Design of Logistic Systems

(Theory and Applications)

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Open Science

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List of Used Shortcuts

AHP – Analytic Hierarchy Process.

C1, C2, C3 – types of campaigns.

CC – Continual casting.

CFS – Complex Forecasting System.

LS – Logistic system.

MOP – Methodology for model design.

MRP – Material Requirements Planning.

NC2 – Number of campaigns C2.

NCS2 – Number of slabs in Campaign 2.

OCEĽ VSŽ a.s. Košice – Name of the factory.

OP N+1, N+2 – Operative plan for next (N+1) period, for next second (N+2) period.

OP WHM – Operative plan of Wide hot mill.

PF – Push furnace.

SAP – Systems Applications and Products in Data Processing.

SWOT analysis – Strengths, Weaknesses, Opportunities, Threats.

TENs – Trans-European Networks.

TINA – Transport Infrastructure Needs Assessment.

WHM (1700) – Wide hot mill (width 1700mm).

Introduction

Design of logistic systems is a final discipline for preparing young engineers from area of logistics to become experts, who are planning and creating new, or improving current logistic systems. For being able to do so, they are using the knowledge from mathematics, statistics, operation analysis, modelling, simulation, system theory and from strategic, production and commercial logistics, of which such a system consists.

A logistic system is a system which controls and enables the realization of "flow" of materials, information and finance.

Content of this book consists of two essential parts: Theory of planning and designing and practical applications, projects, and case studies.

Logistic objects (as a philosophy of management) are the flows (as substance changing its parameter in time and place). These objects are complex and dynamic systems. If we wish to control them, we need to know them – analyze and model. Due to the fact that a flow is also a chain of depended tasks, elementary processes, its modelling in real production, distribution and service systems with help of analytical mathematical models is very challenging and most of the times impossible. For that reason, also the design of logistic systems is not based on exact or approximate methods just like statistical methods, geometric tasks, simulation, heuristics, etc. It mostly focuses on recommended actions, which differ from case to case depending on the level of creator's knowledge, amount of information and his/her own creativity; which approach, model or algorithm he/she will use or create.

Theoretic part of this book mostly concerns design, system projection, types of model used according to the creator's creative power, innovation and phases of projection. These phases mostly mean collecting and studying of information about created system, problems and tasks definition, methods for system analysis, approaches for decomposition of systems, methods for creation of new logistic system structure and design of functional algorithm for logistic system synthesis. We apply the synthesis of logistic system at least to two hierarchical levels: macro-logistical – creation of global logistic system, which mostly covers external relations of object, for which the system is created; and micro-logistical models of individual functions and tasks. This part also includes technical site of projection documentation and standardization of projection tasks.

Theoretical framework of projection are projection methods, which describe approaches, model approaches, case studies, usability of simulation while projection work, heuristic methods, quantitative approaches and reengineering as a radical change.

Experiences in education processes confirmed us, that theory is one thing but its application is another one. Most of the times, study of one created logistic system will give a much better picture about this difficult task then hours of theory. That is the reason why in this book a large space is given to presentation of applications, projects, case studies and models already done for several companies. Reader hopefully will forgive us for not mentioning the real numerical data and detailed steps of innovations in some cases. That way we wanted to preserve the authorization rights of companies and authors as well.

We have found out that exactly this type of scientific literature is missing on market, either in Slovakia or in Finland, that's why we are hoping that it will successfully fill the gap and will become a good and rich study material for students from area of logistics, management and projection of production processes and related areas.

Logistics was an evolutionary impulse in the last 10 years of 20th century and will be at least for next 10 – 15 years. Globalization and creation of almost consistent world market, information networks and technologies, production costs, production and consumption volume is not in balance. That is the reason for creation of flows, which are necessary to be designed, controlled, managed, to what this book might contribute by its value.

Prof. Dušan Malindžák

1

Logistics – Science of Present-Day and Future

Is the logistic only a new trend in the world of nowadays science, technology and economy or is the logistics a science, philosophy and industry, which influence the worlds' economy?

Logistics has become one of the most essential and dynamic factors of worlds' economy in last decades of 20th century and 15-20 years of 21st century. Reasons for that were mostly because of:

1. Globalization of world and globalization of world trade.
2. Unbalance between the resources, production and consumption and its allocation in world-wide environment.
3. Development of new management technologies (in mathematics, cybernetics and informatics).
4. Factor of costs and prices reduction. Global competitiveness – period of logistics.

Ad Point 1

With the world's globalization and in Europe with the end of socialism, a new market was opened. An environment for movement of investments, materials, products, energy, information and human resources was liberalized. The flow volumes of above-mentioned substances are growing. Build up of new transportation systems in roads, railways and aerial navigation (for example in Europe: TINA and TENs) have positively influence this growth. Creation of world-wide information highways and networks with high speed and volume of transport are revolutionary change also in area of flow management of products, information and finance, which mean of logistic systems. Electronic commerce (order, appraisal of orders, automated payments, electronic signature, etc) increase the efficiency and productivity and support the management of business activities – commercial logistics.

Companies realizing the competitive opportunities are creating chains and networks of companies, starting from the raw material mining, processing into polymers and products, delivery to customers, product services, recycling of its wrappings, waste and products itself. Due to these they are creating logistic networks and macro-logistics is developed.

Ad Point 2

Flow as moving substance changing its parameters in time and place, is created as a distinction of potentials. We can explain it analogically by an example of electric field. Electric current results from the interconnection of higher potential (+) with lower potential. Logistics creates conditions for flow establishment, manages them and ensures them.

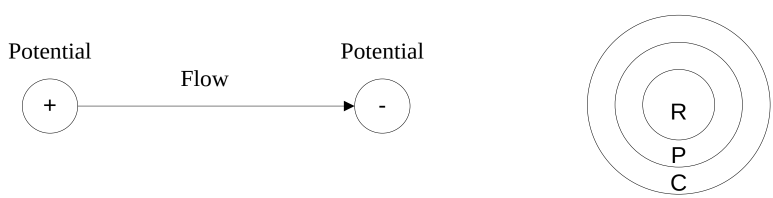


Fig. 1. *Flow as the results of potential distinction.*

There is a main difference among allocation of potentials in the world:

Raw resources → Production → Consumption

These flows are vital important for world economy operation and liberalization of world's economy and they support native balancing of these potentials. Optimal allocation of these potentials from the logistic point of view is in one place.

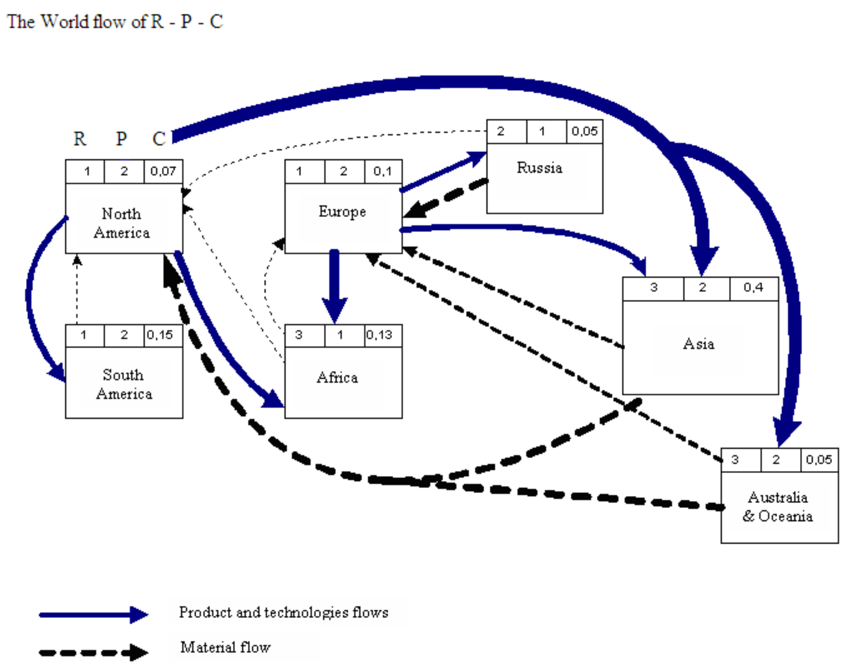


Fig. 2. *Main material flows of the world R/P/C.*

From worlds' statistics it is obvious in the global point of view, if we compare these three potentials resources – production – consumption, then these material flows are established by following factors (Fig. 1):

1. Europe and North America upraise approximately only half of raw materials they need for their industry production. That is the reason they need to import the materials.

2. Russia is dealing with the opposite situation. They upraise almost twice that much of raw materials then they are able to use in their industry production. Asia, Australia and Oceania upraise also almost one third more then they use.

3. On the other hand, Europe and North America and their industry produce much more products and technologies then their market can consume. That is the reason they need to export their products mostly to Asia, Africa, Russia, South America etc. On the (Fig. 1.) we can see the main three material flows. Above each of them, there is a triplet R/P/C

- R/P – proportion of production and consumption of raw materials.
- C – share of world's consumption of goods rising from proportion of population to worlds' population.
- Together with material flow, there are parallel and inverse flows of information and finance are created.

Unbalance among resources – production – consumption is mostly caused by historical development of economy stage, territorial geology, development of population and living standard. Balancing of these potentials and existence of flows are long-term situation needed to be solved for several decades to come. That is the main reason why logistics plays such an important role in costs and competitiveness.

Ad Point 3

Also development of managerial methods contributed to the development of logistics – management of distributed companies' productivity, methods of outsourcing, risk management, concentration of capital into big corporations, etc. development of distributed management methods, modelling and simulation, multi-criteria optimizing and its usability within world information networks gives us tools for dealing with the flows within the world-wide environment.

Ad Point 4

World-wide market and competitiveness, tendency of producers to reach world's markets force the producers to cut and reduce their costs. Automation and informatization have increased the productivity of production systems. Times when automation and informatization were leading the dynamic of worlds' economy are over. They are considered to be prevalence in nowadays production systems. It is difficult to picture a successful production without them. The reduction of costs is that's why in the area of connected operations, supporting processes and in its management – in logistics. In compare to automation and informatization of technological processes, allocation of logistics is less expensive and more effective. Mostly it doesn't require high investment but only a good idea, organization and cooperation.

If we take a look at the 20th century, economical dynamic was always influenced by different factors [3].

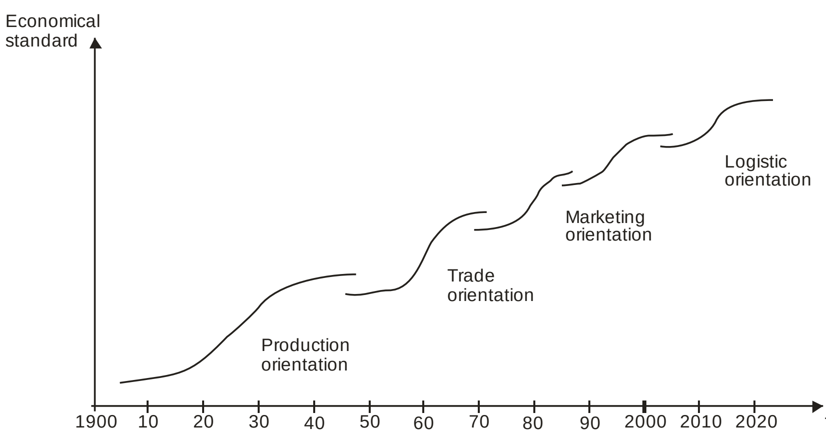


Fig. 3. *Factors influencing the economy of 20th century.*

- *50s – 60s* of 20th century is also called production oriented economy, which focused on maximizing of production. Main issue was to produce as much as possible. Successful companies were those which could produce the most possible amount.

- *50s – 70s* were mostly oriented on sale – maximizing of sale. Production has exceeded the demand; old markets were totally covered by products. Successful companies were those which could sell as much as possible.

- *70s – 90s* are known for their marketing orientation. The aim was to maximize the area of trade. Customers started to be more essential, battles for new markets was common. Research and companies are more interested in marketing strategies. More and more companies base on long-term contracts, strategic customers and trades.

- *Last years of 20th century* – logistic oriented economy focused on maximal satisfaction of customers. The whole chain of company's activities is oriented on global costs reduction and on final customer.

Global optimizing in the whole chain is replacing the local optimizing of activities; internal management is concentrated on coordination and systematic approach. Quality is becoming more essential together with environmental issues.

Research results of Dept. of production economy and productivity of University of Vaasa [2] in Finland supports the above-described idea.

There were three groups of experts participating on the research:

1. Experts in area of research and education.
2. Experts.
3. Companies – firms from Kankajoki region.

These three groups of subjects were supposed to answer following questions:

1. What are the new areas of know-how, factors for new markets and establishment of new companies.

2. Future technologies and directions. Carrier, developing, sophisticated directions and technologies.

3. Key technologies on which nowadays business activities are based on.

Answers were based on life curve of products, technologies and know-how (Fig. 4).

