincided with the availability of relatively cheap, high-capacity; high-speed mini and microcomputers which enable the relatively complex calculations of scientifically based casting design to be carried out at an acceptable cost. The main features of the casting process which contribute to the quality of the final product include:

- The flow of molten metal into the mould cavity.
- The solidification of the metal.
- The feed of liquid metal to the solidification front to counteract shrinkage.
- The generation of residual thermal stresses due to post-solidification cooling.

The process of mould design in the foundry industry has long been based on the intuition and experience of foundry engineers and designers. To bring the industry to a more scientific basis the design process should be integrated with scientific analysis such as fluid flow, heat transfer and stress analysis. Exists different ways to make an optimization in casting process, computer aided optimization, genetic algorithms (GA) and others[9].

Starting with the original design, a computer model is used to simulate the casting process. Given a set of defect criteria, defects can be predicted that suggest modifications to the original design. After several iterations of this *design cycle* an optimum design, free of defects should be produced. From this procedure, it will be possible to determine whether a given mould design will produce a sound casting without having to discover this in the foundry through the usual trial and error process, which can be very tedious, time consuming, and expensive.

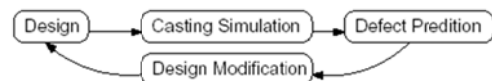


Figure 3: Use of the casting simulation how way to improve the quality of the process.

The promise of CAO has been that as we model physical processes closer to reality, the simulation becomes more accurate, and the defect criteria simpler and more precise. However, this promise comes at a price. First, as the model improves it becomes increasingly sensitive to the thermophysical data. Often these data are difficult to obtain and therefore several new experimental techniques need to be developed. Second, as the mathematics becomes more complex there is a need to either develop efficient solution algorithms or invest in more powerful computer resources.

1.3 Fluid Flow and solidification modelling.

Primary purposes of computer modelling are to increase casting yield, so reducing gross weights

and demand for molten metal, to enhance product quality, reducing scrap and rectification costs, and to reduce lead times from design to finished casting. Apart from the energy savings and associated environmental benefits, results also provide a basis for more reliable cost estimates for quotation purposes.

The challenge facing fluid flow modeling is the development of a solution algorithm that can simultaneously solve the momentum and continuity equations. Although there are a variety of ways this can be done, in the field of solidification modelling, the dominant methods have been iterative. The most popular methods have been: SMAC, SOLA, and SIMPLE. Although each method was designed to be an improvement on its predecessor, in practice each method has a strength that distinguishes it. For example, in a number of applications that involve the modelling of the free surface and fluid flow, the SOLA method has been found to be the most efficient and stable solution algorithm.

The challenge facing the modelling of metal flow during solidification has been to simulate the extinction of velocity at the solid/liquid interface. The easiest technique has been to switch off the velocity in the solid. A second technique has been to add a source term to the momentum equation that damps the fluid velocity in the mushy region. This corresponds to a situation where the liquid metal percolates between columnar dendrites. The third technique has been to modify the viscosity based on the fraction solid. This corresponds to a situation where free floating crystals are transported with the melt. Although these physical interpretations have made the choice between each method much simpler, in practice, it is their numerical behaviour that often dictates their use.

This is an area that needs further experimental and theoretical investigation. While substantial progress has been made to fluid-flow models in the last decade, it has only been in the last few years that they have turned their attention towards solidification modelling.

On many occasions fluid-flow modelling has been used to improve process design. However, it has been found that such models are very sensitive to the choice of numerical parameters, and that validation using experimental data is essential in order to obtain accurate predictions.

Many commercial systems have been used for simulation such as: ProCAST, a product of UES Software Inc, USA and MAGMASoft, originating at the Aachen University of Technology, Germany. The ProCAST system, based on 3D finite element analysis, provides one base module containing the thermal/solidification solver, pre- and post-processors and a material database.

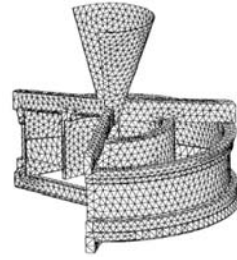


Figure 4: Finite element mesh for ceramic shell mould

1.4 The risers design process optimization.

In occasions with an experiment is not enough to obtain the looked for answers or the achieved levels of improvements are not enough, for what is necessary to experience in a sequential way until finding the wanted level of improvement. In the case of this experiment, a high number of variables that intervene as entrance variables exist.

As one of the objectives of the work it is to determine the good conditions of the process decides to use the methodology of the answer surface, since the same one allows to find conditions of good operation of a process to improve the quality of a product.

Response surface methodology, or RSM, is a collection of mathematical and statistical techniques that are useful for the modeling and analysis of problems in which a response of interest is influenced by several variables and the objective is to optimize this response.

In the design of risers interview different variables, riser geometry (high, diameter), temperature of the melt, type of molding sands and overheat temperature.

The answer or result waited in this case would be the action riser design about the sanity of the piece, that which influences directly on the final quality of the piece and the process.

Conclusion

1. The method proposed by Beckermann offers the best values of efficiency for calculate a geometric of the risers.
2. Through the consulted literature it is evidenced that the simulation like prediction tool is a way to decrease costs, the time that delays a product in arriving again at the market and the quality of the casting.
3. For the optimization of the process the methodology RSM is the better way to guarantee the optimum point of the risers design process

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LOGISTICS NETWORKS

Logistics networks and supply chains are typically characterized by an increasing complexity as well as a rising variability. Therefore, it is necessary to develop new appropriate models and procedures that coordinate logistics networks effectively, organize processes efficiently, contribute to optimizations and provide support to the whole decision making process. The following papers present complex logistics networks from the perspective of the regional development theories, supply chain topics such as collaboration and outsourcing and risk management in virtual networks.

The main difference between the 4PL approach and existing approaches to logistics outsourcing

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Summarizing the regional development theories – Focusing on the importance of logistics

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Concepts of risk-management in virtual logistics systems

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THE MAIN DIFFERENCE BETWEEN THE 4PL APPROACH AND EXISTING APPROACHES TO LOGISTICS OUTSOURCING

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The concept of "logistics" today includes not only transportation, but also monitoring the process of moving goods from producer to consumer. Quite a number of small and medium-sized businesses have their own logistics services, the budget of which can be up to several tens of percent of the annual income of the firm. But not always, these costs are justified. The presence in the logistics services companies increases the load on the information schema of the organization and the human resource. Resolve such issues of concern to all firms. One of the best ways to tackle the problem of increasing costs is to outsource part of the logistics functions, the transfer of the implementation of a third party. Outsourcing of logistics helps to more actively develop trade relations, to expand the boundaries procurement markets, marketing. The development of these markets means that companies involve mediators for organizing the delivery and storage of goods. In general, outsourcing - is the transfer of an outside contractor to some business functions or parts of the company's business processes. Outsourcing can improve the performance of logistics operations for the client company. In this case, the use of secondary functions outsourcing company can focus on those functions that are peculiar to it, the key functions. Outsourcing is a management strategy of the company, it expects the restructuring processes and external relations the focus of the supply chain. The main effect of outsourcing - is to increase the efficiency of logistics management.

High competition between the leading trucking company makes new ways of solving problems. One of the possible solutions is to attract 3PL and 4PL providers. Recourse to the services of an outsourcing company allows the contracting authority to:

- reduce delivery and storage of goods;
- significantly reduce the possible risks (including the one and the other to control the situation in the so-called force majeure);
- focus on core activities;

- significantly reduce the cost of providing optimal performance of its own logistics department.

If all listed add the presence of quality of transport infrastructure, complete control over the document, taking into account and support of products, the ability to shoot on the legal base of relations between the state and businesses, it is precisely such functions and shall perform professional PL-operator. The presence or absence of services mentioned above classifies today's logistics companies in the Russian market. Today, the market of logistics services in Russia is growing rapidly and is a very attractive business sector. This market has also increased and developed in new areas of logistics services like the integration of the supply chain, which is carried out by so-called 4PL-providers. We propose the following classification of logistics service providers:

1. 1RL (First Ragtu Logistic) - Autonomous logistics - the performance of all logistics operations by the cargo owner, in this case the company decides all its logistical problems on its own and only uses its internal resources.
2. 2RL (Second Ragtu Logistic) - Traditional logistics - the traditional set of services for transportation and warehouse management. These companies offer their customers a simple logistics outsourcing: transportation or storage operations.
3. As a result of bringing 3PL-providers to meet the challenges of increasing complexity, first as a subcontractor then as partners - consultants, managers, IT-systems integrators, and business analysts who have become an integral part of the entire supply chain. Qualitative increase in a specified list of logistics services contributed to the emergence of the term 4PL.
4. 4RL (Fourth Party Logistic) - Integrated logistics - integration of all companies involved in the supply chain of goods. 4RL is the process of planning, management and

control of all logistic procedures (for example, the flow of information, raw materials, goods and capital) by a single operator 4PL-to long-term strategic objectives. 4PL - is the integration of all the companies involved in the supply chain. The concept of 4PL-outsourcing (Fourth Party Logistics) - this is an integrating framework that gathers resources, features, and technologies in their organizations and others to develop innovative solutions for the supply chain and their subsequent implementation. 3PL-providers, mainly specialize in providing integrated solutions, services, storage and transportation, that are specific to the activities of the individual customer and meet their needs, based on market conditions and requirements for the delivery of materials and products.

Figure 1 shows a classification of logistics operators.



Figure 1: Classification of logistics operators

Qualitative development of logistics services 4PL-term assignment operators contributed 5PL next horizon logistics. Unlike the previous service 5PL, 4PL is to use the internet as a single virtual platform for solving logistical problems. Organizations that can actually be classified as 4PL solve complex problems or implement strategic prospects of integration of business processes in the supply chain customers. Field 4PL-providers (logistics system integrators) is formed by a qualitative expansion of the function performed, a systematic approach to managing key logistics business processes, integration and coordination of the focus of the company and contractors in the supply chain, including the formation of an effective supply chain and data exchange between the parties in the chain real time with the help of modern information systems and technologies. In a typical list of services 4PL-providers include the following services:

- Design and optimization of supply chains;
- Develop and administer the logistics network;

- Integration of IT-systems and applications contracting the supply chain;
- Monitoring the performance of orders in the supply chain;
- Planning of optimal schemes delivery / transport route optimization; monitoring of commodity-transport streams;
- Integrated inventory management in the supply chain, maintenance of common documents (in electronic form);
- Quality management of logistics services.

4PL-functional companies are qualitatively different from that of 3PL-service providers, including the strategically important business processes for supply chain participants. Differences between the main types of logistics intermediaries in key parameters, including providers 3rd and 4th levels are shown in Table 1.

Traditional setting	Inter-mediary provider	3PL-provider	4PL-provider
Services	Sole function	Multi function	Integrated multi-functional complex services
Access to markets	Local, regional,	Inter-regional	Global. Delivery of "door to door"
Relationship in the supply chain	One-off transaction (contract year)	Long term (3-5 years)	The strategic partnership
Competitiveness	Frag-mented	Co-operation logistics inter-mediaries	Forming alliances several major alliances in the market
Competence of the company	Many assets, performance of individual operations	Offset from the ownership of assets to the ownership information	The focus on information management, integration of IT-based solutions
Value for the clients	Reduce costs by optimizing the individual functions	Reduced costs due to the complex business process optimization	Cost reduction and optimization of business processes through the integration of the supply chain

Table 1: Characteristics of the main types of logistics providers

4PL-provider should be able to integrate the diversity of IT-systems of the enterprises involved in the supply chain. To coordinate the supply chain all the participants need to define the interface between the systems, to provide a standardized electronic exchange. Another function of the 4PL-provider is to ensure order tracking at all levels of supply chains. Need to quickly identify faults in transportation, loading, unloading, handling of cargo. Optimization and path planning should also be the responsibility of the logistics companies such as 4PL.

All cargo throughout the supply chain clients need to go with the best connection to him shippers and carriers, not to break the cycle of orders.

The main difference between the 4PL approach and existing approaches to logistics outsourcing - a unique ability to increase the value of the company and the share price in several ways.

Unlike traditional outsourcing, which has advantages, mainly in some parts of the supply chain, the 4PL approach aims to optimize the logistics chain as a whole, through the influence of the four key components of stock prices: increase revenue, lower operating costs, reduce working capital and reduce the main capital. Revenue growth is achieved through improvement of the quality of the product, its availability and enhancement of customer service through the use of advanced technologies. Since 4PL providers have focused on managing the entire supply chain a significant improvement in the quality of services can be achieved. Increased customer satisfaction also increases the income.

Coordination of activities of the supply chain participants, information flow among actors and the supply chain will reduce operating costs by 15%, as well as reducing the price of the goods due to the integration of processes, improved planning and execution of logistical problems. Logistics outsourcing is a strong potential for development in Russia. The processes of globalization, integration and cooperation, and increasing consumer demand encourages companies that want to be competitive in the market, to apply the logistic approach to its business, as well as use in the activity of such a tool, as a logistics outsourcing.

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SUMMARIZING THE REGIONAL DEVELOPMENT THEORIES – FOCUSING ON THE IMPORTANCE OF LOGISTICS

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1. Theories of regional development

The main difference between the theories of regional growth is the aspect of the source of development. The different schools of regional studies have different answer to the following question: Is there an economical equilibrium on the market of the factors of regional growth? If not, how should the government intervene? Till the early 1970's a regional adaptation of Keynesian economics was used by the governments. [2] In 1973 due to the oil crisis the tools of the Keynesian policy became useless. From that point neoclassical theories based on factor endowment (such as: innovation, education, etc.) have become dominant. Decision-makers trusted the tools which enhance R+D activities and help to strengthen human capital. With the phenomena of globalization the social-economic conditions changed, so as the trends of regional policies. Regional excellence and global competitiveness are handled as interdependent factors. Local co-operations are inevitable to compete on the global market and the presence on the global market can ensure regional development. Previously, regional competitiveness and development was considered as an "imprint" of macroeconomics, but it changed with the 1970's. This means that regional studies have become an independent and distinct system in the world of economics. It is important to realize that the interpretation of regional growth is nowadays focused on productivity, competitiveness and the quality of life rather than on labor and capital. According to that, governmental interventions must differ in every region and must support bottom-up initiations using endogenous factors.

Basically, there are three types of traditional trends in the field of regional development:

- Keynesian export base theory
- Neoclassical (exogenous) regional growth theory
- Neoclassical (endogenous) regional growth theory

1.1 Keynesian export base theory

Till the 1970's Keynesian theory of monetary and fiscal intervention was used to equilibrate the deflections of economic cycles. [6] The fundamental assumption was that the benefits of interventions are greater than the loss of a missed intervention and the solidarity and the social cohesion can also be intensified. The essence of Keynesian intervention is: increase of investments, governmental spending and net export generate a multiplier effect which leads to rising employment and demand growth on the markets. In a region the mechanism of multiplication works as follows [3]: The surplus of the investment is added to the income of the region. This surplus is partly invested in other products and services. According to this the entrepreneurs of these sectors will have a higher income which will also be invested or be consumed. The actual increment of income depends on the willing of consumption as well. The theory of Keynesian regional growth states the following. The differences of the development of regions depend on their productivity, industrial structure, capital intensity. The prices and wages are inelastic so the markets are not in equilibrium. The productivity of the regions won't increase automatically. In contrast, the regional differences are continuously increasing. Regional intervention is needed where the government should invest in the underdeveloped to increase specialization and increase capital inflow. The proper investment can create multiplier effects which can decrease the differences of regional growth.

The base theory distinguishes two different types of the labor market. The economic activities of a labor market are divided into those that produce for the export market (basic industries) and those that produce for the local market (non-basic/service industries). The two sectors are linked in two ways. The basic sector directly purchases goods and services from the non-basic sector. Workers employed in the basic sector purchase food, clothing, shelter, public services from the non-basic sector. Greater demand for the region's exports generates exports sales and income for the basic sector, which basic-sector purchases provide income to the non-basic

sector. This is the multiplier effect. The export base theory's consequence for the decision-makers of the government: active government policies should be performed to support the export activities so that exporting firms gain more from buying local goods and services, while reducing the imports. Regarding the described processes economic growth will start. This will be initiated and maintained by the exporting companies so that in the local economy more jobs are created and incomes are increased as well. This theory was criticized by many. The export capacity of the region does not depend on the investment primarily but on the technical development. In an underdeveloped region, the qualifications and skills of labor are not adequate with the latest technologies so they cannot be deployed in the region. [5]

1.2 Exogenous regional development

The exogenous regional growth theory accepts the self-regulation of the markets and is based on the marginal theories. The ideal framework of exogenous model describes regional growth as the effect of three major factors: increase of capital stock, expansion of labor and technical development. All the three factors can be separated to internal and external ones. Main assumptions of the model are: the productivity of the regions depends on the different factor endowment, especially on the different ratio of capital and labor and partially on the technical development. Basically, the model assumes perfect competition, constant return to scales, efficient self-regulation and free flow of the factors. This leads to the following statement: The factors can flow between the regions unhindered so the labor moves to regions where wages are higher. Because of the increase of wages capital moves to other regions or invest in technological development to save labor costs. Regarding this the supply of labor grows which leads to the decrease of wages. Where wages are lower, labor intensive activities will be established. Due to the high mobility of factors the flow of capital and labor are adverse. According to the aforementioned ideas sooner or later (due the self-regulation of the markets) the differences of the regions will decrease or disappear, so there is no need for governmental intervention to handle regional economic differences, only the free flow of factors should be ensured and proper infrastructure must be established to support the flow. This theory has been also criticized by the researchers. There is no empirical evidence of the equilibrium of regional development in the world. Regional disparities are usually permanent. [5] The labor market is inhomogeneous. The unqualified actors of labor markets can be hardly employed in developed regions.

1.3 Endogenous regional development

This model emphasizes technological development and human capital as the primary sources of regional development. Endogenous models are based on the five following factors:

- Capital intensity (capital/labor ratio)
- Level of technological development
- Technologies developed in the region
- Quality of innovation
- Qualification of human capital

Technology and knowledge are considered as endogenous factors of the region based on their previous efforts and results. The difference of the development of regions is caused by the divergence of capital-labor ratio and the level of knowledge accumulated in the area. The growth of labor productivity is based on the locally developed technologies. These researches can lead to knowledge spill-over in the region and if the human capital reaches the critical level, the results can accumulate for a long time in the region. Highly skilled professionals move to areas where knowledge-intensive sectors provide challenges and higher wages. In these knowledge-based regions this phenomena can cause increasing return to scale. Therefore the different regions have different trajectories of growth and the productivity of the regions will always change. According to this we cannot assume that the differences will disappear nor that they will persist. The message to the decision makers of the endogenous theory: there is a need for governmental intervention in the underdeveloped regions to obtain the experiences of the regions with higher productivity. The negative effects can be override by consolidation of knowledge based in the region by supporting education, research, knowledge transfer, and inspiring the entrepreneurs to cluster. Each region must adopt a tailor-made regional development strategy which is based on bottom-up initiations. This theory is also criticized by many because it only considers supply-side proposals. It assumes that knowledge base support will always lead to innovations and patents and these results will be used in the region where they were "created". By supporting the education it can also happen that the experts leave their region after graduating and won't cause any spill-overs. If there is stimulus effect around an institution of research it is not obvious that this will help in greater range in the region. [3]

2 The history and development of logistics

Logistics, as an integrated science can be classified among the ancient sciences. It has been playing an important role in the global development of our world for almost 5000 years now. Since the construction of the Egypt pyramids excellent logistics solutions have been made that become the basis for the transition to a new economic and historical era. Although logistics exist for thousands of years the definition of the process must be given.

“Logistics must ensure that a recipient is supplied from a point of origin in accordance with his requirements with the correct product (in quantity and variety), in the right condition, at the right time and in the right place at minimum cost.” [4] This holistic view of the logistics has waited a few hundred years to rise until we get to the system of supply chain.

Just as in other fields of the world, the Industrial Revolution brought significant changes in logistics when new road conveyances and the railroad had been discovered that led to the expansion of logistics tasks through new technologies and means of transport. The practical use of the steam engine, the invention of vehicles, railroads and ships as well as the discovery of crude oil ushered in a new economic era that generated new missions, tools and opportunities for logistics. As the original field of logistics (warfare) was the main developer of the ancient Rome, during the World Wars (sadly) military logistics has been again a great facilitator of this science. The basic principles of warfare manufacturing developed several fields of management such as quality assurance or logistics. After decades of military importance as a result of the experiences in the 1940-50's logistics gained an important place in the business world as well. Business awakened to the importance of logistics in adding value to products and the marketing and manufacture of them. The invention of Malcom P. McLean changed production conditions for nearly all industries around the world when he invented the sea container. This also changed the needs of the consumers and the expectations towards the logistics services. Even today, the sea container continues to ensure that harbors gain major contracts, new countries and regions experience commercial booms, markets arise and products from all parts of the world can be bought and sold at reasonable prices. Logistics (before ITC) has significantly contributed to globalization. In the 1960s, it began to appear in business literature in discussions about physical distribution, with a focus on outbound activity. Around 1970-1980 the new conceptions of Japanese production management literature redraw the map of the logistics and it became the fully integrated part of the world of production. Kanban and just-in-time

(JIT) concepts were developed and introduced at Japan's Toyota Motor Co. by Taiichi Ohno – with the objective of effectively linking logistics to other operational functions.

The different levels of the history of logistics are shown on Figure 1. Regarding to this all the goals which have been reached by the logistical optimization are just new steps building one on another fulfill customers' needs. [8]

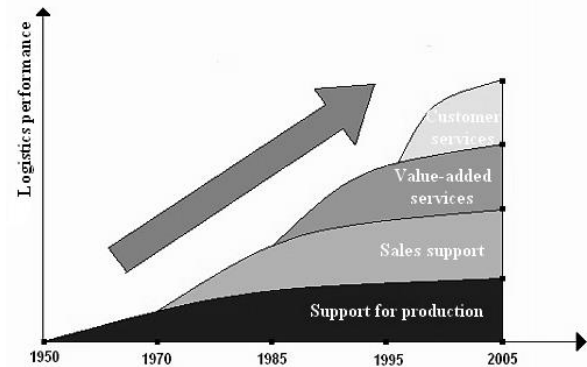


Figure 1: The goals of logistics [8]

A new revolution started in 1989 opened a new perspective on the demographic development. Till the early 1990's little has been written about logistics because logistical problems had required audience. They reach beyond the public interest and not imposed from outside the vital curiosity of the readers of specialists. For a long period of time, logistics has dealt with a small part of the work, considered as minor. After logistics has entered its rights, and content to all sections completed that performs all technical assurance and material, it must be treated with utmost seriousness. The new renaissance of logistics started with the use of ITC tools. In the 1990s the quick response and efficient consumer response technologies were developed and applied by many retail and wholesale companies. These technologies had a major impact on logistics. As a result of this technology, distribution centers are tasked with moving goods instead of storing them. This allows companies to accelerate reaction times to market developments and to set up efficient goods-supply systems. Since the late 1980s supply chain management is a term that has grown enormously in use and significance. In these terms, logistics are more than the mere transport of a good from Point A to Point B. Logistics is the idea and science of organizing and monitoring the entire value chain - so-called supply chains. Logistics is that part of supply chain management that plans, creates and monitors the efficient, cost-effective flow and storage of goods, semi-finished items and manufactured products as well as related information between the point of origin and the

point of consumption in order to meet customers' requirements. [2]

Today, supply chain management is viewed as a holistic consideration of key business processes that extend from the vendor's supplier to the end user.

Figure 2 represents the ways of reaching the goals of logistics. These tools are focusing on the needs of all the stakeholders.

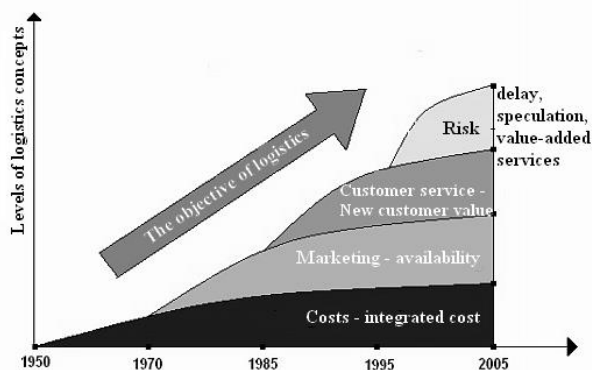


Figure 2: Tools to achieve logistics goals. [8]

First level was the cost reduction concept where the integration of logistical processes into the production methods was the primary objective. At this point the importance of logistics cost was considered as it must be.

The second and the third levels show a higher integration with other fields such as marketing or customer relationship management. The role of time becomes more and more important. Logistics are no more just about transportation but more about customer satisfaction. At this point logistics has become a key factor of competitiveness.

The fourth level shows the point where the logistic processes are outsourced and a new kind of partnership must be built up among the involved actors. This new actor will become the integrated logistics service provider, logistics park or logistics cluster. Elements of information system operations are also outsourced to the logistic service provider so strategic partnerships must be established with the logistics companies to ensure low levels of risk. This leads to the phenomena of supply chains and to the integrated work of supply chain management, where the whole process must be supervised to ensure the satisfaction of the clients. At this point the co-operation cannot be ensured by the complex system of contracts and legal settlements but the idea of trust becomes also important. Trust can be built up between members who interact with each other often and their operations are transparent to each other. This can easily occur in a regional settlement, where the logistic companies work together in a logistics center or park, in a cluster.

3 Conclusion

Logistical service providers tend to cluster in agglomerations where different actors of the logistical processes are managed in one place. These clusters use the endogenous advantages of the area. The reason why these companies work in the same region is that they try to reach the critical level of productivity, accumulate decent knowledge and to benefit from the local positive external effects.

There are several types of logistic clusters can be identified. One is the classification of Sheffi who differentiates clusters by

- Modal orientation
- Scope-based classification (International – Regional – Urban)
- Functional classification
- Among the functional classification Sheffi describes three types of logistics parks such as:
 - Customs and taxation-advantaged places
 - Single commodity logistics parks
 - Special services logistics parks. [7]

My research topic is highly related to initiative in the field of agriculture. I am keenly looking forward to opportunities which can lead Hungary to a solution where agricultural opportunities can be used in a better way.

Regional single commodity logistics parks or special services logistics parks can be useful for the research area of rural, agricultural clusters. These two types of logistics parks can be combined and used to handle the bulk transportation of hazardous biodegradable waste of the food and agricultural industry. Yu [9] classified the logistics parks of China and found out that there is a special type for agricultural logistics parks operating in China.

If we want to enhance the establishment of rural clusters logistic services should be taken into consideration. On one hand the existing logistics parks can be enlarge their services field and also work as an agricultural logistics centers. For that solution Table 1 shows some of the logistics centers of Europe.