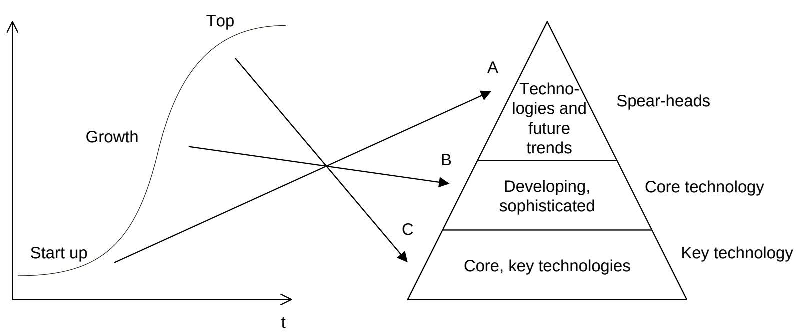
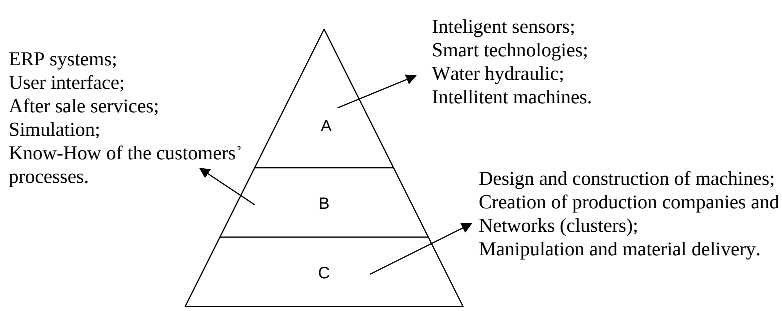


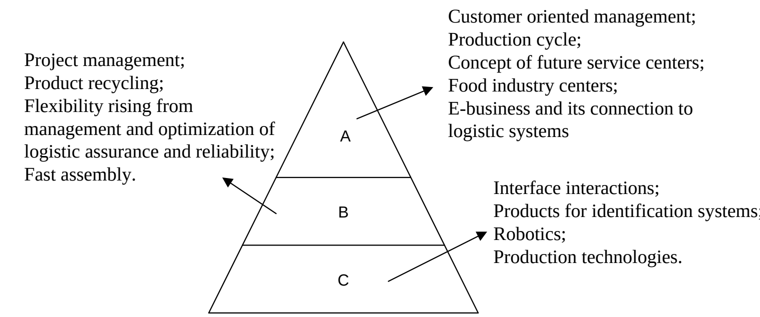
Fig. 4. *Relation between life curve and technological pyramid.*

Research results were as follows:

Regional companies



Experts



Educational and research institutions

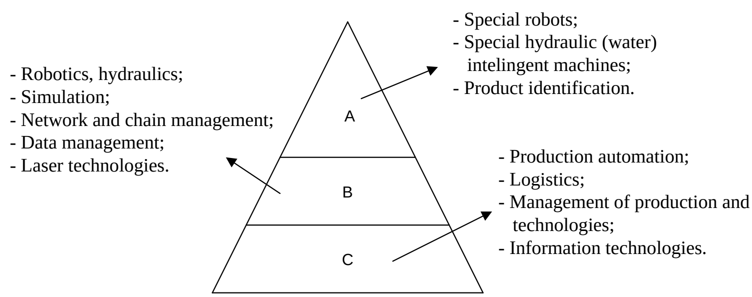


Fig. 5. *Technological pyramids.*

As we can see from the (Fig. 5.), all technological pyramids include inter alia:

1. *The pyramid of companies:*

B - After sale business (part of commercial logistics).

C - Creation of production companies clusters (their management – part of strategic logistics).

Manipulation and distribution of materials (part of production logistics).

2. *The pyramid of experts:*

A - E-business and its connection to logistic systems.

B - Creation of regional clusters and international company networks.

Flexibility rising from management level and optimization of logistic chains.

3. *The pyramid of educational and research institutions:*

A - Identification of products.

B - Simulation.

Networks and chain management (Supply chain management).

C - Logistics.

From above-mentioned information we can conclude that logistics is a science and philosophy, which significantly influences world trends and economy and will keep on influencing it in next decades to come.

2

Logistic Systems

Logistic system is a system, which manages, ensures and executes the “flow” of materials, information and finance.

Logistic system is a hierarchical system. From the system theory point of view, if we want to define its levels, we have to define the position of the observer first. This book is mostly focusing on company’s logistics, which means that the observer is inside of that particular company.

Internal logistics of a company operational level [20] is called the micro-logistics. Inside of it the individual machines, activities and processes are viewed as black boxes.

Higher level, where company as a whole is a part of a higher system (for example logistic chain of companies or logistic network) is called macro-logistics.

If we are not able to sufficiently manage flows and chains within company on the micro level, we would need to decompose the system and take a look at the lower level on elementary operations which are carried out within individual machines, aggregates, robotic processes on the level of nano-logistics.

On each of these three levels, there are several operations carried out according their significant characteristics, outputs, time and so on. But actual internal view consists of three basic processes:

- *transformation* – (processing operation, installation, connection) where quantitative and qualitative parameters of substance $\alpha_{KV,}$ α_Q are changed.
- *transportation* – movement carried out by transport, manipulation, where position parameters are changed α_X.
- *cumulation* – assembling, collecting, where parameter of time is changed α_t and other parameters are not changed $\alpha_{KV,}$ α_Q, α_X.

To define the logistic system means to define its structure, functions, activities, aims… We can view the logistic system from technical and functional side.

From the technical view, elements of the systems are the facilities and tools ensuring and executing the movement – flow in time and place, as for example cars, ships, trains, transportation bells, conveyers, warehousing equipments, chain bells, robots, production lines and machines, etc. When talking about material flows, in that case there are terminals, computers, computer networks, modems, satellite and transmission equipments, etc. When talking about information flows, there are connection to material, information and financial flows.

From the functional point of new – activity point of view, we are talking about allocation, placement, organization, management and coordination of movement of materials, products, information and finance. Important activities like allocation and lay-out of a company, production equipments and machines, warehouses, distribution centres, sales, prognosis and strategic planning of sales, production, purchase and storage, selection of products and services suppliers, what amount to buy, shat system of transport to use, what are supposed to be the designed at input, inter-operation and output warehouses and clusters, what is going to be the optimal production dose, if to use the capacity for 100% and risk that way or if there should be still a resist and that way keep ourselves ready to accept new orders, how to prepare operative plan, in what sequence to produce products, where is going to be the acceptance place between the producer and customer, what system of financing to use, etc.

All these activities are connected one to each other, they are creating a chain, activities knotted to the flows – objects of management and creating a logistic system of functions.

2.1 Place of Logistics in the Managing System of a Company

Complex system of management consists of three hierarchic levels of management according to the objects and processes, which are managed:

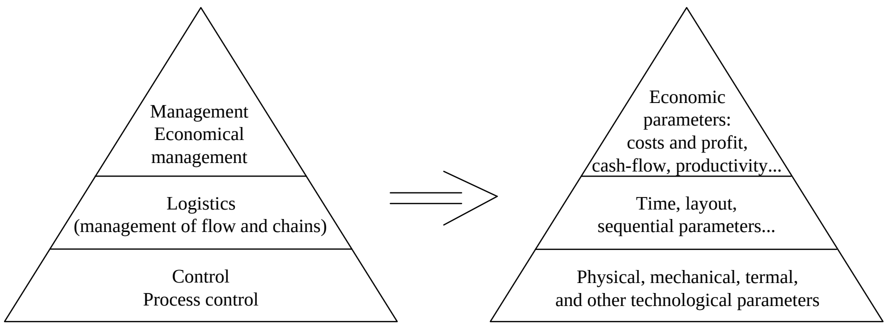


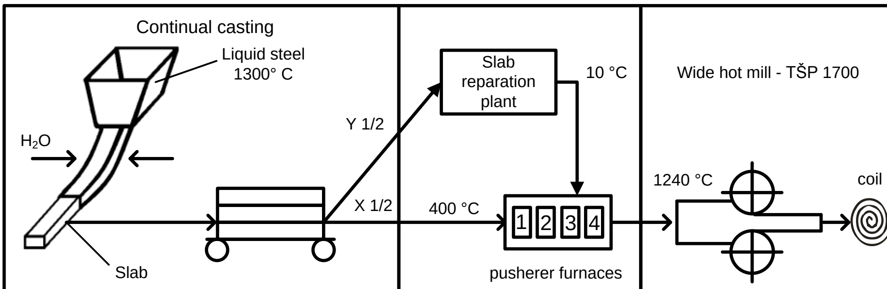
Fig. 6. *Hierarchical levels of managing a company.*

(a) Management is a total control of a company, firm, production, sales, human resources, finance and others through economic parameters like profit, costs, yields, cash flow, productivity, etc. The criteria of management and optimization are of economical character.

(b) Logistics – management of flows and process chains through time, sequential, layer and capacity parameters like capacity usability of equipments, order and amount of produced product, layout of sale and distribution centres, initiate time, processing time and finalizing time of individual processes. Criteria of management are capacitive, time, but in global explanation they are economic. Processes creating chains are purchasing, procurement, storing, transport, production processes, distribution of products, maintenance, etc. managing functions are allocated, layout and set-up, prognosis, aggregation planning, scheduling, dispatching control, monitoring and others.

(c) Control – process management controls of magnitudes physical, mechanical, thermal chemical, etc. like temperature in furnace, compressive force of cylinders, size of engine evolve, level size, etc. Criteria of optimizing are also from the area of technical parameters but at the end they are economic.

Above-mentioned management levels are described on the production process of Division steel.



CONTROL: - speed of casting - quantity of cooling - ...	- furnace temperature control - ratio of air and gas control	- roller pressure power control - distance roller control
LOGISTICS: - min. number of reducing slabs - optimal sequence of casting - optimal number of slabs in sequence - coordination with TŠP	- increase of the ratio of hot slabs - synchronization of heating and roling - optimal system of storing slabs in the warehouse - choice of proper furnace for heating of certain slab	- size amount off rolling - sequence off rolling of each amount and coordination with heating of slabs in pusherer furnaces - coordination of rolling with continual casting
MANAGEMENT: - minimizing of costs of coils production - fulfillment of terms of delivery products - energy, maintenance, performance costs - division production, etc.		

Fig. 7. *Example of management levels.*

We can see that *process management – control* mostly focuses on process control within one aggregate, machine or workstation.

Logistics mostly deals with relationships, coordination among workstations, which is ensured by capacitive and aggregate planning, production scheduling, organization, allocation, by calculation of optimal amounts, batches, times ensuring synchronization and connection of processes and maximal material flow.

By managing the production process as a whole is mostly focused on fulfilment of delivery terms, minimal production costs, and maximal production and so on.

2.2 Logistic Model of a Company

Logistic model of a company, which understand a company as a system of parallel transformed flows of materials, energy, information and finance is represented by a chain and net of activities and operations.

If a company is understood in the environment of market “from a customer to a customer”, then activities of logistic model can be divided according to the meaning and frequency of executing:

(a) Logistic functions of strategic meaning, which define the structure and framework of logistic systems.

(b) Activities with periodicity, which are providing the functionality of logistic system, flows and are represented by micro-logistic company model.

2.2.1 Macro-Logistic Model of Company

Logistic system structure is composed from long-term decisions realized in the company and lasted for long time. These decisions create frame and structure for realizing logistic functions and processes.

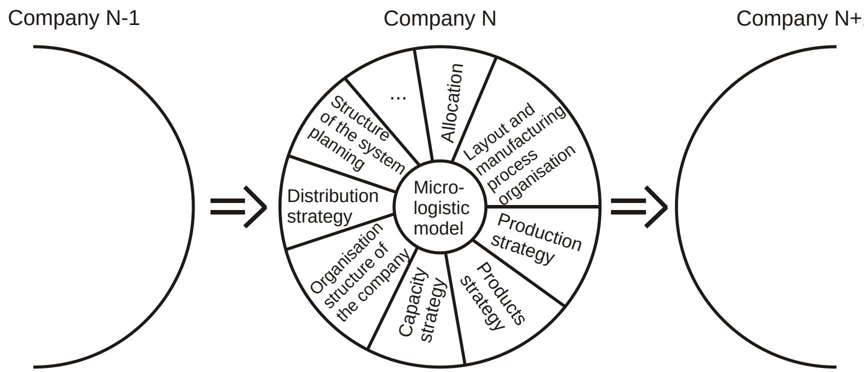


Fig. 8. *Macrologistic model of a manufacturing company.*

Among these activities and decisions, following belongs:

1. Allocation of company.
2. Commodities strategy.
3. Organization of production processes.
4. Production strategy.
5. Organization of company – organization structure.
6. Capacity strategy and determination of marrow place.
7. Structure and parameters of planning systems.
8. Distribution and procurement network.

Ad 1) The Allocation Problem Geographic Positioning of a Company in a Space.

Allocation is influenced by following factors: – production:

- raw material resources.
- energy availability.

- transportation possibilities.
- work force and its classification.

Trade:

- taxation level.
- market.
- communication possibilities.
- price, etc.

Social:

- unemployment.
- production traditions, etc.

Allocation methods base on:

(a) Multi-criteria decisions if factors are difficult to quantify, or.

(b) Solution of geometric task [4].

Ad 2) The Commodities Strategy.

Position of various product selections of a company on the life curve is important for estimation of long-term perspective and stability of that particular company. Position of products on life curve means the amount of product in the phases of development, growth, peak or regress.

Commodities strategy can be easily defined by a matrix.

Products \ Position				
V_1	X			
V_2		X		
V_3		X		
V_4			X	
V_5				X
V_N	X			
Total Optimum [%]	20	40	20	20

Fig. 9. *Commodities matrix.*

Ad 3) The Organization of Production Processes.

According to the product position on the life curve and demand, it is necessary to define the organization of production processes:

(a) functional.

(b) commodities.

(c) combined organization.

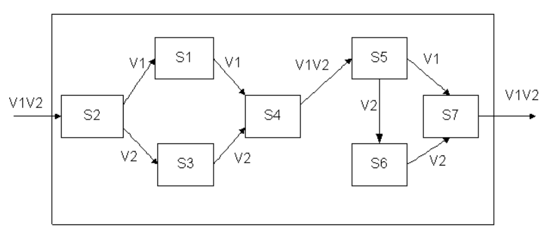


Fig. 10. *Process (functional) organization of production.*

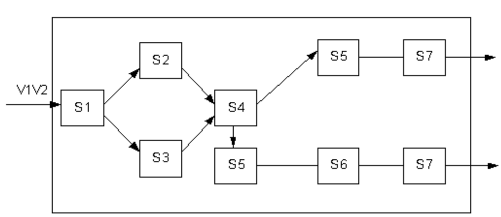


Fig. 11. *Combined organization of production process.*

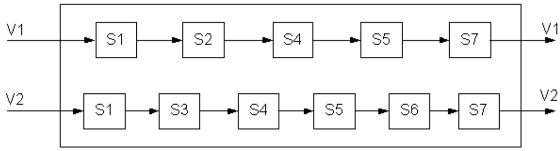


Fig. 12. *Commodities organization of production process.*

Functional organization is mostly put into praxis in start-up and development phases of a product and in order production of non-standard products. A product in that case is going through individual machines (functions) according to technological sequence.

Commodities organization is typical in continuous – homogeneous production processes (e.g. metallurgy, mining, petrochemistry, construction material productions) and in serial and cumulative production of non-homogeneous – discrete production processes.

Combined organization of production process is mostly used when production of component is organized functionally and installation in production way.

Ad 4) The Production Strategy.

1. *Order production* is carried out by *PULL system* based on JIT, meaning produced on certain date according to the order (Due date). From the last operation, finishing times of other operations are calculated. PULL system is carried out by KANBAN method, created by Toyota Motor Company in year 1960.

2. The opposed strategy - *PUSH* (production for storage). Products are planned from the beginning, meaning from the first operation till the last one in technological sequences. A border-line situation could happen in MEPII principle, when at the same time several products are started to be

produced and later connected together, assemble into configurations and final products [5, 6].