Europe	
Denmark	Denmarks Transport Center, Hoeje-Taastrup Transport Center, Nordic Transport Center, Skandinavisk Transport Center, Taulov Transport Center
France	Rungis-Sogaris
Germany	GVZ-Dresden, GVZ-Bremen NW, GVZ Weil am Rhein, GVZ Nuremberg, GVZ Frankfurt/Oder (ettc), GVZ Osnabruck, GVZ Herne-Emscher, GVZ Kiel, GVZ Kassel, GVZ Hamburg, GVZ Bremen SW, GVZ Rostock, GVZ Koblenz
Greece	Promachon S.A.
Hungary	Budapest Intermodal Logistics Center
Italy	Interporto di Bologna, Interporto Marche, Interporto di Novara, Interporto Quadrante Europa, Interporto di Padova, Interporto di Parma, Interporto Rivalta Scrivia, Interporto di Rovigo, Interporto di Torino, Interporto di Venezia, Interporto di Verona
Portugal	Terminal Multimodal Do Vale Do Tejo S.A.
Spain	Bilkakobo-Aparcabisa, Centro de Transportes Aduana de Burgos, Centro de Transportes de Coslada, Centro de Transportes de Irun, Centro de Transportes de Madrid, Centro de Transporte de Vitoria, ZAL Port de Barcelona, Zona Franca de Barcelona, ZAL Gran Europa, Centro De Transportes de Benavente, Cimalsa, Ciudad del Transporte de Pamplona, Ciudad del Transporte de Zaragoza, Plataforma Logistica de Zaragoza
Ukraine	Liski-Ukrainian State Centre of Transport Service
United Kingdom	DIRFT Logistics Park, Keypoint: Swindon's premier logistics park, Kingmoor Park, Port of Tyne, Wakefield Europort, Birch Coppice business park

Table 1: List of reviewed logistic centers [1]

Unfortunately, there is only one large logistic center operating in Hungary which is located far away from the locations where agricultural waste arises.

I accept that with governmental policies we can support the establishment of certain industrial areas in regions where the needed resources are already given. Nevertheless, if we would like to speed up the growth of the region other actors should be supported as well, in this case the actors of the logistical processes.

For rural development, I assumed that the Energy Farm concept (where the waste of the farm is fully reused by bio-gas digesters, fermenting rooms, biomass plants, etc.) is a good start-up for rural cluster initiatives. These start-up clusters must be supported by the logistical parks as well, and in that region single commodity logistics parks or special services logistics parks should be established.

I assume that where industrial clusters exist sooner or later logistic centers must open as well to react to the needs of the market actors. Also, where logistics parks are operating industrial clusters can establish using the local benefits of the logistical companies who already operate in the region.

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CONCEPTS OF RISK-MANAGEMENT IN VIRTUAL LOGISTICS SYSTEMS

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1 Introduction

The significance of cooperative logistics systems, like that of the virtual logistics enterprises, has been continuously on the rise in the recent years. This can be traced back to a need for increased cooperation on the inter-organizational level, and also to the continuous advance of the related IT background in the last two decades. However, a significant challenge in such systems is to facilitate the required level of trust among the different participants, as it is a basic requirement for the proper operation of any cooperative system, especially that of the virtual enterprises. In light of this problem, the publication deals with the presentation of some of the more significant risk-management concepts for IT based inter-organizational systems, together with the introduction of an emerging concept of a general risk-evaluation logistics method that can be easily adapted for virtual logistics organizations.

2 The development of risk-management in virtual enterprise architectures

The introduction of e-commerce in certain fields of the economy dates back to at least three decades by now. While it originally introduced on the closed networks of various financial companies, it quickly found its way into other broad areas like manufacturing, transportation, logistics, different types of services, etc. [11] [12] [13] [14] As a result, the need to assure the proper level of security in e-commerce systems quickly arose, and the experts in the field quickly turned towards well established tools in risk-management (methods like scenario analysis, event and fault-tree analysis, sensitivity analysis, FMEA, the use of questionnaires and expert systems, etc.). However, with the rapid spread of decentralized IT solutions (and the related extended enterprise architectures), the problem of the increased business risk and the decreased levels of trust and reliability in complex e-commerce based systems also became more and more significant, besides of the basic security questions. The studying of the field gained further impetus by the

widespread adoption of the Internet and its related technologies. [12]

As a result, by the turn of the century, the broader questions of risk and trust in e-business models became more relevant than ever. Several works from this period, like that of W. Manchala (2000), accurately predicted that the standard security protocols used in credit card transactions and some other financial operations are inadequate in a more complex e-business model. Instead, several “trust-variables” could be introduced into such complex systems, together with the use of different “trust-models” (based on Boolean relationships, fuzzy logic, transaction processes, etc.), which can be far more capable of describing the various customer-vendor relationships that are present in the above mentioned organization architectures. [2]

Kazanchi and Sutton (2001) also introduced an assurance model that extends over different stages of an IT based B2B relationship. In this model, they made a distinction between three hierarchical levels in the following up-to bottom order:

- Application-User Level,
- Business Level,
- Technical Level.

According to their work, this hierarchy can be identified on all the main stages of the relationship (EDI Adoption, EDI Integration and EDI Outcomes). [3]

Later, the same authors developed the previous model further by defining the critical risk factors on all the three levels. Hence, they identified so-called “technical risks”, “business risks” and “application-user risks”, together with a critical set of B2B risk factors selected from the above classes. Their research was mainly based on the nominal group technique with the use of structured focus groups (internal and external constituency groups), assembled from various professionals in the related industries. [4] Several other risk-models were also developed in this period, and even large companies started to invest considerable resources into the deeper studying of the field. A common element of nearly

all of the proposed models is the utilization of multiple risk-categories that not only affect the overall risk of a B2B relationship, but they often interact with each other as well. Another common characteristic is the identification of different stages in an e-business relationship, with different primary risk-sources in each stage. Based on these theoretical backgrounds, other researchers started to investigate the possibilities of using mathematical modeling tools and software applications for the task of making accurate risk evaluations in certain e-business models. Precursors to such works can be traced back even to the 90s, where a number of large companies started to work on the modeling of their extended supply chains. Such an example can be found at IBM, where researchers developed an "extended-enterprise supply-chain analysis tool", called as the "Asset Management Tool" (AMT). [5] AMT integrated, among other functions, "graphical process modeling, analytical performance optimization, simulation, activity-based costing, and enterprise database connectivity into a single system that allowed the quantitative analysis of extended supply chains". The company used this application to a great effect, which materialized itself in significant cost savings. [5] Partly inspired by the success of these types of applications and also by the appearance of the previously described risk models, researchers involved in risk management started to develop similar tools for the virtual enterprise (VE) architecture, with the intent of calculating the inherent risks of planned collaborations in such IT based environments. Of the different mathematical modeling tools, heuristic algorithms were among the first to be tested in the previous role. Such algorithms are particularly useful for solving different combinatorial problems, which makes them ideally suited for the analysis of the various partner-selection possibilities in a virtual organization. Ip, Huang, Yung and Wang (2003) followed this approach, when they applied a genetic algorithm for a risk-based partner selection problem in a virtual organization. Their method was primarily based around the "inefficient candidate" concept and the use of a "rule-based genetic algorithm (R-GA) with embedded project scheduling capabilities". They demonstrated the performance of their algorithm by applying it to a partner-selection problem encountered in a real-life construction project. [8] More lately, newer risk models based on distributed decision-making also started to appear, which can also utilize heuristic optimization algorithms quite effectively. One example of these is the model introduced by Min Huang, Fu-Qiang Lu, Wai-Ki Ching, Tak Kuen Siu (2011), who proposed an architecture with two levels, called the "top model" and the "base model". This approach acts as a "combination of

both the top-down and bottom-up approaches" and it uses particle swarm optimization to deal with the emerging optimization problems. According to the researchers, this architecture "can improve the description of the relationship between the owner and the partners" in a VE (virtual enterprise), which can help reduce the inherent risks in the system. [10] A number of other heuristics were also developed by various researchers for similar purposes. However, it's probably right to say that fuzzy logic based solutions provide the most examples in the field. Earlier examples include that of Ngai and Wat (2005), who used a "fuzzy decision support system for risk-assessment" in a general e-commerce environment. They combined it with a risk analysis model using the fuzzy set approach, while they also developed a novel web-based version of this application that can be used to analyze any e-commerce based development from a risk-management perspective. [6] Later, Tsung-Yi Chen, Yuh-Min Chen, Chia-Jou Lin and Pin-Yuan Chen (2010) also used a fuzzy-logic based trust evaluation method that was designed especially for virtual enterprises. Their method relied primarily on "correlation evaluation, current trust evaluation and integral trust evaluation", while the amount of "knowledge-sharing" was the mainly examined parameter in this research. [7] Wulan and Petrovic (2012) developed a fuzzy logic based system for VEs and VO's (virtual organizations) too. In this approach, four stages in the life cycle of a VE based collaboration are identified: pre-creation, creation, operation and termination. Then, risk factors are determined in respect to these stages, while the developed algorithm serves for the assessment and evaluation of these factors. The method takes into account both the probability and the impact of each risk factor, moreover a prototype web service called the "Collaboration Risk Evaluator" was also developed and tested in real life conditions. [9] As we could see from the above presented short review of some of the related literature, the need for proper risk assessment in IT based virtual organizations gained significant attention in the last 10-15 years. Most of the developed concepts can also be applied for virtual logistics organizations as well, with more or less efficiency. The purpose of the author is to present another approach in the followings, one that is especially designed for the needs of a virtual logistics enterprise.

3 Introducing a proposed risk evaluation method for virtual logistics systems

As we could see, several different approaches were already developed for the purpose of risk assessment in a virtual organization. The majority

of these methods are based on the utilization of complex risk-models and a certain level of knowledge engineering, while many of them also make use of fuzzy logic or different heuristic algorithms. While the combination of these techniques could certainly provide good results in a lot of different cases, in the field of logistics there is also a strong need for rapid decision making supported by very strong historical and empirical data.

This is the primary motive behind the proposed risk-evaluation method and the related VE architecture. The central element of this following model is the application of the so called 'process-capability' concept, which has been in use in various industrial fields for many decades by now, and has proven itself many times under real-life conditions [1]. In short, the essence of the approach is that the deviation of many key parameters in an industrial process can be adequately described with the use of a few typical statistical distributions (most often with the normal distribution). However, this also means that an adequate sample of the examined parameter can be used for making assumptions about the characteristic deviation (σ) and the mean value (μ) for this parameter. The concept of process capability uses a method where the obtained values of σ and μ are compared with the pre-defined tolerances of the process examined, in this way providing an objective assumption about the general 'capabilities' of the process. In practice, this comparison is made via the calculation of the process capability and critical process-capability parameters (c_p and c_{pk} , respectively) [1]:

$$c_p = \frac{T}{6\sigma} = \frac{OG - UG}{6\sigma} \quad (1)$$

$$c_{pk} = \min\{c_{po}; c_{pu}\} \quad (2)$$

In the first expression, OG is the upper tolerance value and UG is the lower tolerance value for the examined parameter, therefore the difference between the two gives the width of the allowable range for the parameter. In the second expression, c_{po} and c_{pu} are defined as $(OG - \mu)$ and $(\mu - UG)$ respectively (the "upper" and "lower" part of the allowable range), therefore c_{pk} will equal to the smaller, thereof more critical value. It is very important that this approach has started to expand into the service sector, and therefore into the field of logistics services as well, even though the normal distribution alone is rarely applicable in these areas (usually normalization is needed). In

the manufacturing industries, these process capability parameters have already been in use for many decades, combined with various evaluation metrics.

One of the most widely used of the metrics is what is called the 'six sigma' method, which is significant for two reasons: first, it is widely used in a lot of different industrial sectors and a great number of companies even make its use mandatory for their suppliers – therefore it is already used by certain logistics-service providers as well. Secondly, in this metric discrete failure rates are connected to each sigma level which can serve as the starting point for calculating the additional cost of a less-dependable logistics service. For the actual cost calculation, the simplest and most straightforward approach is the linear connection, which is also presented in Table 1 for finding the value of a generic risk parameter ' p ' (values for c_{pk} are calculated with assuming – due to long term distortions – a 1,5-fold shift in the mean value, which is a typical calculation method in the industry).

Of course, in order to make use of the previous methodology, fundamental risk parameters have to be introduced into a virtual logistics system. Basic parameters applicable for the evaluation of the logistics service providers in such a system could be:

- punctuality, which describes the deviation of the actual delivery dates from the planned values at a certain supplier or service provider (denoted by ' p '),
- reliability, which describes the general failure rate in the delivered goods for a certain supplier or service provider (denoted by ' r '),
- calculability, which describes the deviation in the amount of the delivered goods from the planned values at a certain supplier or service provider (denoted by ' c '),

Of course, these are just the basic risk factors that characterize the risk-model and several other parameters could be introduced later, in order for a more complete risk assessment. The objective function below (3) serves as an example of how to incorporate such a metric into the optimization process (in this function, each risk parameter can increase or decrease the total cost of the given bid of the i -th service provider). In the proposed model, this optimization takes place in an extended e-marketplace that serves as the central IT infrastructure of the VE, facilitating not just the auction mechanisms among the participants of the system, but providing other services as well: [14]

At 1.5-fold shift of the mean value (μ)				
C_p	C_{pk}	Sigma level	Failure per million	Value of p
1.00	0.50	3	66 810.6	1.0668
1.33	0.83	4	6 209.7	1.0062
1.67	1.17	5	232.7	1.0002
2.00	1.50	6	3.4	1

Table 1: Values of a generic risk parameter presented together with the associated σ levels [1]

$$C = \sum_{i=1}^n \sum_{j=1}^m c_i r_i p_i c_{ij}^F \left| \frac{q_{ij} - \Delta q_{ij}}{q_{ij}^F} \right| tb_i = \min \quad (3)$$

It can be seen that this approach greatly encourages the service providers to increase the quality of their services, as the cost of their bids can be significantly affected by even a single difference in the sigma level (note the difference between Levels 3 and 4). Naturally, it has to be noted that the linear method can only be applied for the reliability parameter ' r ', where the cost of the failures is more or less linearly related to the average number of faulty products in the shipments. However, this does not affect the usefulness of the approach in general, as more sophisticated relation functions can be worked out for the other parameter types.