3. Advantage of PUSH system is the possibility of production optimization. Larger production batches, independency of production on demand, time delivery, shorter delivery times, etc. PULL strategy minimizes the storage, lower the risk of deployment of product on market, etc.

4. Connection of these two strategies JIT and MRP II (PULL and PUSH) is merging advantages of both of them. The first company, which implemented this combination, was Yamaha Motor Company in 1970 as Synchro MRP [5, 6].

It is important to determine the crash point and balance point, when talking about production strategy based on PUSH strategy.

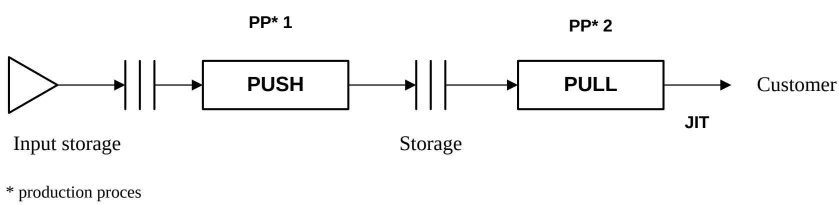


Fig. 13. *PUSH and PULL combination.*

For example, VP I is a component production. Warehouse of components could be the crash point and VP II is the assembly of final products, or it could be a small part of production process or warehouse of semi-final products and material, which are further manipulated into final stage.

Ad 5) The company's organization.

There are three basic organizations of a company:

(a) functional.

(b) commodity.

(c) matrix.

The organization structure of a company depends on the organization of production processes.

A simple rule is applied. A company should be organized according to the organization of its production processes, meaning that if production processes are organized "functionally - procedural", also the company should be functionally organized.

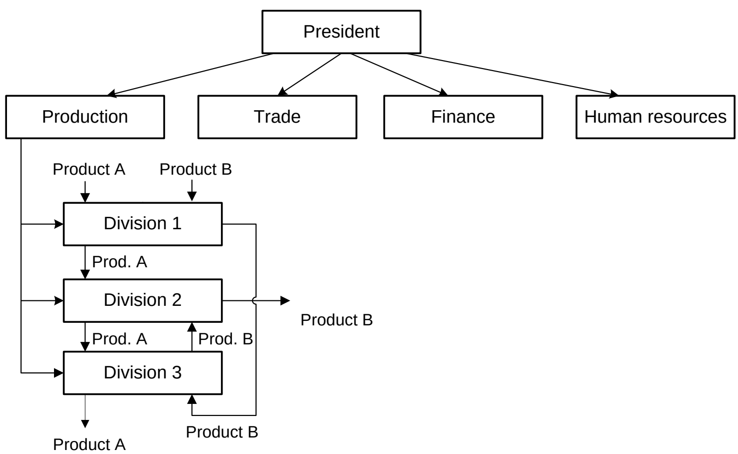


Fig. 14. *Functional organization of a company.*

Divisions can be for example: foundries, pressrooms, mills, etc.

If the production processes are commodity organized, also company should have the same organization of production.

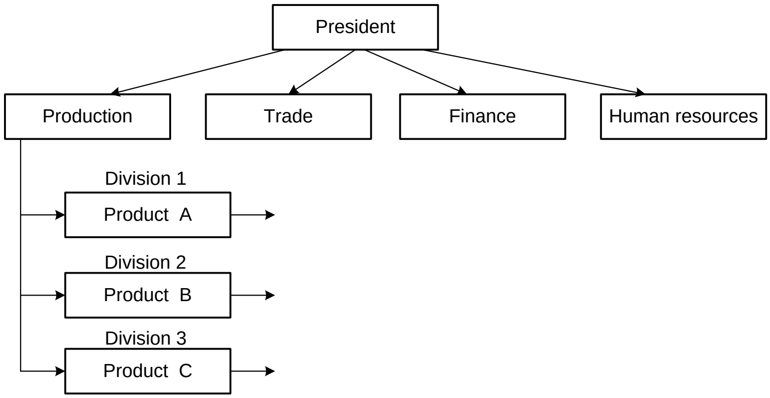


Fig. 15. *Commodity organized structure of a company.*

Divisions produce individual products. If a company works on behalf of projects, then the organization is called matrix.

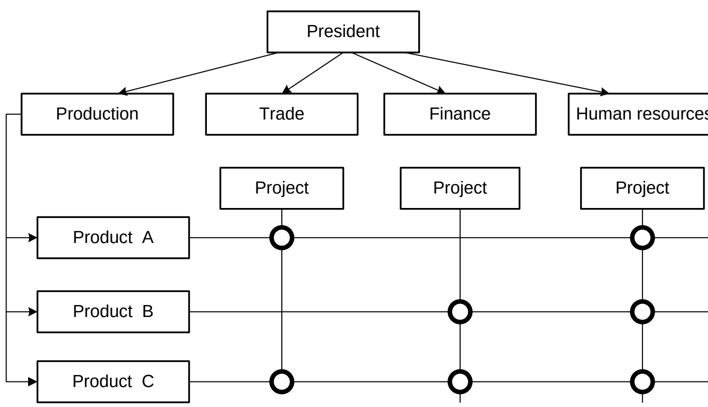


Fig. 16. *Matrix (project) organization of a company.*

Matrix structure enables dynamic creation of solving project teams. It is suitable for areas of research, development, civil industry, main services and everywhere else where a production processes could be understood as a project. The disadvantage of this organization is the subordination of employees to two chiefs, project managers and chief of the initial workstation.

Ad 6) Capacity strategy.

The capacity strategy of a company defines the long-term relation between production capacity – KM and requirements – capacitive demands implicit from demand prognosis – PP on company's products. The capacity strategy raises from capacity formula:

$$KV_T = KM_T - PP_T \quad \text{where } T = 1, 2, 3 \ldots$$

Production capacity cause dilemma. If the production capacities are defined by sum of individual machine times and disposable to product production within planned period T and are higher than requirements, these capacities are not used and cause higher fix costs per production unit. The other way around, if these capacities are lower than requirements, we are not able to carry out all the orders and are automatically losing customers and market.

There are three main capacity strategies:

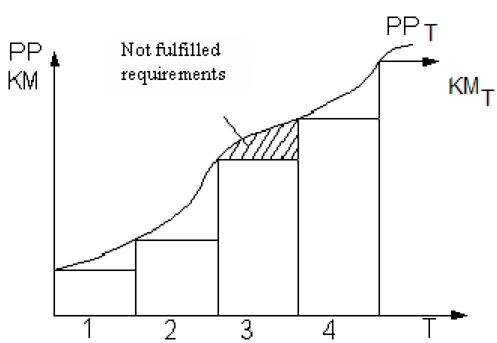


Fig. 17. *The WAIT AND SEE strategy.*

"WAIT AND SEE" strategy is a conservative strategy, when production capacities are changed only in case of long-term higher demand than the company is able to produce. This strategy is a bit risky, because it can cause that part of the orders will not be fulfilled and customer may switch to competitor.

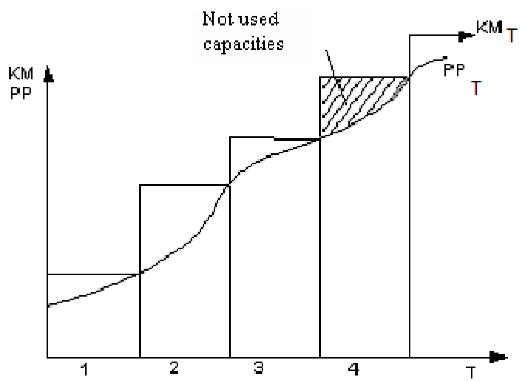


Fig. 18. *The PREEMPT OF COMPETITION strategy.*

"PREEMPT OF COMPETITION" strategy bases on a thought to create new capacities in advance for increased demand.

"PREEMPT OF COMPETOTION" strategy [7] is an aggressive strategy gathering new market. It is suitable for dynamically exploring market sector. Production capacities are established in advance, which might cause a fact that they will stay unused.

There exists also a compromise strategy called "SNAKE" – sneaking. This strategy bases on sequential change of production capacities oscillating around the curve of demand.

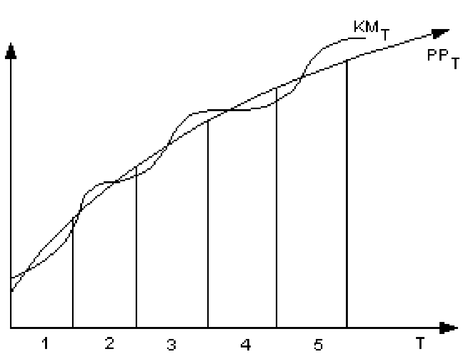


Fig. 19. *The SNAKE strategy.*

Sneaking strategy could be applied only in case the capacities could be changed in small steps – almost continuously. But this is not always possible to carry out because changes are always discrete. Small aberrations are regulated by actions for capacity smoothing.

Ad 7) The structure of planning system.

Planning system provides company’s objective definition. These objectives mostly concern adequate planning period establishment (horizon, time), provision of reconciliation among finance, trade, production and capacities, so that the company would be able to achieve a positive profit.

Planning system structure is assigned by the amount of hierarchical levels and parameters of partial plans.

Plan parameters are:

- L – management level (company, division, workplace, …).
- T – planned period (3 – 5 years, year, quarter, month, week, shift, …).
- M – type of planned item (finance, production volume, sale amount, …).
- S – priority sequence (production order, task priority).
- t^s – initial time of pursuance.
- t^u – finalizing time of pursuance.

Strategic and aggregate planning rises from the company’s vision, from prognosis and not from concrete orders. Long-term contracts and contracts about future contracts are used in aggregate planning. Operative planning is based on concrete collection of orders and contracts.

Strategic planning merges together the company's vision with future prognosis, capacity strategy with production resources (meaning finance, production capacities, human resources, …). It is essential for investments, long-term financial operations, training of employees, preparation of long-term contracts, marketing strategy, etc.

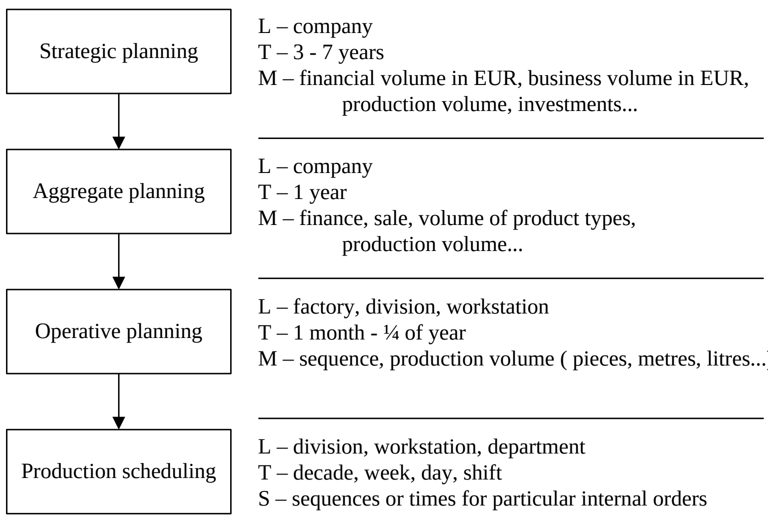


Fig. 20. *Company's planning system structure.*

Aggregate planning is mostly proceeded for one year as the "executive plan". It is a cyclic process, which defines the *financial plan* – finance need (for salaries, investments, maintenance, materials, energy, debts, loans, interests, etc.). Then it is also needed for effective existence of a company. *Business plan* defines types of products, goods, which will fill the financial plan when selling them. *Production plan* defines the amount of products and corresponding range of goods, which will fulfil the business plan.

Operative planning has mostly 2 levels – capacitive planning and production scheduling. Capacitive planning is a part of order logistics – processing of order scope in particular planning period. Its role is to review the orders from technological, economical, capacitive and material point of views. It cumulates the orders into internal company orders, creates production batches and defines the amount of ordered products in planned time period.

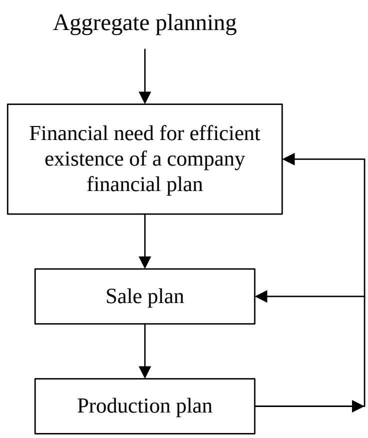


Fig. 21. *Cycle of aggregate planning.*

2.2.2 Micro-Logistic Model of Company

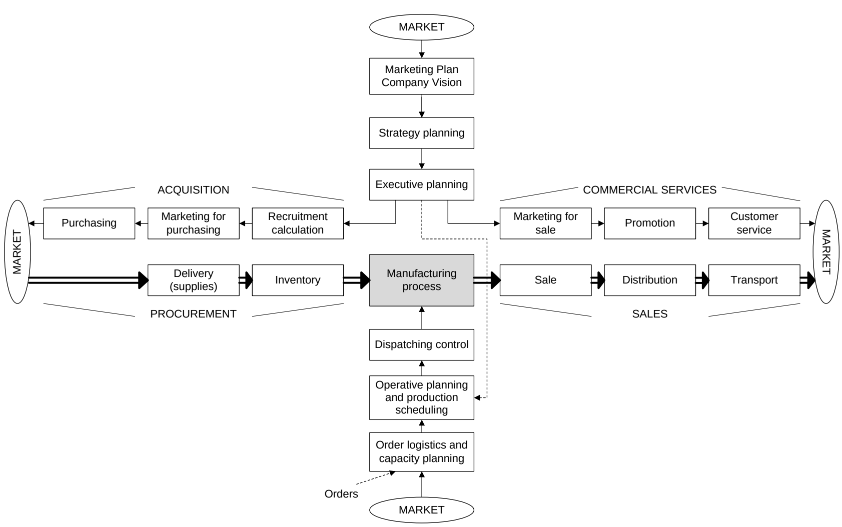


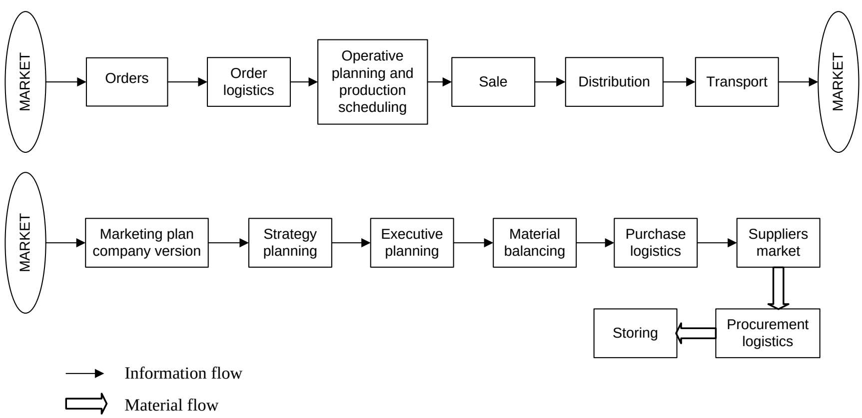
Fig. 22. *Relations of commercial and production logistics activities- micro logistics model of the production company.*

Micro-logistic model represents a model of regular repeated activity on material, information and financial flows of a company. It is a functional model. Company is a system of connected and transformed activities and functions, which create chains and flows.

Commercial Logistics

Logistics according to the definition is a flow management philosophy. In commercial area of a company it is possible to identify following information and material flows:

The logistic chain of the purchase:



It is the following information and material flow in the area of purchase (Logistic chain in a production company):

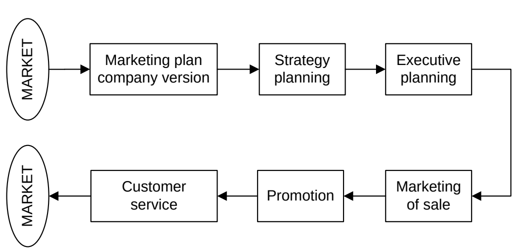


Fig. 23. *Information and material flows in area of purchase and procurement.*

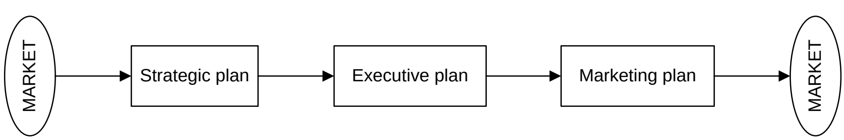
From the quantifying and detailed survey of market needs, the company headquarter adjusts the company's vision to it. Strategic planning for 3 till 7 years the needs of more precise definition of company's intents in the area of purchase, production and sale policy, as well as for the development of production-technical bases – company's production capacities.

For the needs of detailed plans, there is annual material (production-business) plan defined. This plan describes the chronological, capacitive, material, energetic and personal balance together with creating a financial plan for each and every part of the company as well as for the company as whole. The result of material plan definition is the prognosis of company's profit.

For the purchase area, material and energetic balance as the most essential. They specify the objects of acquisition. Purchase logistics actively affects the supply market with the help of purchase marketing tools. The aim is to ensure all necessary inputs in adequate amount, quality, price and time. The respond of purchase logistics comes from the suppliers in form of fulfilled orders and requirements. The transfer of inputs from the reorder point into the input warehouse, its qualitative and quantitative control, storage and preparation to the production process is the main objective of supply logistic.

In the area of product sale the main flows are**:**

a)



b)

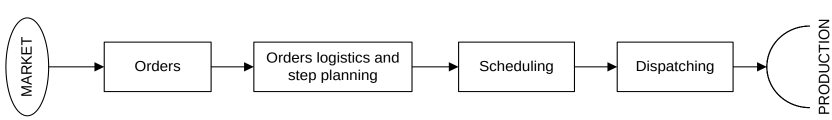


Fig. 24. *(a, b) Information and material flows in area of sales.*

Likewise in the area of purchase, also in area of product sale, intents in long-term marketing plan are defined. Then they are more in detail specified in strategic prognosis and planned in annual executive plan.

Sale logistics deliberately influences the customer market with help of several tools. The result of this influence is the feedback from potential customers expressed in demands and orders. These are the input for customer logistics. Demands and orders of customers initiate the chain of logistic activities needed for its satisfactory fulfilment. At the beginning, the demands and orders of potential customers are evaluated according to economical, technical-technological, material and capacitive criteria. After the submission of particular order and its following permission, contracts of sales are signed. These tasks represent the main information input into the production logistics. A product as a result of production process is by the distribution logistics delivered to customer.

Production Logistics

Production logistics presents connections of acquisition logistics and sale logistic in the production company. The connection of production logistics to commercial logistics can be defined as follows:

- at a common submission of strategic plan of a company.
- at a preparation of background and creation of executive plan.
- at a material balancing of executive plan which represents inputs and requirements of production process, which provision of is the main task of acquisition logistics.
- at a sale plan definition, which is a part of executive plan.
- at a certificate of delivery acceptance.
- at a technical, technological, material and capacitive appraisals of orders.

- at a creation and appraisal of sales agreement.
- at an assigning of CONTRACT – PRODUCT.
- at an acceptance of final products from production to distribution.

Production logistics is created by activities directly participating on management and provision of production and service processes, e.g.:

Service processes

- technical preparation of production.
- procurement.
- storing.
- inter-operation transport and manipulation.
- maintenance.
- energetic and waste economy.
- packaging.

These belong to the managing processes:

- annual planning.
- executive planning.
- capacity planning.
- operative planning and production scheduling.
- dispatching management.
- operative evidence and monitoring.
- analysis of the state and performance of production process.

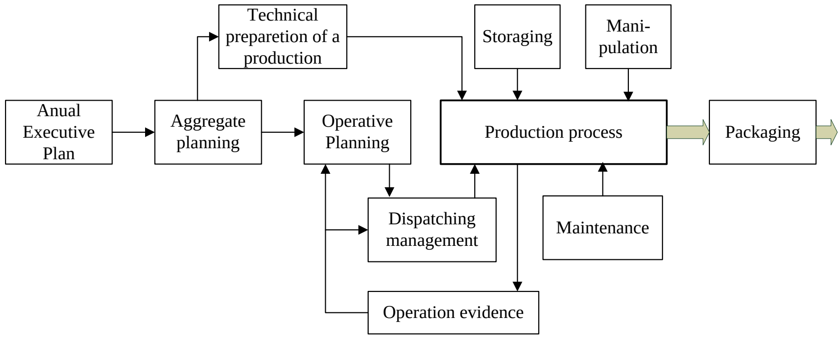


Fig. 25. *Activities and relations of production logistics.*

Information Logistics

The task of the information logistics:

1. Integration of logistic activities by information system creation.
2. Collection and handling of information about customers, suppliers, products, technical practice, machines, etc.
3. Ensures the collection and handling of information about objects and activities of logistics.
4. Ensures the logistic system activities.
5. Management activities of the information logistics have information character.

The main task of information logistics is to provide fast actual information to managers, more efficient flow and chain management and ensures analysis execution and evaluation of concrete data for the purpose of company's performance analysis.

Increased quality of information is very important while estimation and implementation of a company's vision. Incorrect information in this area can cause false decision, which might obstruct company's competitive position on the market and enable dynamic reaction of company to the changing situation on market and that way negatively influence future development of company. Volume of vision implementation can depend on company's possibilities, competences and of course resources.

Business strategy presents the way how to achieve company's vision. The basis is established by answering questions WHAT, HOW and FOR WHOM will company produce. Answers to these questions are obtained from market marketing survey.

After carrying out the marketing survey and making ourselves clear about the aims and intents, based on the predicted demand, company starts to plan and cover all production factors for each production activity

Next important is the question where the company will obtain production inputs. There might be several potential suppliers. That is why, information about suppliers are crucial before creating of an order of signing of contract of the many time, the price is not the most essential decision criteria, but more often is the quality of products, delivery and payment conditions, etc.

After the selection of suppliers, information about what, how much, for what price, in what time, where, with what costs and term of payment are becoming essential. On the other hand, it is of big importance to receive information about the customers, mostly about their solvency and term of payment realization. Also information about tax policy and interest rates are a bit importance for a company except of their own company's internal information.

Other information essential for area of information logistics are the information following and describing the material flow. That information could be found in dispatch notes, forwarding bills, material requisitions, etc.

Financial Logistics

The selection of optimal alternative for financial resources gaining and decision about the ration of own and outside investment depend on the prices of particular investments types (purchase costs) and financial risk. In general while making decisions about optimal financial structure, following are valid:

- Purchase costs and interlocking of own investment are higher the interlocking of outside investments.
- Rising of outside investment ratio to the total investment causes decrease of purchase costs and interlocking of investment [11].

Gained resources are used by company for transformation processes, goal is the transformation of inputs into outputs.

Total duration of this process depends on duration of individual phases of production process. More precise, we are talking about delivery dates of materials, delivery time, time spent in production and assembly, time of order appraisal, delay times, etc. This way, lot of investment gets lost in the process of time cumulation.

Purchase of production and sale of final products is not possible to carry out without system of payments.

System of payments is a collection of steps and tools focused on balance of assets and debts rising from suppliers-customers relationships.

Financial logistics deals with the realization of payment system. Aim of financial logistics is to ensure failure-free payment, ability to pay and company's liquidity.

Company is trying to plan and coordinate financial flows the way, so the outgoing flow will be reduced and the inflow of financial resources will be speeded up.

3

Design of Logistic Systems

If a man want to have something new, a house, a factory, a production line, machine, a piece of furniture; or a park; somebody must prepare the projection, project, model and plan how such an object will look like. At the same time, such a projection will determine how such an object will behave and what functions it will have. Designing is a ubiquitous human conscious activity, a process of a creation of something new.

With the knowledge development, two spheres of natural and technical sciences have been established. Natural science is more oriented towards obtaining new knowledge, defining new principles and rules.

Technical, engineering science is oriented towards the application of this newly discovered knowledge for designing purposes.

3.1 Theoretical Aspects of the LS Design

The design process is similar, irrespective of the subject, concept or design method. The design process shows the aspects of:

(a) Cycle – iteration.

(b) Cognition – novelty.

(c) Evolution, (revolution) – development.

Necessary for the design process are the information, knowledge, rules and evaluation criteria.

Design is a process mainly based on limited information, e.g. incorrectly structured problems. Design process has a character of the theory of science. Creation of one version of a design in time t – N(t), evolves in information and knowledge basis creation for version N(t+Δt). In time t+Δt, design process has a character of a cycle – iteration.

Cognition – creativity are closely related to novelty. A design always includes characteristics of novelty. Novelty can be understood not only as a discovery, an invention; but also as a creation of a new system from already known elements. Also a new structure, application of other method with known information, which improves the qualitative parameters of the design are perceived as novelty in meaning of new elements, new structures, new functions and processes.

A new design in N(t+Δt) rises from the evaluation of previous N(t). The design process is ended with an acceptable design.

Cognition – creativity of the designer bases on:

(a) achieving the higher level of knowledge.

(b) information repletion about particular problem area.

(c) inductive thinking based on analogy.

(d) free-heartedness to changes and new ideas.

(e) ability to generate thoughts, constructions and conclusions no matter the limitations are (there are always some).

(f) motivation and courage making conclusion - decisions.

A design – project presents new solution, moves the quality from the previous status to a newer – higher level. A design might represent an evolutionary, respectively revolutionary, qualitative and systematic change of the object's parameters. Each design should contribute to the overall development. The term "design" means a conceptual, ideological creation of something new.

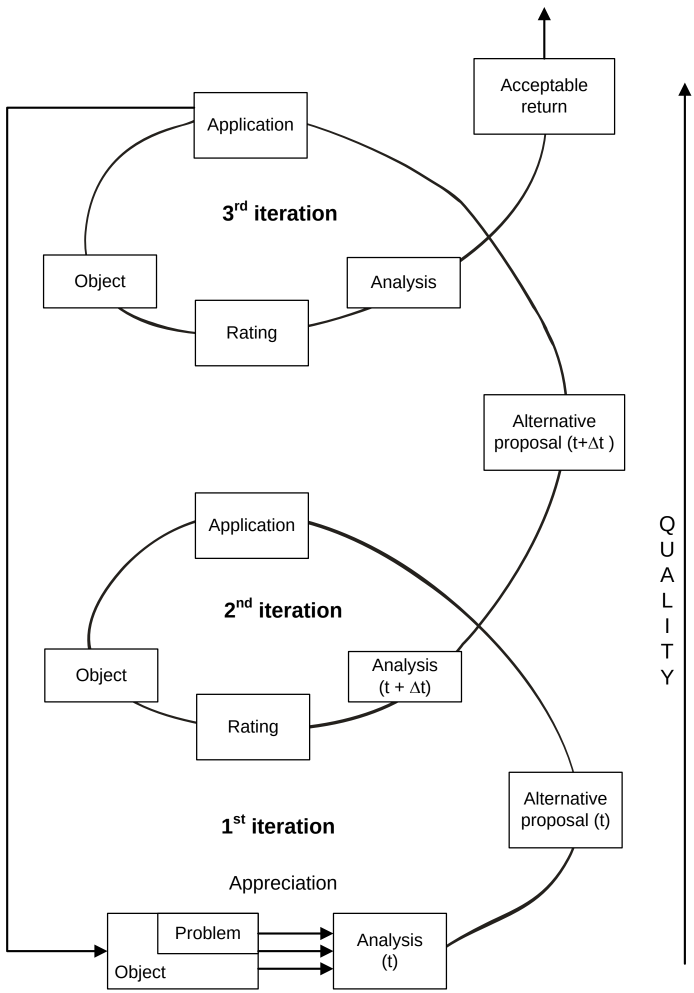


Fig. 26. *Design process.*

Projection is understood as technical, methodical and realization part of the design process (in more details explained in the following chapter). For designing logistical systems, the same regularities (observance, paradigms) are taken into consideration as for any other systems and processes. The differences are only in the objects and projection methods. Objects are the logistical systems and processes, meaning processes ensuring the managerial and realization, material, information and financial flows among companies and within a company. The methods base on the type of the objects and the problems. By reason of incorrectly structured problems, mostly approximate methods are used, e.g. simulation, heuristic, statistical, which are based on imitation, analogy, comparison, induction, algorithms, etc.

3.1.1 Basic Characteristics, Paradigms and Design Requirement

Design process starts with the identification of needs – creation – definition of the problem, analysis of the information status, knowledge, generation and modification of designs, their application and evaluation. This process is repeated in cycles till the acceptable design is finalized. Fig. 26.

Basic characteristics and paradigms of the design:

- design processes and creation process of the designers are carried out in conditions of limited information – *incorrectly structured problems.*
- alternatives, possibilities and results are not known in advance and that is why they are supposed to be found within the process of design.
- in most cases, the *optimal solution* is not expected, an acceptable and suitable solution is searched for.
- Most of the properly structured problems (mathematically described) do not have an optimal solution.