The previously presented method can serve as an important decision making tool for the participants of a virtual logistics organization; however, it does not provide a risk-oriented evaluation of the entire system. For this purpose, the author proposes the introduction of a general variable, which can be called a 'system capability parameter' (derived from the concept of 'process capability' for individual processes). As its name suggests, this parameter would deal with the entire organization in an implicit manner, viewing it as a single and complex process. Thereby it is obvious that this single parameter, serving as an evaluation tool of the entire virtual enterprise, would be the function of the individual risk parameters introduced into the system:

$$P = f(c_1 \dots c_i \dots c_n, r_1 \dots r_i \dots r_n, p_1 \dots p_i \dots p_n) \quad (4)$$

The primary difficulty in this function is how to generalize this for all types of virtual logistics companies though the sizes and the types of services may vary significantly from organization to organization. One starting point in this research may be the fact that P can also be obtained by comparing the estimated cost of each mandate in the organization with its actual realized cost, which (in theory) can only be higher due to certain failures and inefficiencies during the realization:

$$P \sum_{k=1}^p C_k = \sum_{k=1}^p C_{Fk} \quad (5)$$

where:

- C_k is the estimated cost of the k -th mandate in the examined period,
- C_{Fk} is the realized cost of the k -th mandate in the examined period.

This latter method can be used both in operating real-life enterprises as a systematic control tool and in simulation models as a testing and research method.

In the following stages of this research, the expectation is that by combining the use of the two approaches on a wide scale of simulation models, the first function can be determined for a generic virtual logistics enterprise with adequate precision, providing the possibility of making accurate predictions in real-life virtual logistics companies that apply the proposed risk-management concept. As Table 2 below clearly represents, the utilization of the P parameter could also serve as an implicit quality-parameter for a given virtual enterprise, as it is strongly related to the σ levels that are achieved at the individual components (member enterprises), while it also defines an overall σ level for the entire system. One aim of the research is to clarify this relationship, as it can have significant implications for the industry.

4 Conclusions

The paper presented the currently followed approaches of risk-management in virtual enterprise architectures, based on a sufficiently extensive literature review.

This is followed by the introduction of a possible new method for the evaluation of the risk-performance of virtual logistics systems, mainly from a quality based perspective. Hopefully, this method may lead to the development of a general evaluation tool, one that could be used with significant success for the evaluation of virtual logistics enterprises, at least from the aspects of risk and quality management. As the main difficulty of creating cooperative networks lies in achieving a significant level of trust and reliable information sharing among the different participants, such tools may play an important role in the future proliferation of IT based cooperative logistics systems.

Sigma level of components	Sigma level of the system	Failure per million for the system	Value of P
≥ 3	3	66 810.6	≤ 1.0668
≥ 4	4	6 209.7	≤ 1.0062
≥ 5	5	232.7	≤ 1.0002
≥ 6	6	3.4	1

Table 2: Value of P in relation to the σ level of the overall system and to the σ levels of its components

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MOBILITY AND TRANSPORTATION SYSTEMS

Logistics is the key function leading toward mobility, an increasingly important objective of our societies. The logistics task of transportation comprises activities such as effective infrastructure planning and control and the choice of modes of transport under objectives of safety, security and energy efficiency. The following papers therefore present a discussion of operative traffic control, the multi-criteria evaluation of the effectiveness of transit systems, mathematical optimization of distribution systems and the multiple criteria selection between different transportation alternatives.

Classification of interaction flows for individual and public transport on the strategic control level

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Creating mathematical model used for planning locomotive distribution

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Multiple-criteria choice of transportation alternatives in freight transport system for different types of cargo

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CLASSIFICATION OF INTERACTION FLOWS FOR INDIVIDUAL AND PUBLIC TRANSPORT ON THE STRATEGIC CONTROL LEVEL

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1 Challenges for the Traffic Flow

Today, mobility is called as a 'product' for that mobility services are established as a central element. The development of 'cooperative platforms' as so-called 'turntables' of the mobility with integrated services for a holistic cross-protagonist information management has a bright future. [1] According to this fact, an establishment of an intermodal traffic control (ITCS = Intermodal Control System) underlined the strengths of individual methods for transportation. [2] Moreover, social networks could influence interpersonal interaction in traffic by using modern media e.g. 'Passenger 2.0' and 'Smart Phones'. The exchange of information in transportation systems continuously wins on importance. Modern Information and Communication Technologies (ICT) make it possible to build up integrated data models, as well as planning and control systems, which achieve the aims of useful transparency, reaction, integration, intermodality and sustainability. [1] The flow of information of every transportation system has the advantage not to be fixed directly on matter or substance. An expansion of information exchanges – in comparison to the physical traffic – has considerably much potential, which is shown as the saturation curve (Compertz Function). [3] The 'Urban Future Initiative' of Audi uses the following quotation for that: "The urban mobility of the future will be organized barrier-free to a much greater extent than it is today [...], because all participants in traffic will be electronically networked with each other and each participant's need for space will be continuously determined. In this way frozen structures in the urban space will come into a flow". [4] In those visions the car will play a decisive key role for a 'networked mobility' in the future. The improvement of transportation comfort seems to be in the center, but is not the only effect.

Today, primarily traffic safety, security and energy efficiency is in focus. According to the statements of the United Nations Organization, 1.3 million people die every year by traffic accidents, whereby 90 % are caused by driving errors of human being on the road. Within the next ten

years, the amount of traffic deaths increases to 1.9 million. [5] Especially developing nations – holding 50 % of all global vehicles – have catastrophic statistics in which the possibility to die by traffic accident is nine times higher compared to industrial countries (WHO). Europe could reduce more or less 50 % of its deadly accidents between 2003 and 2010, but the whole amount of traffic accidents did not change. To halve the amount of deadly accidents between 2010 and 2020 and to reduce accidents in general, implementations of only passive safety innovations are not enough. [6] Active traffic safety, security and controlling influences based on ICT could have the needed potential.

Another problem is traffic congestion which is caused by an increasing amount of traffic worldwide. In Germany, the Motorized Individual Transport (MIT) demand stays constant until 2050, whereas goods traffic on road increases to 120 %. [7] Also, active controlling interventions inside the road traffic flow or as part of an intermodal network connect traffic elements and strengthen the interactions. With increasing and improving traffic interactions, transparency of transport processes can be realized by traffic flow decrease and optimization, which fit the aims to improve traffic safety, security and efficiency in the use of energy, resources, space and time as well as environmental protection. This is an assumption which should be analyzed and proved.

2 Transport Carrier Comprehensive Approach

This paper focused on the direct procedures inside the traffic flow. Thus, the construction and composition of a transportation system or its elements as part of the 'Traffic Planning' is not an objective of this work. Traffic avoidance as well as modal and geographical shift activities are not influencing directly IC flows to control urban road transportation and refer to traffic planning. If the material flow and/or IC flow is mentioned, we are talking about 'Control' instead of 'Planning', although every step of control needs some specific time of planning. Therefore, beside the fact that

human being and its conscious discerning is in the center of this behavioral approach, 'Control' can be categorized in different control levels. The level with no planning horizon is called 'Physical Control' which represents the physical interaction and its exchange of simple signals between matter e.g. to step on the gas pedal. 'Operative Control' gives e.g. human being the opportunity to react consciously in a specific traffic situation, either to stabilize the car during the driving task (lit. stabilization), or even to give an operative order for a horizontal or vertical action (lit. driving). [8] This control is more complex than the physical control, because there is an understanding of the situation, e.g. the reason for stepping on the gas pedal. The 'Tactical Control' refers either to a communication outside the field of human and/or sensor vision, or to a specific route, which the driver likes to drive (lit. navigation). [8] In this case, the mentioned example to step on the gas pedal includes specific information, but is not necessary to understand the complex wish to use for instance the shortest route to move from one location to another. Also 'Strategic Control' refers to the navigation in form of a route, but with the difference to choose more than only one traffic carrier. It represents in comparison to the tactical control a more complex system, in which rather the whole transport chain than a single transport process is going to be analyzed. Figure 1 shows the levels of traffic control combined with the traffic carrier Water, Rail, Road and Air. In comparison to activities of the traffic planning (traffic avoidance), strategic and tactical control includes measurements of traffic reduction (mainly energy efficiency), whereas the operative and physical control refer to traffic optimization (mainly safety and security).

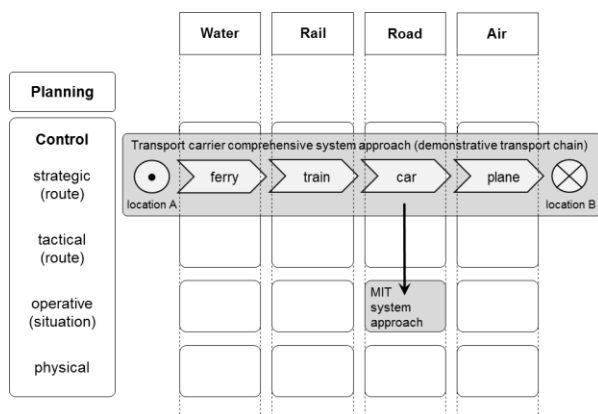


Figure 1: System Boundary by Traffic Carrier and Control Level

3 Model Configuration

Figure 1 shows a demonstrative transport chain on the strategic control level to move from location A to B. Beside the restriction of a given transport chain, the system boundary integrates every transport carrier by using demonstrative means of

transport. Their type and order of the connection do not play a role for configuring the traffic carrier comprehensive model. But the later following evaluation needs a defined type of a means of transport.

After defining the functional (strategic transportation flow) and spatial (every carrier for public transport) system boundary, basic traffic elements and their relation to each other are concretized. An interaction is defined by a physical and informational flow between two elements. The first element acts and is sending information to another element, which receives the information and reacts as a result. Figure 2 shows the basic process of a traffic interaction. Here, the activities to perceive and to process information as well as the output in form of information and/or a physical reaction describe an interaction.

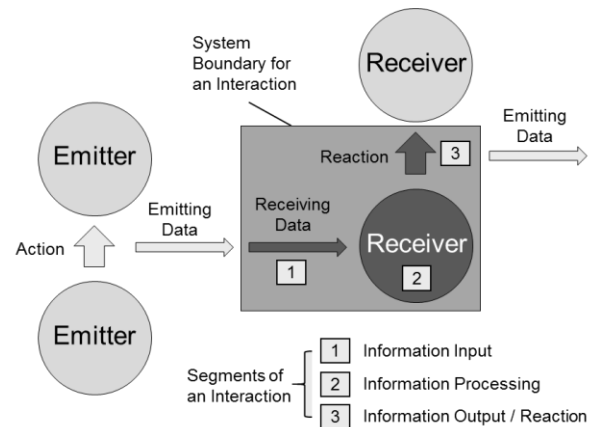


Figure 2: Definition of a basic traffic interaction process

Now, a separation of different interactions and moreover, a classification of interaction types is possible. The difference between interactions is seen in its communicating partners. The combination of different traffic elements as emitter and receiver leads to a suitable classification of interaction types. The basic traffic elements are shown in Figure 3.

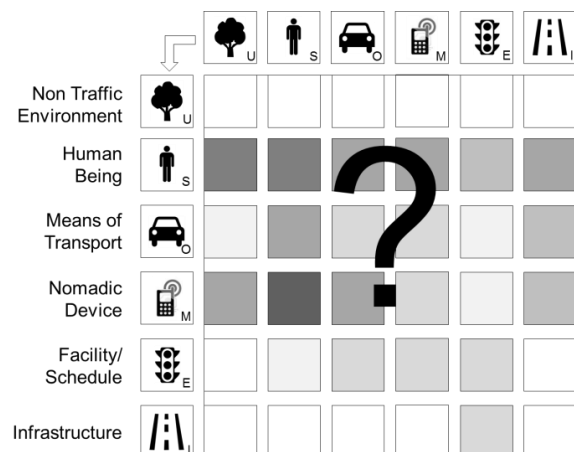


Figure 3: Definition of basic traffic elements

The system contains the elements: 'Non Traffic Environment' in a role as a disturbing element, 'Human Being' e.g. a driver or passenger, the 'Means of Transport' e.g. tram, 'Nomadic Device' e.g. mobile phone, 'Infrastructure Accompanying Facilities' like traffic signs as well as timetables etc. and 'Traffic Infrastructure'. The classification of these elements is partially used in literature and own researches. [8] The pairwise combination of these traffic elements – by the use of a cross-impact approach [10] – leads to 36 interaction types for the whole traffic system, in general. Figure 3 also shows the direction of the IC flow which runs from the top line (emitter) to the left column (receiver). To represent an interaction from an emitter to a receiver element, a special form of expression is used. Every element has an expression as a single letter (see Fig. 3). As an interaction code, the letter of the emitter stands on the left and the receiver on the right side. Both elements are combined by a horizontal line, for instance: 'O-S'. The explanation for every type is shown in Table 2.

After configuring the model in general, some elements of the transport carrier comprehensive system approach must be defined more in detail. Four public transportation systems (PT, inland) are chosen. Each system represents a carrier. The carrier 'Road' includes the additional system of the Motorized Individual Transport (MIT). Here, the transportation object (O) is the 'Car', whereby the "Bus" represents the public transportation system, beside the means of transport of 'Ferry', 'Plane' and 'Train' for the other carriers. Nomadic devices (M) are portable navigation systems, smart and cell phones as well as pre-trip-documents. The facilities (E) comprises for PT timetables especially at an interchange station (not inside a vehicle). Inside the MIT, facilities represent traffic signs, lights, markings etc. Infrastructure (I) stands for the contact between vehicle and its traffic medium and presents the geographical structure of transportation ways of each system. The environment (U) stands for disturbing factors (e.g. weather conditions) as well as objects (e.g. animal on the road). Traffic subjects (S) are passengers of PT or drivers of MIT. In principle, PT systems are very similar compared to each other, whereas the MIT system has partially another definition for the elements.