Two basic paradigms are applied for design processes. Paradigms are approaches describing design from the assignment and problem definition till its application and consignment to the executor. Paradigm is a frame – schema, instruction for one or more methods of design. They are typical for particular streams and schools.

There are two basic approaches of a paradigm:

- Case studies.
- Modelling approach.

There are several types of models (mathematic, algorithmic, simulation, heuristic), but basic approach is always Analysis – Synthesis – Evaluation (A-S-E). Basic paradigms applied on logistical systems are:

- model approach (A – S – E).
- simulation approach.
- heuristic approach.
- case studies.
- re-engineering (phylogeny design).

Each of these paradigms includes basic processes:

- problem definition.
- problem analysis.
- gathering of information, knowledge and problem investigation.
- generation of alternatives for solutions – synthesis.
- evaluation of alternatives.
- Application of the solution.

In each paradigm, some of the processes might be realized differently. While gathering of information, selection of knowledge, research, generation of alternatives is dominant in model approach (scientific approach), in case studies is this phase simplified into search for solution with similar conditions and situations. Focus is given to the evaluation of the alternatives and suitability of the solution (pragmatic approach). In simulation, the focus is on generation of solutions and evaluation of the simulation (functional model). Heuristic approach uses solution methods applied by a human and definition of rules and limitations, which such a design – solution should fulfil.

The usability of one of the above mentioned paradigms depends on the conditions, in which the design is created in, precision of the problem definition, level of information we are able to gather about particular object and suitability of one of the application methods for projection. Designers decide for the design paradigm based on this objective information, know-how and the level of their own knowledge and experiences.

Basic algorithm for design can be illustrated as follows:

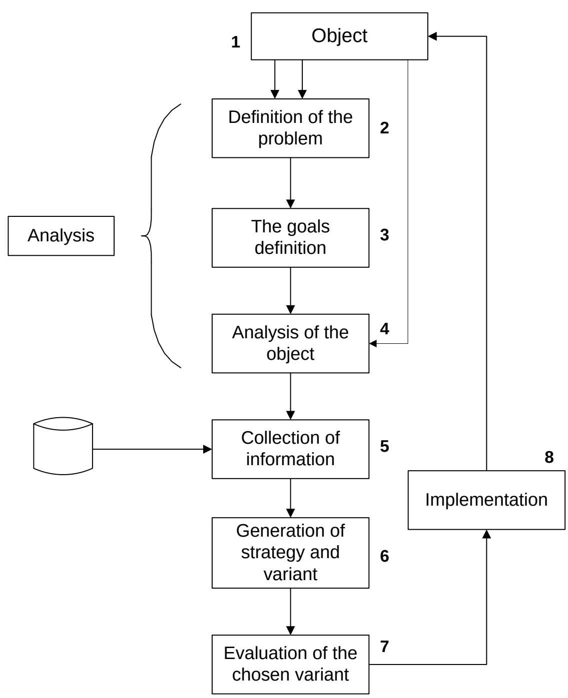


Fig. 27. *Generic design algorithm.*

The paradigms might differ mostly in the phase 6 – generation of solutions. In case we use a model for the preparation of the design (mathematical, graphical, and statistical); based on the analysis, then if we follow all phases of the design, we are talking about model approach.

If we use a technique from a similar analogical situation for a preparation of a design solution and we carry out the analysis in appropriate depth, then we are talking about a case study.

If we use a simulation model for generation, which will imitate the functionality of the forthcoming object or process and we experiment of such a model, then we are talking about the simulation approach.

If we define conditions, criteria and limitations for the forthcoming design in form of rules (heuristics, expert rules, and limitations) and we create a heuristic model base on these rules, then we are talking about heuristic design – projection.

Design requirements express observable – measurable or empirically identified characteristics of the final object. The most important and most common requirements are:

- functionality.
- performance – productivity.
- reliability.
- modifiability in real (optimal), global operation expenses.

Functionality – is ability of the object, process or a system to accomplish particular requested activities of a function. Note. Behaving characterizes a development – a global function of the whole system, process in time.

Performance – productivity, expresses how well (efficiently) the object supplies its functions.

Reliability – likelihood to perform requested functions and behaving (with requested quality of the performance) within particular period.

Modifiability (adaptability) – is an ability to adapt to changing conditions. It fully supports the evolution of design process, sequential changes and improvements of the initial design.

Non-measurable requirements belong to the category of the incomplete, ambiguously defined requirements. Such defined task belongs to the incorrectly structured tasks. There is a tendency to transform them into measurable requirements. This kind of process is called extraction [2] of requirements. Extraction is performed by further study and decomposition into elementary processes at lower hierarchical level.

3.1.2 Relation Between Design, Decision Making and Projection

Decision making is a process of sequential application of criteria to a group of possible versions of a solution.

If we know all possible versions of a solution, then we are talking about a complete decision making, respectively about a properly structured problem. In case that not all solutions are known, or the problem is not completely defined, then we talk about incorrectly structured problem.

From evaluation analysis we can see that the decision making has a similar structure as the process of design. In addition parts 5, 6, 7in design algorithm (Fig. 27) is actually decision. The difference is in the duration. Evaluation of several versions in design is moved for duration of an iteration cycle Δt; while in decision making we review all existing versions in time t.

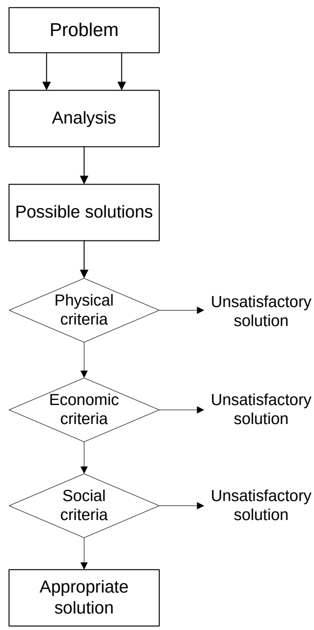


Fig. 28. *Generic algorithm of decision making.*

Decision making in design is mostly related to complex situation. Traditional methods of decision are based on classical model of full rationality. It means that they are exact knowledge about the solution present. However, this assumption is almost never fulfilled. In case of a non-complete task it means meaning:

- not all alternatives are knows.
- it is not possible to find an optimal solution with known conditions.
- there is not enough time for solution and there are not sufficient resources available.

In those cases, multi-criteria methods for decision making and heuristic methods are used. These methods provide suitable solutions. Design is, however, a far more wide process than decision. Decision making is one of the basic processes of design.

The design is wider for its technical side – projection. Under this term we understand:

- preparation of a conceptual design.
- its examination from functional, technical, economical, security, ecological point of view. This examination is carried out by scientific consortium.
- preparation of a technical project.
- its examination from the future user, investor point of view.
- preparation of the realization – implementation project.
- ultimate objection of the project.
- operative, ultimate and user guide book.
- realization of the project (expert and engineering control).

It is possible to return to the previous step after each objection and examination. This serves the needs of adding information, improving the project documentation before further detail elaboration of the design. This technical side of design is called projection. This part of the design process is a component of a synthesis. These detailed steps and project documentation are used in all other important and large projects. In most cases this "four steps documentation" is reduced into two steps:

- Conceptual design + technical project (Preliminary study).
- Executive, implementation project + operative hand book (Operative project).

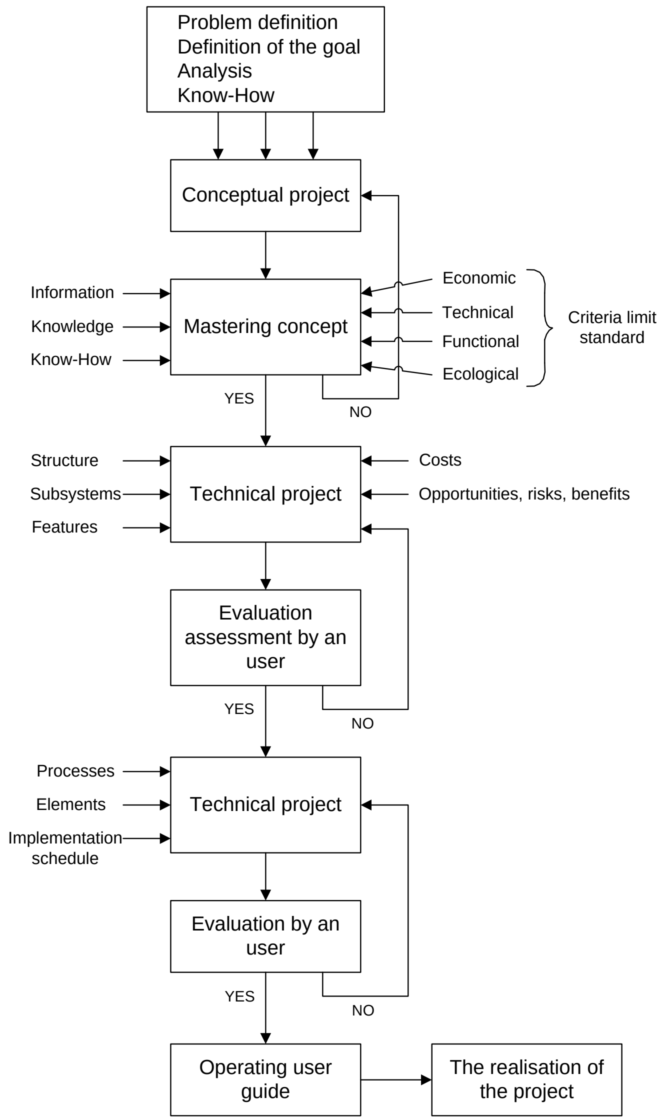


Fig. 29. *Technical side of the design realization – projection.*

In such simplified projection process there is always a danger that:

- designers will understand something else under certain terms and proposals than the consumer.

- some activities and relations not precisely described on conceptual level will be to underestimate.
- the volume of work, project expenses and realization expenses will not be evaluation properly.
- there are no sufficient analytical, information and knowledge records available for the preparation of the executive project.

On the other side, this kind of proceeding accelerates the overall time of the projection and project realization.

3.1.3 Design Classifying

Projects, projection are one of the basic characteristics of the society's evolution at the end of 20th century and the beginning of the 21st century. Projection, preparation of projects and their management is one of the basic factors for success of a human being, firm, institution. We can even talk about "project-mania", because none other activity could go without a project.

What is a project?

Project is a planned and organized allocation of resources focused on fulfilment of particular aims [9].

A project consists of aims, tasks, activities and terms from the formal side. Tasks and activities are work units in between particular terms. Project has a creative and technical-managerial side.

Creative side of a project defines and describes how such a logistical system will function, fulfil the aims and behaving, how particular activities will be carried out, how the parameters will be managed, what organizational structure such a logistical system will have, how individual parts of the systems will be coordinated, what priorities and methods of optimization will be applied, how the gathering of data, control and feedback will be provided, etc.

Technical – managerial side of the project solves the problem of the functions, structure of the solving team, composition of the project into phases, technique of work verification (control days, objections), project documentation, time schedule, realization technique, delivery of the project, etc.

Projects can be divided based on the *cognition* – novelty – originality they include into following categories:

- Creative project.
- Innovation project.
- Routine project.

Each type of a design has its own specification and initial conditions.

In creative project – extent of the solution, transformation processes and solution methods are mostly unknown. We know the aim, respectively the future behaving or requested functions. The key element is the *transition from subconscious to conscious approach.* Creative design generates qualitatively new structure, new system from new or known elements of sub-systems. Creative design includes novelty and originality. Preparation of the creative design is a spontaneous, uncertain, chaotic, iterative and creative process.

Innovation project is a final product, which doesn't change the structure of the system, object or process but changes its functions and behaving in order to achieve altered aims. Modification, redesign is needed because:

- initial product didn't fulfil some of the basic, initial requirements (aging, depreciation) due to the changes of endogenous parameters.
- the initial environment and conditions have changed – new conditions were created.

Routine project – final shape of the product, actuating conditions are known in advance. The designer repeats the design realized for different purpose and based on analogy and similarity applies the already realized project (several times with small modifications, for adaptation for concrete conditions of the customer).

Based on the level of formalization – project, we divide projects into:

(a) *Formalized project*, expressed in form of mathematical models and mathematical-logistical concept, programs and algorithms.

(b) *Quasi-formal design* – its essential parts are expresses in form of graphs, schemas, block schemas, data flow diagrams and tables. This approach is used when we are not able to model the problem mathematically; respectively it is not necessary to describe the information, functions, processes and relations between them mathematically – but symbolically.

(c) *Non-formal design* – essential parts and relations are described verbally.

(d) *Combined design* – uses all previous approaches. Combined approach is mostly used among formally expressed designs.

Based on the subtlety of the product description and purpose of us as previously shown, projects can be divided:

(a) Conceptual design (Preliminary study, Hypothetic purpose, Capital purpose).

(b) Technical project

(c) Executive project (realized, implementation project).

(d) Operational project (Used guide book, service instructions, operational documentation).

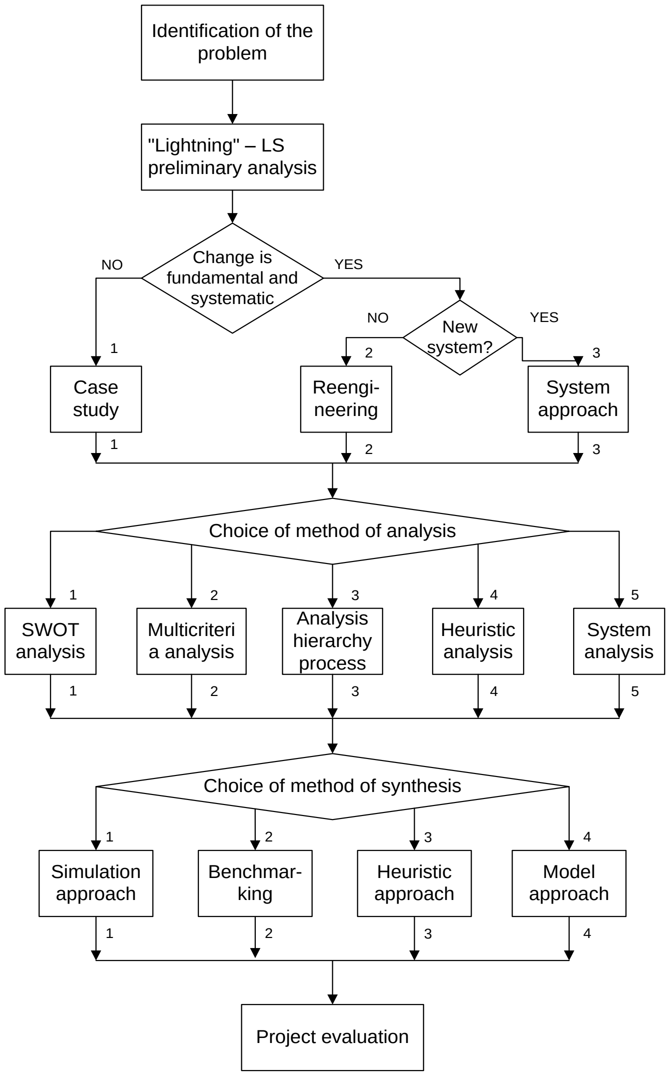


Fig. 30. *Selection of paradigm, analysis and synthesis of the design.*

3.2 Phases and Steps of Design Process

As we have described in the presented in the algorithm "technical side of project realization" design process can be divided into following phases and steps:

A. Project Identification:

- A1 - Problem definition, current state.
- A2 - Definition of aims.
- A3 - Solution strategy of the project.
- A4 - Forming of solution team.