4 Evaluation and Results

The aim is a holistic evaluation of interaction types on the strategic control level. Despite many requirements for identifying an interaction type, some versions of interaction are nevertheless integrated. Because of this, the following evaluation was done together by a research team with a very fuzzy scale combined with an explanation log for every interaction measurement. Furthermore,

the interaction depends on a given traffic situation in industrial countries like Germany or Japan in 2011, which is described by three scenarios: the current status (Reality), the capability of realization (Opportunity) and future trend (Necessity). The strength of an interaction type is composed by interaction frequency (H) and complexity (K). Both indicators are measured separately – with an equal importance – by a scale of '0' (never/none), '1' (seldom/simple), '2' (from time to time/complicated), '3' (often/complex). The arithmetic average represents the strength (V). Thus, the strength of an interaction represents the intensity and quality of a direct oriented information flow from an emitter to a receiver. Another indicator is about the reliability (Z) of an interaction which is measured by the same scale. Table 1 shows a section of the evaluation matrix which all in all includes 900 interaction types and 3600 values only for the scenario 'Reality'. Beside the matrixes R (Reality), M (Opportunity), N (Necessity), a matrix combination in form of a mathematical difference can be created:

$$A = M - R$$

$$F = N - M$$

The difference A 'State of the Art' describes the potential for activities which are available nowadays and which need no basic research for implementation in an existing traffic system. F stands for 'Necessity of Research' and describes the need for further research activities on that field.

Scenario: Reality	U1a (Automobile)				U1b (Bus)				U2 (Train)			
	H	K	V	Z	H	K	V	Z	H	K	V	Z
U1a	0	0	0	0	0	0	0	0	0	0	0	0
U1b	0	0	0	0	0	0	0	0	0	0	0	0
U2	0	0	0	0	0	0	0	0	0	0	0	0
U3	0	0	0	0	0	0	0	0	0	0	0	0
U4	0	0	0	0	0	0	0	0	0	0	0	0
S1a	1	1	1	1	0	0	0	0	0	0	0	0
S1b	0	0	0	0	1	0	0.5	0	0	0	0	0
S2	0	0	0	0	0	0	0	0	0	1	0	0.5
S3	0	0	0	0	0	0	0	0	0	0	0	0
S4	0	0	0	0	0	0	0	0	0	0	0	0
O1a	0	0	0	0	0	0	0	0	0	0	0	0
O1b	0	0	0	0	0	0	0	0	0	0	0	0
O2	0	0	0	0	0	0	0	0	0	0	0	0
O3	0	0	0	0	0	0	0	0	0	0	0	0
O4	0	0	0	0	0	0	0	0	0	0	0	0
M1a	2	2	2	2	0	1	0.5	1	0	1	0.5	1
M1b	0	1	0.5	1	0	1	0.5	1	0	1	0.5	1
M2	0	1	0.5	1	0	1	0.5	1	0	1	0.5	1
M3	0	1	0.5	1	0	1	0.5	1	0	1	0.5	1
M4	0	1	0.5	1	0	1	0.5	1	0	1	0.5	1

Table 1: Section of evaluation matrix

In total, the amount of 18,000 unwrought values must be combined to data on a more complex level. The following mathematical notation provides the basis for the data analysis:

- x_{ijkl} ... element of matrix R, M, N, A, F, describes indicator $H+K=V$ or Z with index:
- i ... emitter U, S, O, M, E, I ($N \in 1 \dots 6$)
- j ... emitter System MIT, Bus, Train, Plane, Ferry ($N \in 1 \dots 5$)
- k ... receiver U, S, O, M, E, I, ($N \in 1 \dots 6$)

/ ... receiver System MIT, BUS, Train, Plane, Ferry ($N \in 1 \dots 5$)

$$x_{ik} = \frac{\sum_{j=2}^n (\sum_{l=2}^n x_{ijkl})}{n^2 - 3n + 2} \quad (l \neq j)$$

The following cases of interaction were analyzed:

1. Connection of the whole traffic system, summarized as an equal arithmetic average
2. Internal connection of the MIT system
3. Internal connection of each PT system, summarized as an equal arithmetic average
4. External connection of the MIT system with all PT systems, summarized as an equal arithmetic average
5. External connection of all PT systems to each other, summarized as an equal arithmetic average

The kind of computation for each of the 36 interaction types x_{ik} (Fig. 3) depends on the mentioned cases. For every interaction type x_{ik} inside a case is set, with $n=5$ transport systems:

case 1:

$$x_{ik} = \frac{\sum_{j=1}^n (\sum_{l=1}^n x_{ijkl})}{n^2}$$

case 2:

$$x_{ik} = x_{i1k1}$$

case 3:

$$x_{ik} = \frac{\sum_{j=2}^n x_{ijkj}}{n-1}$$

case 4:

$$x_{ik} = \frac{\sum_{j=2}^n x_{ijk1} + \sum_{l=2}^n x_{i1kl}}{2(n-1)}$$

case 5:

As a result, a matrix with the six basic elements shows the strength or reliability of its interaction types for a specific case and scenario. In total – with 3+2 scenarios and 5 cases – 25 matrixes are created similar to Fig. 3 with values (conversion into percentage), in different colors or contrasts as well as specific definitions.

Additionally to that, an indicator for every interaction type is created as the quotient of interaction strength and reliability. If this indicator has a value >1 , the interaction type is critical uncertain in this case. Table 2 shows the definitions for the general traffic system and some strengths (case 2, 3, 4) of interaction in the boxes. At last, a summary illustrates the results of the given boxes as part of a bigger amount of data.

- There is no big need for research in direct communication without media between passengers or between drivers, because its potential is limited and the increased interaction supply of other elements reduces the demand for interpersonal communication.
- Nowadays, the strongest communication takes place between car and driver. But in long-term, the car will not need a complex input of the driver if the car takes more responsibility

Traffic System	Environment	Traffic Participant	Means of Transport	Mobile I&C Device	Traffic Facility	Traffic Infrastructure
Environment (e.g. tree on the railway)	Environment is not able to give a tactical traffic controlled reaction					
Traffic Participant (e.g. train passenger)	Participants discern their surrounding environment (e.g. weather condition) and react on its influences	Participants communicate directly with each other (e.g. a talk) <div>MIT -9% PT -23%</div>	Participants react on information of the surrounding means of transport (e.g. dynamical information systems inside a train) <div>MIT 90%</div>	Reaction of participants by the use of portable device data (e.g. using information from smart phone)	Traffic facilities inform and guide participants (e.g. timetable, traffic sign, etc.) <div>MIT 90% PT 73%</div>	Participants discern their surrounding infrastructure (e.g. road) and react tactically
Means of Transport (e.g. car)	Autonomous means of transport (e.g. autonomous car) perceive their environment and react on its influences	Means of transport are influenced by participants (e.g. using a car) <div>MIT >96% MIT -27%</div>	Autonomous communication (by fixed transmitter/responder) between means of transport (e.g. autonomous subway in Paris) <div>MIT <50% PT 55%</div>	Autonomous means of transport are supported by mobile IC Device data (e.g. navigation system as tactical orientation) <div>MIT <50%</div>	Autonomous means of transport are guided by traffic facilities (e.g. Car2Infrastructure) <div>MIT 73%</div>	Autonomous means of transport (e.g. autonomous car) perceive their surrounding infrastructure (e.g. road) and react on its subsistence
Nomadic Device (e.g. smart phone)	Providing information of the environment for mobile IC devices (e.g. TMC) <div>PT 64% TCN 64%</div>	Handling of mobile IC devices by participants (e.g. searching for the timetable via smart phone) <div>TCN 47%</div>	Providing traffic flow information of means of transport with a fixed transmitter/responder (e.g. GPS) by mobile I&C devices <div>MIT 63% PT 61% TCN 61%</div>	Data connecting of mobile IC devices as a network of traffic elements (e.g. Tom Tom: navigation systems work together) <div>PT 61% TCN 61%</div>	Nomadic devices present data about traffic facilities (e.g. traffic light status, actual timetable, etc.) <div>TCN 17% TCN 48%</div>	Infrastructure data is provided by mobile IC devices (e.g. portable navigation system) <div>PT 55% TCN 48%</div>
Traffic Facility (traffic light, timetable)	Traffic facilities or management centers react on environment influences (e.g. traffic panels are going to show an alternative route caused by an accident)	Acquisition of participant information by traffic facilities for regulating the traffic flow (e.g. camera readouts facial data) <div>PT 34%</div>	Acquisition of means of transport data by traffic facilities for regulating the traffic flow (e.g. inductor at the traffic light) <div>MIT 90% PT 82%</div>	Supporting traffic facilities and centers by mobile IC device data (e.g. traffic light control by the use of smart phone gps data) <div>MIT 63% PT 61% TCN 61%</div>	Data connection between many traffic facility units (e.g. timetable connection, green line, etc.) <div>PT 92%</div>	Traffic facilities and centers as well as infrastructure are stationary elements and lead not to a tactical traffic interaction (set by traffic planning)
Traffic Infrastructure (e.g. river)	Infrastructure is not able to give a tactical traffic controlled reaction					

Key: MIT Motorized Individual Transport (road carrier)
PT Public Transport (isolated transport carriers)
TCN Transport Carrier Networking (between MIT and PT)

MIT

 Current Status (reality)

PT

 State of the Art (capability of realization)

TCN

 Necessity of Research (future trend)

Table 2: Results for the strength of interaction

- Today, traffic participants are mostly guided collectively by timetables and road infrastructure accompanying facilities e.g. traffic signs.
- Researches about vehicle to vehicle communication inside each traffic system, researches for providing cars with mobile data and the implementation of C2I communication seems to be very important.
- Nomadic devices have a communication range to connect different transport carriers as well as to strengthen single systems. Whereas the dynamic collecting of traffic infrastructure and facility data via nomadic device is part of the research, the dynamic collecting of data about position and movement of vehicles and other nomadic device data could lead to first implementations in traffic.
- Currently, nomadic devices support traffic carrier comprehensive data in form of timetables via smart phone applications just in time. Also information about weather, accidents and roadwork as well as passenger supply and demand could be provided more often by mobile device if participants have and could use these devices until now.
- Inside the existing traffic system, means of transport are (often unknowingly) sending data about their position to a management center or traffic light. Especially the facilities of the public transport on railway are strongly connected to hold timetables and to avoid accidents.
- More activities for providing mobile data for traffic facilities should be realized to generate more transparency for passenger flows. Researches for a direct registration and check of passengers by the use of facilities could have a future e.g. automatic body scanner on airport to increase security and safety, but also has critical aspects to control society, too.

Beside the analysis of interaction types between two elements, also the characteristics of a single element and its development for interaction are in focus. The sum of emitting activities of an element demonstrates its ability to be recognized in the traffic system, because it is very important and/or needed to be controlled by other elements. The sum of receiving activities demonstrates the ability to recognize and to control the traffic system and/or to be influenced by other elements. The sum of emitting and receiving activities presents the 'Element Activity', which measures the quantity of interaction. The mathematical difference between emitting and receiving presents the 'Element Character' which gives an impression if the element is active (called 'child') or reactive (called 'mother').

The activity and character of emitting and receiving data is expressed by the following notation for each of the six basic elements i/k ($m=6$) and the given notation of x_{ik} shown on p.3:

Emitting (action): Receiving (reaction)

$$x_i = \frac{\sum_{k=1}^m x_{ik}}{m}$$

$$x_k = \frac{\sum_{i=1}^m x_{ik}}{m}$$

Element Activity

Element Character

$$x_{i/k} = x_i + x_k$$

$$x_{i/k} = x_i - x_k$$

The results are shown in Table 3 for case 2, 3 and 4 (p.6) and reveal some conclusions:

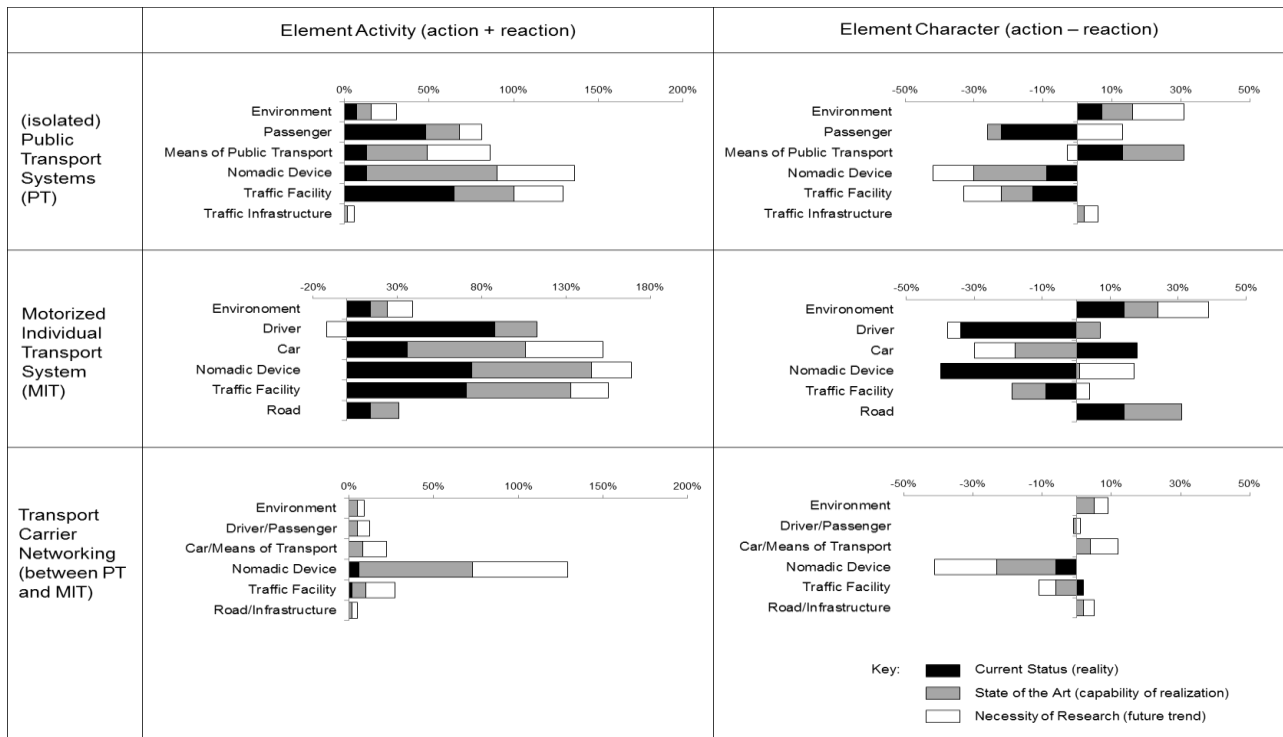
- In comparison to PT and MIT, transport carrier comprehensive interactions are extremely weak marked without much potential or need for the future.
- Merely the nomadic device has the strong potential to connect different means of transport. It has a controlling function as a very reactive element.
- Today, public transportation exists mainly by passenger and timetable interactions during the transport process.
- The potential for implementation and research in PT leads to a stronger activity of public vehicles, nomadic devices and traffic facilities. In future, PT will be mainly controlled by nomadic devices combined with dynamic timetables.
- In PT, environment, passengers and infrastructure are seen as given elements without much activity potential which have long-term an active character.
- MIT is in comparison to PT stronger connected nowadays, but in the future quit similar in quantity. The difference exists in the Element Character. Beside nomadic devices and facilities, the driver keeps and the car gets a reactive character. This fact leads to the assumption that MIT compared to PT keeps its individual role, in which the car takes more often control.
- Today, the car has less self-control, but could play a leading role beside IC devices and road facilities in the future.

5 Conclusion

This paper illustrated the importance of the traffic flow control besides the traffic flow planning. Whereas the planning comprises traffic avoidance as well as modal and geographical shift, control is very useful for traffic reduction and optimization. The 'Compertz Function' led to the assumption that ICT and its support for exchanging data and information improves the processes inside the traffic flow. Thus, the improvement of traffic inter-

actions could fit the aims of traffic safety, security and efficiency.

also used in a second step for the isolated MIT system on the operative and tactical control level.



After explaining the necessity of a differentiation in traffic control levels and the setting of system boundaries, a transport carrier comprehensive system approach on the strategic control level was developed. In that first step, basic traffic elements were defined and pairwise combined in form of a cross-impact method. Thus, interaction types could be defined and later quantified. Some results of the holistic data evaluation were shown. The transport carrier comprehensive system approach is located on the highest control level. This means, on the one hand an advantage by a wide ranged use and connection of general data, but on the other hand also a disadvantage by using very uncertain and fuzzy data. Although a group of researchers, a log for discussing different traffic situations and a very holistic scale tried to make the evaluation plausible, the evaluation of a single interaction stays very complex and includes a bigger risk to be wrong. Here, the benefit is seen in the combination of fuzzy data to generate new data. Finally, the created data – with a critical and holistic view from the distance – led to conclusions which give an impression about the traffic flow network of today, its current opportunities and its necessity for further research. Another disadvantage is seen in the lack of already existing data. The transport carrier comprehensive system approach uses the knowledge, experience and opinion of traffic experts, but without a deeper proof. Thus, this approach illustrates – as a first step – the structure of a model that is

Table 3: Results of Element Activity and Character

This system uses statistical data in a timeline, transforms it to interaction data and compares it with statistics of car accidents or energy use development. The MIT system approach for instance could analyze the differences of deadly accidents between chosen developing and industrial countries or could give an answer whether today's road traffic is already breaking the rules of the 'Vienna Convention on Road Traffic 1968' or if there is a competition between collective and individual as well as human and technical control on the road.

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The success of these ports and logistics development projects depends strongly on the development of transit traffic.

The National Transport Development Programme is a document of plan character that constitutes the activities (actions, tasks, types of activities) of economic, organizational, institutional nature and other-type of programmes falling within one system. The key goal of the National Transport Development Programme is to ensure the planned development of an efficient transport system in order to satisfy the constantly growing demand of the national economy and people for quantitative and qualitative transport that demonstrate safety, firm guarantees and reasonable costs.

In order to solve the problems with regard to the development of separate transport sectors, the sector (roads, road transport, sea transport, railways transport, air transport, road safety) development state programmes have already been worked out. In these programmes, problems of a complex nature were touched upon vaguely or completely ignored. For instance, transport statistics, transport system integration, etc. That's why it is important and interesting to make system analysis of transit operations, and it is also necessary to develop the special device for the analysis and transit operations efficiency improvement. The main task of the research is to work out general indicators of the transit services system efficiency. Using this tool we are going to create an effective system of cargo transportation by different transport types through the terminals construction for combined transportation based on the existing infrastructure of railroads, railroads development and converting to logistics centres. Transport hubs should work as connecting links between different transportation types to improve the efficiency and competitiveness of intermodal solutions, as well as between transportations and other logistics operations. There is one approach to efficient transport hub model creating, which is very successful in the countries of the European Union, - the creation of logistics centres. Logistics centres development contains a wide range of motivations, including:

- Responding to environmental issues, economic restrictions related to cargo transportations over long distances within the region;
- Responding to the lack of competitiveness in existing businesses, especially in the area of transport and logistics;
- Regional economy support by attracting more kinds of business (orientated to the future), especially additional services with high productivity;
- Stimulating innovative transportation and logistics solutions development and

implementation, which supports balanced use of resources (by creating synergetic effects);

- Offered logistics services quality improving in terms of customer satisfaction, safety, reliability, and the use of advanced information technologies increasing.

Key performance indicators for logistics centres successful development can be summarized as follows:

- Openness: Logistics centres are open to all companies who want to stay in the centre on a commercial basis;
- Common opportunities: Availability of freight management opportunities that can be used according to equity pricing principles or as general merchandise in logistics centres;
- Organization: The existence of a legal entity that can act on behalf of the transportation centre and to protect the common interests of companies located in the Logistics Centre;
- Intermodality: Logistics centers support concept of combined and intermodal transportations, thereby contributing to the efficient European transport system establishment.

2 The analysis of factors influencing transit system

Factor analysis starts from a differential analysis of the economic and political situation. The second set of issues which need to be investigated is the transport and logistics sector's specific conditions in the region where the logistics centre is placed. Special study should focus on cargo flows in the region, which are also important for international transportation and logistics centres within the main traffic routes and networks.

The main environmental factors that affect the goods supply chain, and the transits net as well, were defined by the author. There are factors which help to develop one another and cooperate, i.e. improvement of one factor (positive development) will develop other factors, and positively influence to the development of a transit chain. And there are also factors, which can bring a dissonance conflicting with other factors. Systems theory was one of the first management theories to explicitly state that changing one of the subsystems could have an impact on the total system. Synergy was developed as a measure of the effectiveness of the joint efforts of various subsystems. Synergy can be a positive or negative outcome of combined efforts.

According to the American Heritage Dictionary, the term "synergy" is derived from the Greek word *sunergos*, meaning "working together." Positive synergy is sometimes called the $2 + 2 = 5$ effect. Operating independently, each subsystem can produce two units of output. However, by combining their efforts and working together effectively, the two subsystems can produce five units of output.

Negative synergy can be called the $2 + 2 = 3$ effect. Again, individuals operating alone can each produce two units of output. However, with negative synergy, the combination of their efforts results in less output than what they would have achieved if they had each worked alone. Negative synergy can result from inefficient committees, business units that lack strategic fit, and from other poorly functioning joint efforts.

To keep efficiency of logistical system in the shifting world – is one of the basic strategic problems of the enterprise. It is very important by means of monitoring an external environment condition to define the true moment and a true orientation of the enterprise internal logistical processes necessary changes that result of these changes have harmoniously coincided with most favourable interaction of an external environment. Certainly, it will help to react in time as to falling of the market (it will be prepared for crisis), and will be prepared for its prompt growth (inexperience to growth is not less dangerous, than crisis). Logistical processes statement at the enterprise is necessary to consider as the decision of a business-processes optimization problem, with the purpose of achievement of the best result (profit, profitability, use of resources, etc.). Thus, the organization of the internal environment in adequate conformity with influence of an external environment has dominating value.

Some of synergy effects in logistics are described in European projects, for example in project NeLoC "Service Concept Report for Logistics Centres". A definition of the Service Concept according to the project "Service Concept Report for Logistics Centres" is the following:

A Service Concept is an activity in the handling of goods, which in principal has the purpose to create increment (value added) directly or indirectly related to the Logistics Centre operations.

In accordance with the concept description and with the Logistics Centre definition a Logistics Centre mainly consist of Small and Medium sized Enterprises (SME), which basically operate on a commercial level. There are also interested parties such as public authorities (e.g. customer service, veterinary authorities, etc.) in the

Logistics Centres, which objective is to service the Logistics Centre operators non-profitably.

This division of physical operators in the Logistics Centre means that the focus on Service Concepts can be divided into different concepts, which have different objectives for the overall concept frame. The Service concept is based on a synergy effect (win/win situations), were a clustering of different operators/actors can supplement each other - even with the paradox of full competition in the market and within the Logistics Centre.

develop and cooperate (synergetic effect "+")	dissonance and conflict (synergetic effect "-")
The level of economic development in the country	The political situation (the level of legislative basis development, the interest of the ruling parties in the logistics development in the country)
Road infrastructure development, as well as the existence of rail, marine and air routes	Natural environment, climate
The level of warehouses, technological parks (ensuring the required number of warehouse space in the right places and their quality, extra services, customs) development	The state of the labour market. This means, because of the lack of qualified personnel, the demographic factor may contradict in some cases other factors influence.
Technical, scientific and technological development (new programmes introduction to accelerate the movement of material flows in transit net)	New transport corridors development out of the State
The economic situation in countries that are major suppliers of transit goods	Competitors' transit services market development
The economic situation in countries that are major consumers of transit goods	
New transport corridors development inside the State	
Government's strategy to introduce the euro in 2014	

Table 1: Factors influencing transit system

Thus, the actions pertaining to the first group of factors influencing the system, as a whole, will introduce synergetic effect in the transit system. The second clashing group of factors will weaken the system. And, as well as the first group of factors they will give synergetic effect but with a negative sign «-».

3 Model creation

For the research of dynamic change of factors influencing transit system, and identification of existing interrelations between these factors a method of system dynamics is offered for model creating.

System dynamics is based on Jay Forrester's (1958) industrial dynamics, where the chase is to model behavior of entities through relations, delays and feedback. System Dynamics (SD) is a methodology and mathematical modeling technique for framing, understanding, and discussing complex issues and problems. Originally developed in the 1950s to help corporate managers improve their understanding of industrial processes, system dynamics is currently being used throughout the public and private sector for policy analysis and design. System Dynamics is an aspect of systems theory as a method for understanding the dynamic behavior of complex systems. The building blocks in system dynamics are flows that describe change, stocks that are accumulated based on flows, information exchange in the system, and delays. Although the building blocks are simple, simulation models can have complex behavior. This complex behavior can arise from many interconnected simple connections. This approach to imitation model creation assumes high level of abstraction. Elements of model are hubs; they are connected by wires (roads), with different capacity.

4 Conclusions

The Ministry of Transport defined a purpose to reach stable transit volume increase and maximise the value added for transit, paying singular attention to the containers transportation increase and Logistics Centres development. As for transit goods, there is a purpose to reach a transit freight volume 100 million tonnes per year till 2020, including container cargo 2 million tonne. In 2010, the list of countries with the most developed logistics system was head by Germany with the index 4.11 points. 155 countries were analyzed in this research. Latvia takes 37-th place with the index 3.25 in this list. Latvia took the highest place between the Baltic Countries - Estonia had 43-d place, Lithuania was at 45-th place. However, it is necessary to make the

analysis of results to improve the situation in the field of logistics in the future. [9]
In accordance with the analyzed criteria Latvia got the following points:

- 1) Customs – 2.94;
- 2) Infrastructure - 2.88;
- 3) The international delivery – 3.38;
- 4) Quality and competence in the field of logistics – 2.96;
- 5) Cargo tracking - 3.55;
- 6) Delivery timeliness - 3.62.

The analysis of results showed that the best indexes are reached in Cargo tracking and Delivery timeliness. Weak places in logistics development of Latvia are Infrastructure and Customs. There are essential weaknesses of Latvian logistic system as various sources specify, and also there is a high potential of development of logistic services, as it said in different researches of the Latvian scientists, and also it is visible from experience of other EU countries development. The potential of development can be divided into two important parts:

- Potential, which is available in already existing systems. It is necessary to investigate and estimate the system, to estimate its present use and to plan the system optimization.
- Potential, which appears during the development of a transit system, its modernization and the construction of new infrastructure objects like roads and the Logistics centres.

This potential is limited by monetary, time and human resources which the state and private enterprises can enclose in this system. Therefore it is very important to estimate and optimize the existing capacity of transit system correctly to reach optimal results in the conditions of limited resources.

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CREATING MATHEMATICAL MODEL USED FOR PLANNING LOCOMOTIVE DISTRIBUTION

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1 Abstract

Rail freight transport is fundamental in plans improving on European freight transport since modern logistics trends have been occurring, environment aspects have been strengthening and public road-system have become too busy. For the reason of optimal operation, the number of operations associated with moving locomotives and wagons, planning their schedule must be minimal, which leads to lower operating cost. In this paper, a mathematical model used for optimal organization of locomotives at each node is going to be presented.

2 Introduction

Importance of advanced intermodal transportation systems emerges in different European studies and researches in order to improve transportation systems and make them more environmentally friendly. Trends strive to ease effects of huge road traffic and requires creating new models which are implementable on existing systems. New trends in the European Union tend to increase significance of railway transportation. For this, it is necessary to rise its reliability in the eyes of prospective partners. [2]
In order to rise the reliability of railway transport, more sectors must develop its planning and designing processes such as identification, tracking and tracing, utilization of resources (locomotives, transshipment equipments), blocking wagons, scheduling processes as well as satisfying the demand of public transportation. The systems and models have some important cardinal points. Detailed studying of the stock of available and fitting systems and their implementations is indispensable along the whole intermodal

chain as it is necessary to access tracibility of different modes of transport (typically railway and road) in modality-shifts [2].