B. Selection of paradigm of design process:

- B1- "Flash" system analysis.
- B2 - Paradigm selection (method) of design.
- B3 - Case study.
- B4 - Model approach.
- B5 - Re-engineering.

C. System analysis:

- C1 - Gathering of data, information and object description.
- C2 - Selection of the analysis method.
- C3 - Realization of analysis based on selected method.
- C4 - Summary of the analysis.

D. Synthesis of the logistical system:

- D1 - Selection of the synthesis method.
- D2 - Conceptual design of the system.
- D3 - Design of the functions, processes, models, databases.
- D4 - Processing of project documentation.
- D5 - Conceptual design verification.
- D6 - Processing of the operational-realization project, program, design of technical realization, processing of user documentation.

E. Project evaluation:

- E1 - Project submission.
- E2 - Evaluation of the aim fulfillment, transformation of the system, behaving of the system.
- E3 - Evaluation of particular functions, processes.
- E4 - Verification, testing operation.
- E5 - Economical, qualitative, environmental evaluation of project contribution.

3.2.1 Project Identification

Definition of the Problem, Project Tasks and Aims

Globalization of world markets, new methods of communication, new methods of modelling and management force companies to minimize the expenses, constantly sustain its competitive position on the free market. Last 10 years of 20th century and first years of the new century are typical for so called “logistical economy”. Companies achieved the economical efficiency by a complex view on material, information and financial flows with their own contribution by their organization, management and coordination – by logistics.

A company can define a problem willing to be solved in the area of logistics in three cases:

(a) A new company is being created; respectively a company is re-structured in to other organizational, business or manufacturing structure.

(b) Management is aware of the position on the market and sees the gaps in the company' logistics.

(c) Company is getting into a crisis and seeks for increase of the efficiency and productivity, wants to minimize the expenses. The outer conditions force the company to deal with its management system and also with the logistics.

It is always better when the problem and tasks are defined by the inner conditions and by the awareness of the owner and management than when the company is forced by outer pressure and existing conditions on market.

If the problem and aims are defined consciously, beforehand, there is enough time for the solution and mostly also enough financial and human resources. There is a space for the preparation of the project time schedule, selection and creation of solution team, time for solution, verification of the application and final evaluation.

When management looks for the improvement of company's functioning, it *defines aims globally:*

(a) Increase of manufacturing productivity.

(b) Increase of product and service efficiency or other activities provided by the company.

(c) Decrease of expenses.

The solution is carried out in three levels:

(a) Technological processes.

(b) Logistical, organizational processes.

(c) Economical processes.

To be able to change the technological processes (changing technology) always requires investment and high expenses. Here gains are achieved the most difficult and expensive way. Changes in the economy are related to the position of the company on the market, but also to the relations with the consumers, suppliers and customers.

The one shift are the logistical processes – logistical system with its organization, coordination, sequence, time and capacity management, changes in manufacturing strategy, planning, operative management and set-up of processes (with its management and organization changes) is capable to achieve relatively high savings of the expenses.

The first area with applied automation and management was the area of technological processes.

Automation of the information systems and economical processes has been carried out in the 80's and 90's of the last century. The automation was carried out in systems where it was possible to create type system (e.g. SAP). For automation of economical activities, which base on easy algorithms, are simply automated. It is not necessary to create new models, algorithm and programs separately for each company, because these systems are the same.

The solution at that time was increase the efficiency of logistical processes, creation of new effective organizational structures, manufacturing processes, what in the end effect meant realization of logistical approaches and methods.

Efficiency is achieved mostly by fulfilling the sub-aims:

- Efficient selection of the suppliers.
- Application of the program of order logistics.
- Balancing the manufacturing process, application of the theory of narrow place.
- Finding equilibrium point of the PULL and PUSH system (SYNCHRO-MRP).
- Optimization of the inter-operational, incoming and outgoing storehouses with finished products.
- Harmonization of the organization structure with the organization of the manufacturing processes and services.
- Flexibility of the production process towards consumers – customers.
- System objectification towards planning and its line up line up to the order management, etc.

Selection of the Solution Strategy and Formatting of the Solution Team

Project design for logistical system can be solved by two approaches:

- on the order.
- the cooperation approach.

Order approach is such a strategy, when preparation of the design and project is ordered from other projection-consultant company. This approach is also called "key design" – tailored made. A company names the workers responsible for the realization of the project and communication with the solution company.

One of the disadvantages is that the solution is bought as a "black-box", when all other additional changes require the same author's company (from which we ordered the solution). It is an expensive approach with a permanent dependency on the supplying company.

The cooperation approach operation is defined by a creation of a common solution team consisting of the solution company and from the experts company itself. The composition is of a great importance for its solution as well as for the future application:

- It is very effective if the top management is also involved in the solution. Top management knows the best what they want from their own company and where are the problem areas. Their involvement improves the communication with the subordinate workers.

- It is also very important that the managers of logistics, planning, operative management, maintenance, procurement and marketing are also members of the solution team. They know the processes and their functions in detail and mostly in the analytical and evaluation part of the design, these persons are irretrievable.

- The leader of the team should be a creative person (outside of the company) who is capable creatively generate and review ideas and solutions with sufficient theoretical background and experiences in projection of logistic systems.

- Wide-spectral team of workers (university, research institutions, consulting companies) from economic, technical, logistical, information, mathematical, etc. background is also of a great importance for the future success of the project.

Design – project – solution carried out by such a team is easily applicable because it has been done by a person from inside of the company and so it is considered as "their own", they have their piece of involvement in it and possibly can be directly financially involved in the solution and realization.

When to define project aims? The rule holds good:

- At the beginning it is important to define global project aims.
- After analysis it is needed to define partial aims and ways of achievement.

At the beginning of the solution we are mostly not able to determine by what such benefits will be achieved. This is possible after a detail analysis of individual processes, finance, relations and structures, meaning after the data gathering and analysis.

When the project and aims are defined and the company crisis is also determined, then a rule is applied:

"Change those processes, where it is possible to achieve maximal benefits with the minimal expenses in the shortest time".

Projects and company's development design are supposed to be defined when the company is still successful, where resources are available. This moment is mostly forgotten by the management.

Projects for increase of efficiency, innovation and re-engineering should be a continuous part of a successful company. Based on the dynamics of the external changes, the modification and adaptation of company's activities and processes should be supported by continuous internal changes – by company's development.

3.2.2 Selection of Design Paradigm

Flash System Analysis

If a company has a global problem:

- it is not fulfilling the order dates.
- has a non-sufficient cash-flow.
- it stagnates in the long term.
- is in negative economic values.
- is in bankrupt, etc.

And such a company has decided for “order or cooperative” problem solution approach in area of logistics, the solution team carries out a flash analysis. This enables them to define the tasks, activities, select the strategy – design paradigm, define the project price and prepare the contract for project preparation. In most cases, it is necessary to solve the problem right away. Flash analysis shortens the time for the preparation steps for the confidence building between the company’s workers and external workers. Such an analysis was applied in many Slovak and Finland companies e.g. Siderit s.r.o. Nižná Slaná, Chemosvit a.s. Svit, SEZ a.s. Krompachy, Tatravagónka a.s. Poprad, Casspos a.s. Košice, etc.

Flash analysis consists of following activities:

A. One-day “analytical workshop” of flash analysis.

Before one-day workshop it is important for the solution team member to study at last the minimal documentation of the company - annual report from the last year, technical and production techniques, etc.

What is the role of the initial workshop of flash analysis?

1. Initial meeting of the solution team with the strategic management, production managers, heads of departments

   - logistics and planning.
   - purchase and procurement.
   - sales and distribution (transport).
   - (lead president and the leader of the solution team).

2. Presentation of the company, its problems and expectations from the project solutions.

3. Excursion through the production processes from the incoming warehouses in direction of the material flow till the outgoing warehouses.

4. Interview in order of the professions; company's experts and solution team; gathering of new documents, forms and techniques, etc.

B. Brainstorming of the solution team

After the initial workshop it is important to give the solution team at least 1 week time for studying of the gathered documents and for the initial generation of the ideas. Longer period of time is not recommended due to the possibility of forgetting all details, losing the contact with the overall situation. Next step is the preparation for the first official meeting of the solution team where each member will present his/her proposals for company's problem solving.

- Which problems they see in their solution area.
- Which problems have priority and which are dominant for solving the global problem.
- They define tasks necessary to be solved.

Particular problems, tasks, ideas will be evaluated, duplicity will be avoid and non-important issues will be eliminated.

Tasks will be divided based on their significance (strategic, operative), based on time table, financial expenses and solvability – know-how. This will make sure that the solution team will be able to solve those problems.

The lead of the solution team prepares “the first proposal for solution content” and delivers it to the worker responsible for the project solution in the company.

The company considers this proposal within 1 – 2 weeks and prepare for the *2nd workshop “stock-exchange of thoughts”* (with the same participants as at the 1st workshop). Here:

- solution proposals from the solution team will be presented.
- proposals from the company will be presented.
- solution priority from the company point of view will be defined.
- deadlines for particular tasks will be proposed.

Based on the defined tasks, terms and priorities, it is possible to see the scale of the problem area. It means that is it visible whether the total change of the logistic system is necessary or the only solution of some individual separate problems would be sufficient. The outcome of the 2nd workshop is the selection of the design paradigm.

Decision About the Paradigm of the Design Process

Next steps for the design process, methods, forms, tools, expenses, etc. depend on the selection of the paradigm (Fig. 30). It is possible to select the design paradigm based on the current analysis and project aims:

(a) Case study.

(b) Re-engineering.

(c) Systematic (model) approach.

The order is given by the multitude, volume and quality of the solution.

A. We choose the *case study*, if we are talking about the solution of a separate case, which does not have a definitive impact on the other logistical activities and significantly does not interfere the whole logistic system. E.g. if a problem is to find an optimal distribution path of goods ordered for customers for summer season; this is a one-shot solution prepared and realized fast.

B. Re-engineering method is applied when we are talking about radical change of the logistical system, which interfere with several functional areas of the company. E.g. if it is needed:

- To find an optimal composition of product selection and find a sequence of its production.
- It is needed to decide whether SINCRO- MRP wouldn't be better for the system than the PULL system.
- Flexibility of order observation is not sufficient, it is necessary to decide about the structure of planning system.
- Current criteria of order cumulation don't reflect the new situation in the energy prices, etc.

But we are still talking about a large main system change.

C. Model, system approach is chosen in case of a new proposal for new logistic system for an enlarged company, for an area which was not taken into consideration so far. There is enough time and financial resources for such a change. E.g. a company enlarges its production with some new range of goods for a new market. It is important to design logistical system for a new division, new procurement system, system of production processes management, distribution system, etc. and connect such a system to the existing logistical system of the company.

This is a change in the structure of the logistical system, systemic change.

The selection of the paradigm will influence the whole further design process and project preparation.

E.g. in case we will select a system approach design, we have to take into consideration the system analysis, respectively method of multi-criteria evaluation (but almost never a SWOT analysis, or heuristic analysis). For the synthesis is typical model approach.

Other way around, if we choose “case study”, then we apply SWOT analysis or method of hierarchical processes focusing on the problem area (but not the system analysis) and for the synthesis we will choose the heuristic approach or benchmarking but not the model approach.

a) Case Study

Current literature focusing on case studies is very “poor”. As much as this strategy is used in projection and research, it is forgetting about contribution to its theoretical and methodological background.

Case study focuses on research and projection of a concrete case and its pragmatic solution provision, not theoretical solution. That is why it is possible to consider this approach for an *empirical approach to a synthesis* of a logistical system.

	Theoretical	Empirical
Describing analytic (How things are like)	Conceptual analytic approach	Monotheistic approach
Normative (How things cold be like)	Methodological approach	Constructive approach

Projection methods can be analytically divided :

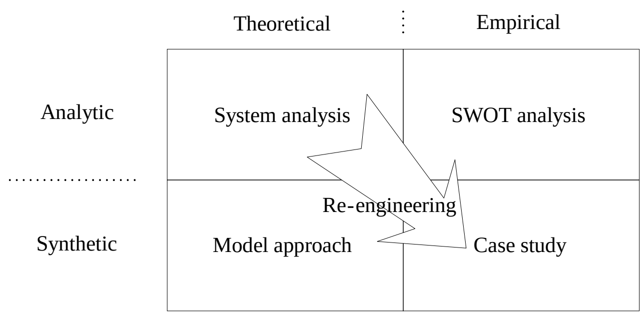


Fig. 31. *Methods classification of analysis and synthesis.*

Case study is more a method of application research than a basic research. *One unique solution* of particular case creates the result of this approach. The result is a concrete project of solution application, not a theoretical knowledge, principle or method.

Case study bases on analogy. We are looking for a solution by comparing details (case, situation) of another solution for other similar case. If such a gauge is found, we use it and adjust it to the specific conditions of our case. Analogy in this case is a theoretical principle of case studies.

There are two situations when cases are analogical:

- If they have the same structure.
- If they have same characteristics of their elements.