In this research study, first the background and actuality of the issues mentioned above will be presented, then the main issues of railway transportation in the European Union and Hungary will be emphasized. Lastly a mathematical model will be described on how locomotive distribution is planned.

3 Actuality of improving rail cargo systems

There are more running projects in the European Union (such as ChemLog) that are also connected to Regulation (Eu) No 913/2010 which wants to develop freight rail transport in Central-East Europe. The regulation is an important background of further improvements ensuring sustainable development of rail transport and growing competitiveness of this sector. In order to establish well-organized infrastructure, the creation of 5 rail corridors was regulated by law-makers (Figure 1 and Figure 2). [2,3]



Figure 1: Pan-European transport corridors



Figure 2: Pan-European railway corridor V

Generally these projects have very similar objectives:

- Strengthening of the territorial cohesion in Central Europe.
- Improvement of competitiveness of rail transportation, getting bigger markets in logistics sector.
- Strengthening of rail transport in comparison to road in order to make it safer. Environmental protection, reducing costs and increasing speed and flexibility of supply chains are cardinal point of views.
- Support the development of logistic centers for intermodal transport and their integration in infrastructure planning.
- Initiate transnational know-how and technology transfer for the development of transport and guidance systems focused in the West-East direction.
- Supporting the realization of Trans-European Traffic routes and harmonization of regulations and coordinated planning of infrastructure and the use of Structural Funds. [2]

4 Development in the mirror of Hungary

Hungary is one of the doorways to the East via Ukraine and Russia – with its Schengen-boarder one of the entrance/exit points to/from the big marketplace European Union. Two different cultures meet here, not only the letters differ on both sides of the boarder, the custom and technical regulations, but the gauge and – until recently – the content of the delivery notes too.

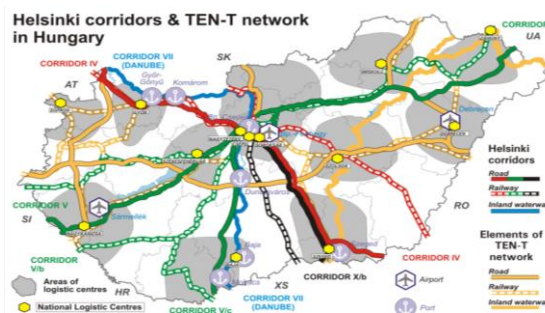


Figure 3: Transportation corridors in Hungary

The focus is directed onto the part of Corridor 5, that lies in Hungary (Figure 3), between Záhony (UA border) and Slovenia (Va), Croatia (V) and Serbia (Vc). The geopolitical situation shows, that Hungary is more challenged in this direction. [2]

5 Description of the problem

Before launching of the problem descriptions, it would be important to mention some of the tasks that can occur when managing a rail transportation chain. First of all, managing loading, unloading and transshipment, organizing all the equipment, locomotives and wagons and setting up the trains/wagons are the cardinal points of operating a train transportation chain effectively (Figure 4).

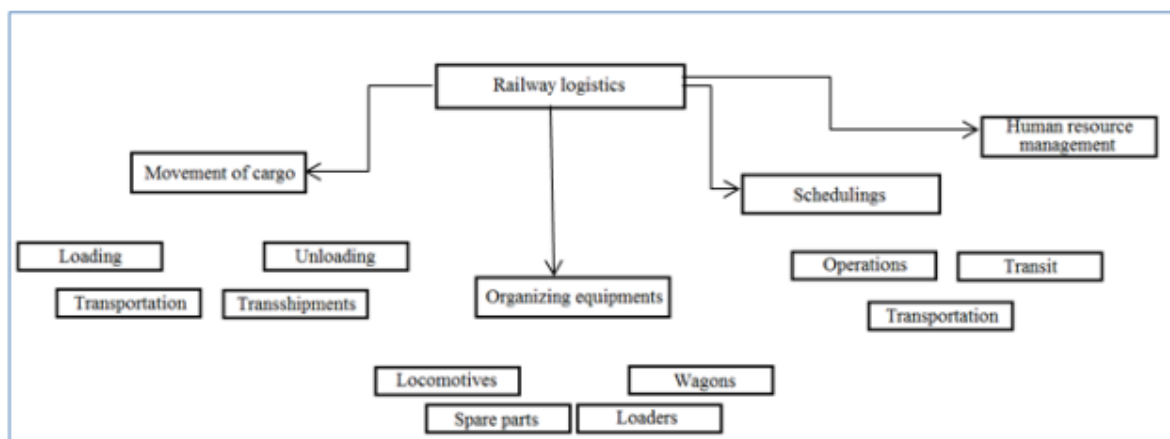


Figure 4: Railway Logistics

6 Mathematical model for designing and planning locomotive distribution

In this section of the study, special problems in the railway sector are going to be described that can occur at railway stations as well as intermodal logistics centres specialized in railway freight forwarding solutions. The model provides optimal solutions for shortening lead times and utilize the existing capacities, and at the same time increasing reliability and customer satisfaction through these. It addresses the management and planning locomotives that is related to organizing an effective distribution network in order to satisfy demands of logistics providers sending or receiving a shipment via railways. Planning locomotive distribution is a very important part of operating an effective railway network in order to satisfy needs occurring at railway stations and marshalling yards. The core problem is to determine the exact number of locomotives which are able to satisfy shipment needs while optimizing the total cost of operating locomotives and delays. The system also must handle the not-symmetric effects like repositioning of the units using deadheading locomotives on trains. [1] [4] Next, a simplified model of the locomotive distribution problem is presented. This formulation does not contain maintenance constraints, service reliability and bonus/penalty conditions. This is a multicommodity flow problem with resource constraint which is only the time between the units. Each commodity represents the locomotive class and the flow on each arc represents the number of locomotives. A time-space network is constructed for each commodity as follows [1]:

Sets:

K	set of commodities;
W	sets of trains;
G	network where $G=(V,A)$, $V=N \setminus \{o,d\}$ is the node set and A is the arc set;
T	time horizon;

Parameters:

K_v	number of locomotives that must be routed to a destination;
N_k	number of sites that may be visited by the locomotives of class k leaving from the source node o and arriving at the sink node d; the arc (o,d) is always exists;

n_w	minimum number of locomotives to cover arc train task $w \in W$;
c_{ijk}	cost of a locomotive of class k on arc (i,j);
d_{ijk}	cost of a deadhed locomotive of class k on arc (i,j);
D_k	available number of locomotives of class k at the source node at the beginning of the week;
T_{ik}	the accumulated operating time of the unit $k \in K_c$ at node i, starting from its initial departure at the beginning of the week;
t_{ijk}	travel time from node i to node j for locomotive of class k;

Binary variables:

a_{wijk}	binary variable, 1 if arc (i,j) covers task w, 0 otherwise.
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Decision variables:

X_{ijk}	the number of pulling locomotives of class k covering the train task on arc (i,j);
F_{ijk}	the number of deadheads in the consist that covers the train task on arc (i,j);

Model:

$$\min \sum_{k \in K} \sum_{(i,j) \in A} (c_{ijk} X_{ijk} + d_{ijk} F_{ijk})$$

- minimize the total cost of pulling and deadheading;

subject to

$$\sum_{k \in K} \sum_{(i,j) \in A} a_{wijk} X_{ijk} \geq n_w \quad w \in W$$

- cover the train required expressed in minimum number of locomotives;

$$\sum_{j: (o(k),i) \in A_k} X_{k,o(k),i} = D_k \quad k \in K$$

- If a locomotive of class k is not required for a task, take arc (o(k),d(k)) to the destination node;

$$\sum_{j: (i,j) \in A_k} (X_{ijk} + F_{ijk}) - \sum_{j: (j,i) \in A_k} (X_{jik} + F_{jik}) = 0 \quad k \in K \quad i \in N_k$$

- Conservation of flow, number of outgoing and number of incoming locomotives must be equal on each arc;

$$\sum_{j: (j,d(k)) \in A_k} X_{j,o(k),k} = D_k \quad k \in K$$

- All the available locomotives are at the source;

$$X_{ijk}(T_{ik} + t_{ijk} - T_{jk}) \leq 0$$

$$k \in K \quad (i, j) \in A$$

- Compatibility constraint between the flow and time variables;

$$a_{ik} \leq T_{ik} \leq b_{ik}$$

$$k \in K \quad i \in V$$

- Time constraint for units to be routed to the destination;

$$X_{ijk} \geq 0$$

$$F_{ijk} \geq 0$$

$$k \in K \quad (i, j) \in A_k$$

- The decision variables can be only integral values.

This formulation will result in a very large number of columns and rows for any of the major railroads. [1] Programming in GAMS and simulation experiences are in process. In my next study I would like to deal with this program's results and its mistakes, then to create an other model that minimize the number of operations needed at a node and compare to this model how many similar solution they will have, if any.

7 Conclusion

In the research study there was an emphasis on why railway transport has a highlighted role in European transportation. Also the Hungarian situation is mentioned since it must have a

significant role in operating Corridor V effectively.

By increasing the reliability of railway transportation and shortening lead times, a higher rate of customer satisfaction can be reached. Railway transport solutions are more environmentally friendly which is also a key factor in current logistic trends. In railway transport, there are more main area where costs can be cut. In this study a model were described which addressed optimizing locomotive distribution costs.

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MULTIPLE-CRITERIA CHOICE OF TRANSPORTATION ALTERNATIVES IN FREIGHT TRANSPORT SYSTEM FOR DIFFERENT TYPES OF CARGO

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1 Abstract

In the paper the problem of multiple criteria choice of transportation mode for different types of cargo within one model is considered. The following main tasks are highlighted: selection of a set of indices, characterizing efficiency of freight transportations and formation of efficiency criteria of the transportation system on their basis; choice of multiple-criteria methods for evaluation and selection of cargo transportation alternatives; evaluation of the efficiency of employing AHP method to solve the problem of choosing the transportation route and mode for different types of cargo.

2 Introduction

Search for the best solution or finding a set of good alternatives in realization of freight transportation should be based on the different initial data, considering logistical principles, and be done using modern mathematical methods and information technologies. [1&2] Solving the choice problem we have to take into account such important factors as: a complicated structure of transportation, high dynamics and rapidity of transport processes, the random factors influencing these processes, and geographical dispersion of participants of the transportation. In case of freight transportation by one transport, the task of finding the optimal route is solved as the shortest path problem by employing the methods of mathematical programming. [3&4] As a rule, the task is solved in the single criterion setting, and this criterion is the shortest path of cargo transportation. Along with this, the transportation companies are interested in optimization of different indicators in the process of the route choosing: delivery time, cost of transportation, number of transport facilities, etc. Even under the condition of employing several criteria the task of searching the optimal route is quite often reduced to the single-criterion setting. Moreover, all the criteria are comprised in the integral one (most commonly, it is a cost criterion), by sometimes summing up all of them with their own weights,

or by choosing one optimization criterion from the group of criteria and the remaining criteria are used as constraints. Many researchers are interested in multi-criteria shortest path problems and suggest different approaches for it, they are as follows: bi-criteria path problems [5&6], multi-criteria shortest path problems [7] and multi-criteria Pareto Search. Considering the multimodal freight transportation, the task of choosing the optimal solution becomes significantly more complicated, since it comprises not only the choice of route, but also mode of transportation, the freight transshipment and warehousing on the route. As a rule, it is considered as the task of multiple criteria choice. This approach does not require the employment of complicated apparatus of mathematical programming and suggests numerous methods based on the expert evaluation. There are a number of researches for expert evaluating and choosing the alternatives of cargo transportation, for example, see analysis in. [9] Similar to the classical optimization approach, there are two variants of creating the choosing criteria: reducing all the criteria to the integrated criterion [10] and employing the independent choice criteria. Multiple criteria approach is implemented in the work [9], where three criteria for route choice (shipping time, shipping price, shipping safety) are applied. But in practice there exist more different criteria which determine the efficiency of cargo transportation. [11] Another factor, that makes the task of choosing the optimal solution more complicated, is considering more than one cargo type, as in most cases models are constructed for one cargo type. Such approach is considered in. [11] However, cargoes have different weight, size, physical, chemical and other characteristics. They can relate to different classes (dangerous, perishables), which has different transportation requirements. Moreover, the same cargos can be transported using different transportation technologies and combinations of transport within one route. The main problem of the presented research comprises in development of the approach, which would have a single tool for

decision support for choosing a cargo transportation mode. At the same time the developed model should consider specifics of transportation of different types of cargo on different routes, using different modes of transportation. In the presented research, the following main tasks, which require solutions, are highlighted:

- Selection of a set of indices, characterizing efficiency of freight transportations, and formation of efficiency criteria of the system on their basis, using a set of criteria for different types of cargoes;
- Choice of multiple-criteria method for evaluation and selection of cargo transportation alternatives;
- Evaluation and selection of cargo transportation routes and modes using suggested method;
- Evaluation of the efficiency of suggested method to solve the problem of choosing the best routes and modes of freight transportation for different types of cargo.

3 Performance criteria of the transportation system

To estimate the efficiency of transportation, the system of indices including cost, duration, reliability and ecological safety of transportation of cargo is used.

- Delivery costs -includes financial costs for performing transportation of goods from origin to destination points, including costs for loading, transportation, handling costs, connected to the customs clearance, documentation, storage, demurrage and others.
- Delivery time – a total time needed to move goods from origin point to destination point, including time for loading, transportation, handling, costs connected to the customs clearance, documentation, storage, demurrage and others.
- Reliability of the transportation system – a complex criteria, which includes indexes like reliability of transportation (fulfillment of delivery time, reliability of transport means, fulfillment of other transportation contract terms and others) and safety of transportation (safety of cargo, protection from unauthorized access to cargo and others).
- Ecological impact – criteria, which reflects losses from the harmful impacts of transportation means on the environment on the different routes, as well as cost of

activities for protection of the environment from these harmful impacts.