Situations S_1 a S_2:

$$S_1\ (t_1, \alpha_1) < \varnothing >n\ (S_{11}\ (t_1, \alpha_{11}), S_{12}\ (t_1, \alpha_{12})\ \ldots),$$

$$S_2\ (t_2, \alpha_2) < \varnothing >n\ (S_{21}\ (t_2, \alpha_{21}), S_{22}\ (t, \alpha_{22})\ \ldots)$$

are analogical when operator of system relations $\varnothing$ (the same structure) are the same and also the characteristics of the elements α_1, α_2, α_{11}, α_{12}, α_{21}, α_{22} are the same [4].

Compared to the heuristic approach, case study differs in the definition of rules for solution. Heuristic approach uses the same analogy for such definition of rules and based on them indicates valid rules (rules of heuristic).

Case study bases on a similar approach as "benchmarking": There is always a risk of stability and validity of such a solution due to conclusion making based on one or several cases. The results of such solution might be less trustworthy. Other risks evolves from the non-systematic of such solution, meaning it cannot be included into the system (e.g. company management – when problems from non-comprehension of relations and impacts on other functions and processes might occur).

On the other side, based on the concluded volume of problem, it is possible to analyze it into the depth and find available and acceptable solution.

Case study belongs to "approximate methods" of design. From the project type point of view, case study provides an innovative, respectively repetitive proposal for solution.

Methodology and algorithm of case study solution case be divided into following items:

- Problem and goal definition.

- Fast analysis, e.g. SWOT analysis or docile analysis of particular problem.
- Searching for gauge (etalon) of a similar case.
- Gauge adjustment and specification design (theory of analogy).
- Application and realization.
- Evaluation of goal achievements.

In case study solving several steps might merge, overlap, they formally don't differ etc.

In some cases, the result of case study can be a generic theoretical conclusion, a model, algorithm or sequences of steps, which might be applied to a wider group of similar problems. This happens when more similar case studies are solved, e.g. when designing a distribution network.

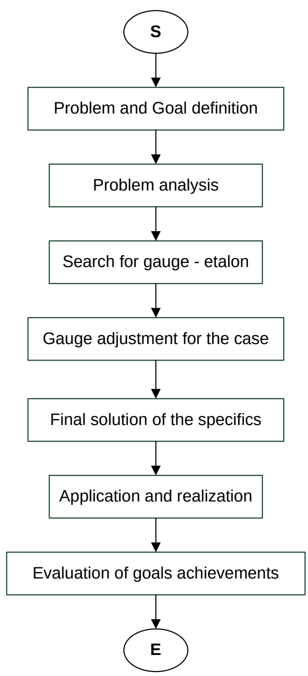


Fig. 32. *Algorithm of solution steps for case studies.*

b) System – Model Approach

Model approach belongs to theoretical, scientific and normative approaches or strategy of design.

In this book we perceive a logistic system as a system of functions – tasks. The object of analysis and synthesis is in that case a mainly management logistic system. That is why the focus will be given to material, information and financial flows, their management and realization. Model approach has gained its name based on three view points:

A) *From global structure of design steps* – meaning that we apply a model problem → goals → analysis → synthesis → realization (simulation) → evaluation; it uses the whole systemic projection technique.

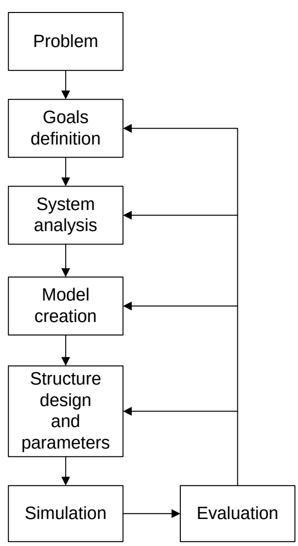


Fig. 33. *Model approach steps.*

B) *From inner view point* – whole design is bases on model creation of observed – projected system or process. The solution is searched with the help of model, e.g.

analytical, simulation, heuristic, statistical, information. The optimal or suitable solution is found on the model and that solution is then applied to the real system.

C) *From cybernetic point of view* – logistic systems are stochastic systems with big inertia and long time reaction to managing decision. That is why a forwards control system is used. It bases on an existence of a model, actively used in managing actions in real time.

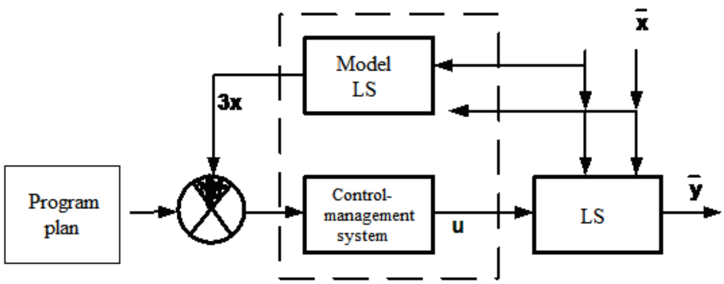


Fig. 34. *Forward control system.*

Model approach is applied in new system design or in case of a major change and reconstruction of the system, when its structure is modified. Due to these reasons, the synthesis of logistic system focuses on

- Design of logistic system structure.
- Design of functions.
- Design of processes, where inputs, output, outer relations are defined.

Model approach is time consuming because system analysis is most used. System is decomposed according to pre-defined view points, so the analysis tasks are divided and simplified. It is essential for creation of logistic system model to find necessary dependencies, regularities, create the model and prove its validity. Iteration process is applied, where aims are preferred, analysis is conducted and model is finalized. In some cases it is necessary to create the model also in algorithmic or program version. In this case, it is required to be skilled in one of the modelling tools usage, e.g. simulation. Matlab, etc. these requirements demand additional capacities, time and expenses. At the end, model is provided in formal respectively mathematical presentation.

All phases are precisely finalized to avoid additional work on non-correct performed previous phase. Last phase is also time-consuming. It requires evaluation and defend objection from external experts.

These sequences of steps – or by other words this paradigm is used for creative and innovative projects. The result is presented in form of a method, technique, algorithm, master project, etc. Their result contributes to theory and at the final stage to the realization in real-life conditions.

An emphasis is given to written documentation of such solution and to formal and documented presentation of project results (systemic analysis, preliminary study, technical project, executive project, operating instructions and guides).

c) Re-engineering

Re-engineering is a design paradigm enabling and using model approach in cases, where all business processes – technological, logistical, economical, etc. are about to be analyzed in their whole scale. Then those processes are selected which with the smallest expenses bring the biggest profit (SWOT analysis features) and usually it is needed to pragmatically realize them (case study) in shortest time possible. Re-engineering method uses advantages of all basic projection principles (Fig. 31).

Second characteristic feature of re-engineering is, that logistic system design is carried out in already existing company, which has “some logistic system”. It is possible that all other possibilities for new solution have been used by sequential innovative tasks (kaizen, evolution approach) and it is needed to change some of the processes radically. But a radical change does not mean a systemic change. It doesn't design a completely new system because a solution must be applied during operation and several times while critical status of a company.

That is why re-engineering project is a *radical innovative project*.

Re-engineering is one of the methods that ensure the competitiveness of a company and which solves the problem of attrition of possibilities for effectiveness and rationalization of micro-processes. Re-engineering can be applied in 3 levels:

(a) technological.

(b) logistical.

(c) economic.

Re-engineering can be focused on:

- saving company's expenses.
- increase of production quality, respectively quality of operated activities.
- security of production process.
- environmental aspects of production.

Re-engineering re-values the basis of individual processes, investigates their quantitative and qualitative features and at the same time focuses on validity of their execution in relation to global criterion. If particular process doesn't add any added value to the product, if it doesn't improve services oriented to customers, doesn't improve the position of company on the market or if it doesn't influence the product quality, it is necessary to start thinking about the reason of such process's existence. Current conditions of entrepreneur's praxis and ambition to remain competitive lead to such, "hard optimization".

It is not possible to apply re-engineering without knowledge on impact from design radical changes on existing business but mostly production-technological processes. For getting the whole picture of the possible impacts of re-engineering actions, an existence of suitable tool (multi-criteria optimization method, simulation optimization model, etc.) is required.

Kovac M. [36, 39] defined re-engineering as "the basic and dramatic change" in the way of thinking and radical re-build of business process, which aim is to achieve a significant improvement of current critical parameters of performance like expenses, quality, security, speed and services.

This approach bases on assumption that even continuous improvement is not sufficient after a while to satisfy the market needs. Companies willing to be successful need to achieve a big improvement in performances to be able to compete with their competitors. Re-engineering comprises massive improvements rather than small steps of sequential and continuous growth.

Re-engineering is asking these questions: *Why do it, what we do, does it have to be like that and whether we have to do it?* It is not getting satisfied with improvements or partial changes of business activities but it thinks complexly. That way it differs from lasting process of improvement.

In re-engineering, all currently operating processes are critically viewed, newly structured and re-build. It is determined how such process should look like so it satisfied requirements of the customers and the market and not considering the currently valid organizational structure. Processes, not the organizational units are in the middle of the attention. Re-engineering doesn't focus on changes within individual parts but views the company as one big entity.

A radically changed process doesn't have any specific valid feature but it is important to follow these principles and employ following factor:

- definition of clear company vision, strategic approach and reasoning.
- enterprising and business processes are managed by customers.
- interest and active support of top management and company's owners.
- current usability of advantages of centralization and decentralization.
- creative employment of information technologies for achieving new goals.
- processes approach instead of functional.
- integration and gathering of operating tasks, reduction of general expenses.
- change of process order, their parallelism and synchronization.
- restriction of non-value addition tasks, e.g. control, supervision, adjustment.
- conveyance of tasks and processes behind the borders of units or even companies (outsourcing).

Re-engineering means getting rid of established techniques and taking a look at processes through different view. Re-engineering is a tool needed to help and assist in conditions where wide improvement is necessary. On the other hand, it doesn't replace the concept of continuous improvement. If a process is been re-engineered and this process has a feature of a project, it is important to apply techniques of continuous improvement to prevent its regression.

Reasons for Application of Re-engineering in a Company.

A project of re-engineering is applied by companies, who:

- have big problems and have almost no chance to survive,

- have not these problems yet, but their management is aware of a fact that such situation can raise any time soon,
- are on the top of their performance and have an ambitious and aggressive management. Companies in this category consider re-engineering for stabilization tool for their competitiveness.

A company is ready for applying re-engineering, if any of following problems occur:

- The key to success are new product, the competition is better in launching them on market.
- A company employs significantly more people for the same tasks as their competitors.
- It is necessary to decrease the expenses due to the prices set by the market. Due to that, a company is not capable to create any profit.
- A company has a high number of defective works. It s has problems to sustain the quality when production volume dramatically rises or slides.
- It is important to significantly increase the productivity with more several tens of percents to ensure the company's sustainability.
- A company has problems with delivery delays of products. Customers require shorted delivery dates and company cannot see any other reserves for speeding up the delivery realization.
- A company produces a product which doesn't fulfil the customers' requirements. Basic requirements for product and service quality and price are not met.

- Company’s share on market is decreasing.
- A company wants to penetrate global economy, e.g. export to new markets or to get to international business networks.
- Governmental regulation arrangements and legislation force the company to perform visible changes in the area of environment.
- Changes on market threaten the company’s survival on market.
- A company plans to implement a new information system or significantly modify the existing one, hoping for bringing additional benefits and competitive advantage.

Re-engineering Team.

Re-engineering team is formed by people who practically re-form the company. Members of the team must be aware of the fact that they will make mistakes and that they should learn from them. People not capable to work this way don’t belong to the team.

A team should consist of people from several areas: technology, engineering, logistics, economy, consultant, human resource management, information, etc.

Separate Phases of Re-engineering Process.

Re-engineering strategies:

- customer oriented.
- cooperative.
- combined.

Although there is none standard methodology for carrying out process of re-engineering, it might be helpful to define the process of change invocation. It is essential to understand that implementation is much harder than development of the solution. Re-engineering means dramatic change. At the same time, it generates an intensive *resistance to any changes*.

Only precisely prepared project in the early stages can help to prevent the feeling of resistance. This way, implementation is made easier. Prediction and readiness at the beginning and by using principles of “change management” (like good communication, concern, motivation) and good coordination can enormously advance the chances for easier and successful implementation.

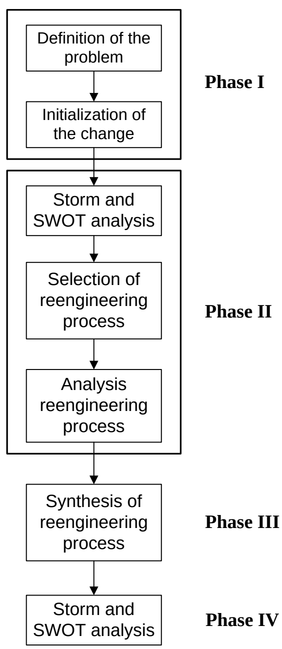


Fig. 35. *Sequences of step for re-engineering application.*

Based on above-mentioned knowledge from preliminary studies about re-engineering, following methodology, respectively techniques of re-engineering process have been specified:

Re-engineering process consists of following phases [17] [18] [19]:

- Phase I. Change initialization – understanding of the need for change.
- Phase II. Identification of defections on existing process.
- Phase III. Process innovation.
- Phase IV. Change implementation.

Phase I. Change Initialization – Understanding of the Need for Change.

This phase determines why a company should change and what it wants to become.

This phase has following stages:

(a) Determination of reasons for the necessity of such change.

(b) Definition of strategic aims and requirements on the change.

(c) Creation of a map of existing business processes.

(d) Selection of suitable processes for change and preparation of the process owners.

(e) Organizational assurance of the re-engineering project.

Phase II. Identification of Defections on Existing Process.

It is important to understand what the existing process does and why it has been design that way. This information is then compared with the company's aims what creates the basis for process evaluation.

These stages are required:

(a) Analysis of outer company environment.

(b) Understanding of customers' needs.

(c) Analysis of internal company environment.

(d) Definition of key process components.

(e) Identification of weak places of the current model.

(f) Definition of conceptual goals and request for change.

Phase III. Process Innovation.

Process innovation means creation of a new idea and style about organization and performance of the task, so that the goals and needs are fulfilled. It requires input information from key persons while creation of the new idea. This way the chances for successful transformation into new stage will be assured.

The following stages need to be performed:

(a) Identification of potential innovations.

(b) Development of initial idea of a new process.

(c) Identification of incremental improvements.

(d) Development of final ideal of a new process.

(e) Definition of resources for change performance.

(f) Acceptance of change impulse.

Phase IV. Change implementation.

Change implementation incorporates the development of strategy and new business plans for the transformation into new process idea. It is necessary to manage the natural resistance to change at all levels.

Critical stages include:

(a) Creation of transformation plan for change.