Another important issue is safety of activity of the people (emissions of harmful substances in the atmosphere, the soil and reservoirs, death and a traumatism of people, destruction of buildings and constructions in a consequence of their vibration, etc.).

It is easy to notice that the suggested indices have the various physical natures and are measured by different physical magnitudes. The part of indices is deterministic, the part is stochastic. Additional difficulties for estimating the system's indices are related to the fact that one part of indices has quantitative nature and the other has qualitative nature. For example, cost and durations of transportation are quantities, but reliability, safety and environmental impact, estimated by experts, are qualitative parameters.

4 Selection of the method for a choice of the best solution

There are currently various methods that have been developed and implemented to analyze and choose from a range of alternatives using different criteria. These methods include multiple-criteria decision making (MCDM), multiple-criteria decision analysis (MCDA), and multiple attribute decision making (MADM). [12]

The existence of this variety of methods makes the issue of choosing the most suitable one rather difficult. [13]

In the author's opinion the MCDA methods of pairwise comparison are the most suitable for the examined problem. In the given paper the author has analyzed the possibility of employing one of the most popular pairwise comparison methods – Analytic Hierarchy Process (AHP) method. [14]

The AHP allows structuring the choice procedure as a hierarchy of several levels. It allows the distribution of the criteria by several groups, and evaluates the significance of each group's components. Consequently, the different groups of criteria have been evaluated by different experts. For instance, the economists have assessed the cost criteria; the transport technologists have evaluated the reliability and ecological criteria, while the managers have estimated the time criteria. The opportunity of the pairwise comparison of a smaller number of criteria in every group allows the experts to determine better weighted values according to these criteria. The author have concluded that the optimal number of criteria in each considered group should be from 3 to 7. The estimation of the significance of the criteria groups was determined by the experts with greater qualification. The AHP method also allows the possibility of controlling

the consistency of the experts' judgments, making it possible to increase the reliability of estimation. In summary, the multi-criteria analysis determined the AHP as the most suitable method for comparative evaluation of different alternatives of the cargo transportation.

5 Evaluation and selection of cargo transportation routes

To illustrate the efficiency of the suggested AHP method for choosing freight transportation mode, five alternative routes from Dortmund, Germany to Kazan, Russia have been evaluated. The suggested routes are the following: 1) Dortmund – Kazan (direct by truck); 2) Dortmund - Travemunde - Ventspils - Kazan (road + ferry + road); 3) Dortmund - Sassnitz - Klaipeda -Kazan (road + ferry + rail); 4) Dortmund - Travemunde - Ventspils -Kazan (rail + ferry + road); 5) Dortmund - Sassnitz - Klaipeda -Kazan (rail + ferry + rail). The offered example is considered for two types of cargo: general cargo and oversized cargo. However the offered approach can also be used for perishables and dangerous goods. Let us consider each route in details.

- 1. Dortmund - Kazan (direct by truck). This route considers transportation of cargo from Dortmund to Kazan directly by truck without reloading;
- 2. Dortmund - Travemunde - Ventspils - Kazan (road + ferry + road). Cargo by truck is delivered from Dortmund to port in Travemunde. Thereafter truck is delivered to Ventspils port (Latvia) by ferry after which drives to Kazan. Cargo is not reloaded;
- 3. Dortmund - Sassnitz - Klaipeda -Kazan (road + ferry + rail, container or reloading of cargo). Cargo or container by truck is delivered from Dortmund to port in Sassnitz, thereafter either cargo or container is delivered to port of Klaipeda (Lithuania). Then cargo or container is reloaded onto rail and delivered to Kazan;
- 4. Dortmund - Travemunde - Ventspils - Kazan (rail + ferry + road). Cargo in wagon or container by rail is delivered from Dortmund to port in Travemunde, thereafter either cargo or trailer/container is delivered to port of Ventspils. Then the cargo/container is reloaded onto truck or is delivered in the same trailer by road to Kazan;
- 5. Dortmund - Sassnitz - Klaipeda - Kazan (rail + ferry + rail). Cargo or container by rail is delivered from Dortmund to port in Sassnitz, thereafter either cargo or trailer/container is delivered to port of Klaipeda. Then cargo or container is reloaded onto rail and is delivered to Kazan.

For the calculation of the efficiency of freight transportations it is suggested to use a system of criteria. It consists of 27 criteria, which are combined in 4 groups as shown in Table 1. This set covers major aspects of transportation of above mentioned four cargo types.

Name of group	Criteria
Cost of cargo delivery	Transportation costs; handling costs; seasonal fluctuation of tariffs; Documentation costs processing; penalties (missing delivery terms); possible additional costs during transportation; additional insurance (insufficient safety); exchange rate fluctuation; costs of special permits; costs of lashing.
Time of delivery	Time for transportation; time for border crossing; time for customs clearance; time for preparation of special permits, time for lashing; time restrictions during transportation.
Reliability of cargo transportation	Exceed of delivery time; cargo safety (loss, damage of cargo); availability of transport units; safety (theft, unauthorized access to cargo); reliability of transport means
Ecological impact	Emission of CO ₂ ; emissions of harmful substances; noise and vibration; accidents and disasters from the ecological point of view; death and traumatism of people; additional emission of climate equipment.

Table 1: Criteria for cargo transportation evaluation

Each route has own values on each criterion. Therefore, each route can win or lose on one or several criteria. For the choice of route the priority among cost, delivery time, reliability and ecological compatibility should be chosen. In this case multiple criteria decision method should be applied. The implementation of the multiple criteria approach allows taking into consideration several criteria for proper results.

6 Choice of transportation mode Using AHP method

To perform the calculations of criteria, the author have used standard algorithms of the AHP method with the commonly used pairwise comparison scale 1–9. This scale proposed by Saaty [15] has the following values: 1 – if two alternatives **A1** and **A2** are equal in importance; 3 – if **A1** is slightly more important than **A2**; 5 – if **A1** is strongly more important than **A2**; 7 – if **A1** is very strongly more important than **A2**; 9 – if **A1** is absolutely more important than **A2**; and 2, 4, 6, and 8 are intermediate values between the two adjacent judgments. The summary data of the pairwise comparisons for the criteria of the first hierarchy level for each group is presented in Table 2 and Table 3 for general cargo and oversized cargo accordingly. The importance of the criteria is evident from the evaluation of the criteria priority vector. It is easy to notice that “Cost” criteria is more important for the transportation of both types of cargo with value 0,6091 of priority vector for general cargo and 0,5850 for oversized cargo.

Criteria	Cost	Time	Reliability	Ecology	Priority Vector
Cost	1	4	6	7	0,6091
Time	1/4	1	3	4	0,2226
Reliability	1/6	1/3	1	4	0,1161
Ecology	1/7	1/4	1/4	1	0,0520

Table 2: Paired comparisons matrix for 4 groups of criteria (first hierarchy level) for general cargo

Criteria	Cost	Time	Reliability	Ecology	Priority Vector
Cost	1	4	4	7	0,5850
Time	1/4	1	1	4	0,1798
Reliability	1/4	1	1	4	0,1798
Ecology	1/7	1/4	1/4	1	0,0552

Table 3: Paired comparisons matrix for 4 groups of criteria (first hierarchy level) for oversized cargo

Matrices of the evaluations of the priority vector for the suggested routes based on the evaluation of the criteria priority vector of two levels of the hierarchy have been calculated. Table 4 and Table 5 give an example of the results of pairwise

comparisons and a normalized evaluation of the criterion “Costs for transportation” for general cargo and oversized cargo within group of criteria “Costs”.

	Route 1	Route 2	Route 3	Route 4	Route 5	Priority Vector
Route 1	1	1/2	5	4	6	0,32864
Route 2	3	1	5	4	6	0,43365
Route 3	1/4	1/5	1	1/2	1	0,06626
Route 4	1/3	1/4	2	1	2	0,10982
Route 5	1/5	1/6	1	1/2	1	0,06160

Table 4: Paired comparisons matrix and results of a normalized evaluation of the criterion “Transportation costs” for general cargo among all Routes

	Route 1	Route 2	Route 3	Route 4	Route 5	Priority Vector
Route 1	1	1/3	1/5	1/3	1/3	0,061107
Route 2	3	1	1/4	1/3	1/2	0,107532
Route 3	5	4	1	2	3	0,424611
Route 4	3	3	1/2	1	1/2	0,191687
Route 5	3	2	1/3	2	1	0,215064

Table 5: Paired comparisons matrix and results of a normalized evaluation of the criterion “Transportation costs” for oversized cargo among all Routes

Table 6 and Table 7 present examples of calculating the priorities of the second level group of criteria “Costs” for considered types of cargo. As can be seen in Table 6, criterion “Costs of special permits” and criterion “Lashing costs” has a minimum value of priority vector - 0,011 each. This shows that these criteria are unimportant for transportation of general cargo, and has no influence on the final results. Opposite, these two criteria has bigger values in terms of transportation of oversized cargo, as can be seen in Table 7.

Alternatives	Criteria										Priorities in group COSTS
	Transportations costs	Handling costs	Documentation costs	Seasonal tariff fluctuation	Possibility of additional costs	Additional insurance (insufficient safety)	Penalties (missed delivery terms)	Exchange rate fluctuations	Costs of special permits	Lashing costs	
	Numerical value of priority vector										
	0,3104	0,1218	0,0342	0,0704	0,0595	0,0923	0,0940	0,1954	0,0110	0,0110	
Route 1	0,3286	0,5955	0,5133	0,3286	0,0581	0,0525	0,1032	0,4014	0,2000	0,2000	0,3161
Route 2	0,4337	0,1853	0,2017	0,2433	0,0880	0,0525	0,0605	0,2287	0,2000	0,2000	0,2460
Route 3	0,0663	0,1093	0,1082	0,1605	0,3830	0,3831	0,3087	0,0665	0,2000	0,2000	0,1535
Route 4	0,1098	0,0565	0,1227	0,1700	0,0880	0,1502	0,0656	0,2287	0,2000	0,2000	0,1315
Route 5	0,0616	0,0534	0,0540	0,0976	0,3830	0,3617	0,4620	0,0746	0,2000	0,2000	0,1529

Table 6: Matrix of evaluations of the vector of the criteria priorities of the “Cost” group for general cargo

Alternatives	Criteria										Priorities in group COSTS
	Transportations costs	Handling costs	Documentation costs	Seasonal tariff fluctuation	Possibility of additional costs	Additional insurance (insufficient safety)	Penalties (missed delivery terms)	Exchange rate fluctuations	Costs of special permits	Lashing costs	
	Numerical value of priority vector										
	0,3226	0,0671	0,0165	0,0346	0,0749	0,0902	0,0679	0,0409	0,2091	0,0762	
Route 1	0,0611	0,4834	0,4565	0,0605	0,0687	0,0687	0,3717	0,1651	0,0578	0,4975	0,1551
Route 2	0,1075	0,2449	0,3068	0,0605	0,0687	0,0687	0,2135	0,2502	0,1155	0,2410	0,1369
Route 3	0,4246	0,1080	0,0968	0,3251	0,3693	0,3693	0,1104	0,1154	0,2366	0,0853	0,2862
Route 4	0,1917	0,1129	0,0968	0,1522	0,1557	0,1557	0,2315	0,4060	0,2012	0,1220	0,1857
Route 5	0,2151	0,0508	0,0432	0,4017	0,3377	0,3377	0,0729	0,0634	0,3889	0,0543	0,2361

Table 7: Matrix of evaluations of the vector of the criteria priorities of the “Cost” group for oversized cargo

The evaluations of the vector of the global alternatives of priorities are shown below in Table 8 and Table 9. The results of the evaluations show that for the General Cargo route 1 has the highest value of priority 0,2728, at the same time

for Oversized Cargo route 3 with the value 0,2610 should be selected for transportation from Dortmund to Kazan.

Alternatives	Criteria				Global Priorities
	COSTS	TIME	RELIABILITY	ECOLOGY	
	Numerical value of priority vector				
	0,609145	0,222676	0,116169	0,052010	
Route 1	0,316071	0,293680	0,111349	0,036819	0,272779
Route 2	0,246037	0,191416	0,147183	0,064950	0,212972
Route 3	0,153465	0,126775	0,198290	0,222853	0,156338
Route 4	0,131489	0,183826	0,151982	0,135688	0,145742
Route 5	0,152937	0,204303	0,391195	0,539690	0,212169

Table 8: Evaluating result for freight transportation for General Cargo

Alternatives	Criteria				Global Priorities
	COSTS	TIME	RELIABILITY	ECOLOGY	
	Numerical value of priority vector				
	0,585042	0,179838	0,179838	0,055281	
Route 1	0,155098	0,160515	0,143677	0,048042	0,148100
Route 2	0,136873	0,172266	0,149410	0,087597	0,142768
Route 3	0,286202	0,154574	0,273663	0,299534	0,261013
Route 4	0,185684	0,268139	0,139971	0,154545	0,190570
Route 5	0,236143	0,244507	0,293279	0,410282	0,257549

Table 9: Evaluating result for freight transportation for Oversized Cargo

7 Conclusions

Searching for the best transportation scheme of different types of cargo on different routes and applying different transportation modes is not a trivial task. Having a single model for choosing the best transportation alternative can avoid involving big resources for management of transportation flows. The presented study has shown that it is possible to receive a single approach to the task of selection of the best alternative for different types of cargo by having a single set of criteria for optimization.

The AHP seems to be the most attractive multiple-criteria method in this context since it allows structuring the choice procedure as a hierarchy of several levels. It allows for the distribution of criteria into several groups and the evaluation of the significance of every group's component. Consequently, the different group's criteria have been evaluated by different experts with proper qualification.

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