(b) Definition of roles for managing changes in team.

(c) Beginning with the transformation “change” management.

(d) Prototype and test of initial application.

(e) Finalizing of the transformation into the new process.

(f) Change evaluation.

(g) Continuous improvements of the process.

Creation of a New Project of Re-engineered Process.

It is advised to follow these steps while creating new project of a process to be re-engineered:

1. What Should be Achieved?

It is difficult to define the project aims and determine frame strategy leading to their achievement, if following questions are not answered:

- Why is it important to achieve exactly this aim?
- Why the change should be carried out exactly by this team?
- Why should exactly these steps and methods used?
- Why the tasks should be performed exactly in this order?

It might be needed to re-evaluate determined aims and project strategy. New information, changes in competitive environment or business priorities can contribute to modification of initial aims. Not clear and not sufficiently determined aims and strategy can lead to inefficient usage of resources, non-effective project behaviour and overall project elongation.

2. What should be done?

Relatively simple project have only couple of bigger tasks. On the other hand, large project consist of large amount of differently scaled tasks.

Identification of the tasks enables to form a list of tasks and order them based on their dependencies. It is necessary to determine, which key tasks demand realization of other project as their prerequisites.

3. Who should realize the project and who is responsible for what?

When company decides about re-engineering of company's processes, the priority is to create a division of responsibilities and state who will perform re-engineering and who will be responsible for which part. That is essential for the creation of re-engineering team.

4. When are particular parts carried out?

Tasks are logically ordered based on their relations. Tasks are also evaluated from the time point of view needed for realization. For these purposes, a time table of re-engineering project is prepared.

5. What do resources and expenses need?

It is required to prepare a budget for a re-engineering project. When demand for human resources is present, it is important to focus on the precise consistence including their skills and knowledge.

6. How to control project tasks?

It is needed to determine how often and how project tasks will be controlled.

Examples of control:

- by comparison of real expenses with those stated in the budget and by following the cash flow.
- following the changes of incoming project conditions and determining their impacts on project tasks.
- by evaluating the quality of work performed.
- by evaluating assumptions for meeting the finalizing dates.

7. Risks

Each project is to some extend a risk matter. Performed project is characterized by its uniqueness and singularity. Success of a project is influenced by numerous forces (internal, external) and it is necessary to prevent them, so they do not interfere a successful realization of a re-engineering project.

3.3 Analysis of Logistic Systems

The main target of logistic system analyse is to collect and gathering of information and data realised analyse by selected method, for decision making or design logistic system.

3.3.1 Gathering of Information, Data and Evidence about an Object, Respectively a Process (C1)

Methods for Information Gathering

a) Study of company’s materials:

- From Internet, promotion materials.
- From company’s documentation.

b) *Managed interview* – it is performed into a pre-defined form. The result is an algorithm, a sequence of steps for carrying out tasks, description of inputs and outputs, time, capacitive and personnel intensity, frequency and execution times, synchronisation, succession, outcomes, changes, problems.

Realization of this method differs based on the selected type. In case of customer oriented approach (key delivery), provision of information evolving from worker involvement starts to get problematic. On the other hand in case of cooperative approach, company workers are members of the solving team and participate on the solution creation, results. It is needed to realize that each solution requires time, concentration and for company workers it means additional tasks.

Managed interview should follow the study company documents, company's excursion so the analyst was informed. Analyst knows theory, methodology but the workers know exact problems, information and data about analysed problem of the company. *"A positive approach of both groups evolves into synergy. Each of them alone would do almost nothing, but common effort can bring them to a successful end".*

c) *Excursion and brainstorming* are mostly used during problem formulation and during the selection process of problems needed for further analysis. Brainstorming might be used in the analysis of process control, decision making, when particular processes might be viewed differently by the employees, managers and the owners.

Brainstorming serves the needs of a unification and faster problem description.

d) *Questionnaire* is prepared for particular processes. Workers carrying out analytical tasks will answer it. This is a passive approach of an analysis and is mostly used for survey than for an analysis.

e) *Scientific literature study*, *conferences*, *seminars* are suitable for finding of an analytical method but are mostly used in the logistic system synthesis.

f) *Screening and monitoring*, that means data and information collection in real time. It is mostly needed in case of technological – organizational problems, e.g. design of a maintenance system, system of machines and equipment, administration processes operation, dispatch control systems, creation of an order database, etc.

g) *Study and analysis of databases and files of company's information system.* In case a company has a working information system, its databases are a great source for analysis and data gathering about any company processes or products (machine load, range of goods, customers, etc.).

3.3.2 The Method Analysis Selection (C2)

The strategy – paradigm we approach the problem solution is same important within the processes of data collection as during the selection of method for the analysis. Paradigm narrows the variety of possible methods for analysis. *Analysis should provide us with such information that is essential for the design – solution – synthesis.* That is why these following steps are closely related with the goal that should be achieved. These are available methods for analysis:

- SWOT analysis.
- Multi-criterion analysis.
- Analysis of hierarchical progress (AHP).
- Heuristic analysis.
- Systemic analysis.

These methods differ in their rationale. Their main features are:

- *SWOT analysis* describes strength and weaknesses of a company and opportunities and dangerousness for particular problem.

- *Multi-criterion analysis* determines factors influencing solution of a problem, we modify them – evaluate and add their weight to them based on their importance for the solution. These factors can be analyses on one hierarchical level (ratio-index method) or they can be arranged into a *hierarchical level* (AHP method).

- *Heuristic analysis* is defined by a decomposition of the problem based on the principle of elementary information processes. Problem of a situation is divided according rules till a level of its elements, where the problem is easy to be described, quantified. A tree structure is created, a non-complete labyrinth of system elements based on heuristics, experts' rules, technological rules and criteria requiring experience, praxis, intuition, knowledge and experts in particular area.

- *Systems analysis understands the object process as the system.*

- *Systemic analysis* bases on problem decomposition. Decomposition is carried out based on several view points:

  - functional (planning, control, realization).
  - objects (production, procurement, distribution).
  - time (year, month, day, etc.).

Due to such decomposition, sub-systems and elements are created. These are analyzed and a system is then described. Each element is viewed from the angle of a process, relation to its environment, behaving in time and space, aim it is fulfilling – from the system approach point of view.

A combination of these methods is commonly used. E.g. first SWOT analysis is used and later on for particular factors, multi-criterion analysis is applied. For each method of analysis, several tools can be used, e.g. mathematical, statistical, information technologies, theory of detail, analogy, benchmarking, etc.

Following characteristics may influence the selection of method for analysis:

(a) *Problem nature*, meaning if a problem is essential, strategic, global or it requires only partial changes, if it is an isolated problem with small impact on company's activities, etc.

(b) *Selection of design paradigm*, which depends on the problem nature.

(c) *Economical situation of the company*, in sense that the solution is systematic, planning, recalled by assumed development of a company or that it is urgent and recalled by the outer factors.

(d) *Based on time* available for the solution.

(e) *Based on capacities and performance of the solving team*.

(f) *Based on solvability*, novelty of the situation and the problem, capability to find suitable solution, etc.

Timely and economical seriousness of individual methods grows exponentially based on their description at the beginning of this chapter. The fastest and easiest is SWOT analysis and the most difficult is the systemic analysis.

Methods for Realisation of Analyse

Systems analysis is the most complicated and the most challenging method for analysis. Systems analysis sees a company or a process to be analyzed as a system. It applies systemic approach. It decompose the problem into separate sub-systems and elements, analyzes them, compares with the theory, looks for regularity and relations for creation of a model of such investigated system.

Systems analysis uses principles of systemic approach, theory of systems and cybernetics. It uses them during solving of complex technical, economical, organizational and similar problems. The knowledge is presented in a form of mathematic modelling, theory of expectation, statistical methods, methods of operative analysis, graph theory and other exact techniques.

Systems analysis is used in creation of projects or designs for a new system (large re-engineering tasks). Systemic analysis investigates existing system in detail, evaluates the operation of its functions, its aiming behaving en bloc as well as its particular parts.

Systemic analysis is carried out in three phases:

1. It verifies the correctness of aims definition, environmental and systemic elements are projected, relations among elements of system and environment are defined and suitable presentation form of a system is selected (matrix of graphical).

2. In the second phase, system structure and its behaving are analyzed. The formulation of real existing relations in analyzed systems, element definition needed by the system and function of these elements enabling the goal achievement are resulting.

3. Possibilities for further improvement of the existing systems are defined in the last phase of systemic analysis.

Logistic system analysis can be understood from two points of views:

a) Analyzed company is a part of a logistic chain (logistic network), meaning it is a part of a higher system (macro-logistic view).

b) Analyzed company is a complex system, which is analyzed into its depth (micro-logistic view).

Ad Point a) In a case of *macro-logistic view*, company and its functions carried out in a higher superior system are analyzed, e.g.:

1. Capacity adjustment to the market requirements (capacity strategy, investment strategy, personal strategy).

2. Position on the product market (production strategy).

3. Examination of manufacturing strategy (flexibility and competency of supplies, PUSH, PULL strategy, order production, warehouse production, etc.).

4. Distribution network structure.

5. Size and allocation of warehouses.

And if following criteria meet these macro-logical factors:

- Company's organization structure.

- Structure of a planning system.

- Selection of suppliers and customers.

- Level of logistic technical equipment (warehouse furnishing, means of transport, packaging techniques, etc.).

- Reversible logistics (waist, return packages, palette, containers, etc.).

- Information system structure and level.

A company is analyzed according to a gauge - macro-logistic model. In this sense the system analysis of logistic system differs in compares to e.g. analysis of economic processes.

Ad Point b) when systemic analysis is applied inside the company, then it's present in a form of a micro-logistic model [10], (simple scheme is on fig 36).

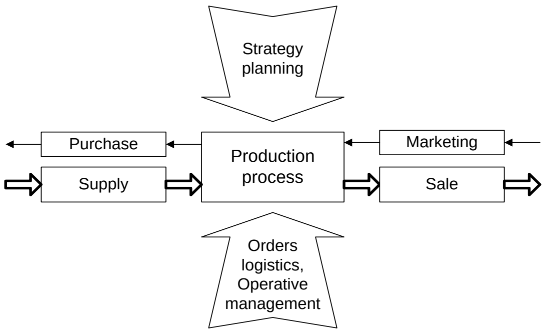


Fig. 36. *Cross micro-logistic mode.*

Analysis is mostly focused on smoothness and joint cohesion for flows: *material* (executed by procurement, manufacturing, inner company transportation and manipulation, selling and distribution), *information flows* (strategic and tactical planning, planning, marketing and advertisement, order and operative control, dispatch control) and *financial flows* (invoicing, accounting, banking services etc.

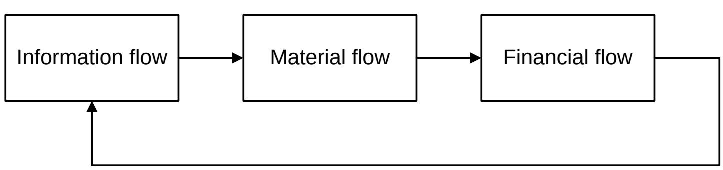


Fig. 37. *Logistic chain of continuing flows.*

Logistic flows are performed by tasks and processes and systemic approach contributes to their joint cohesion and execution according optimal algorithms.

Systems analysis of a micro-logistic system is defined as a system of interconnected tasks and processes, which enables joint transformation of mathematical, information and financial flows (Fig. 37.) executed by particular activities of a company.

System Decomposition.

Vast and complexity of system analysis, investigated system is required to be divided into smaller parts – elements due to following reasons:

- systematic (joint relations and complexity).
- division of labour among experts (during project preparation).
- time and capacity control.

Decomposition means division of a problem into sub-systems, groups of tasks and processes.

System can be divided according to:

- functions (planning, control, management, evidence, monitoring).
- object (purchase, procurement, manufacturing, sales, distribution).
- time (year, month, decade, day, shift, …).
- purpose (minimization of relations).

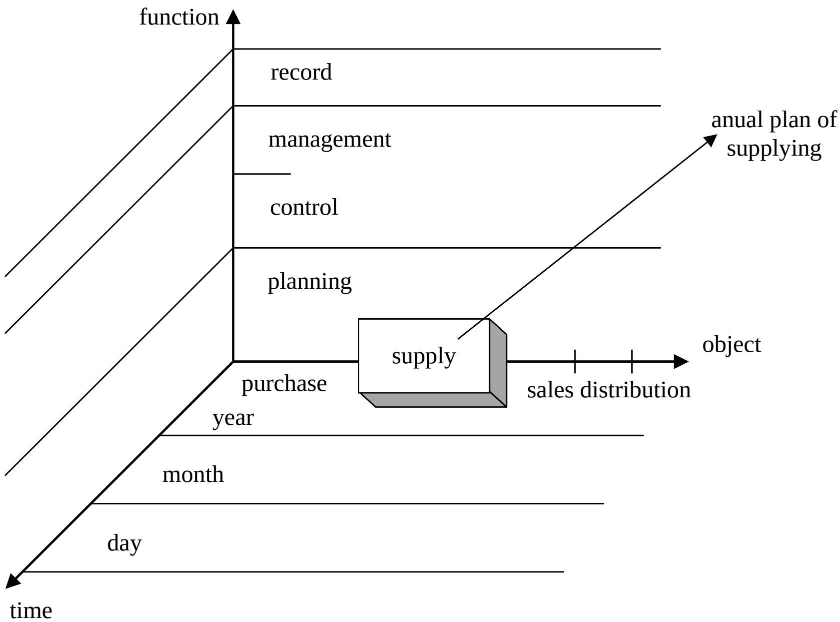


Fig. 38. *Decomposition of company's space.*

Functional, objective (content), timely decompositions belong to the most commonly used types of decompositions. Such decomposition must strictly follow pre-defined rules. E.g. management of product distribution doesn't have to be divided further according to time or annual executive plan is also a plan of manufacturing, purchase, sales, etc.

Decomposition according to its "purpose" is very often applied. Such elements (sub-systems) are created that have strong relations inwards but weak relation outwards. With the decomposition, relatively separately solvable elements are created.

System analysis requires content and time coordination:

a) It is required to create a methodology for gathering relevant information:

- description of particular process activities.

- incoming and outgoing files,
- for algorithms of particular activities.

b) Analysis of the content, sequences of steps, relations, appearance frequency, time, capacity and financial seriousness, coordination and activities synchronization, inputs and outputs are analyzed:

- Time table of analysis is created.
- It is needed to determine the way of coordination and control and creation of external and internal workers.
- It's required to prepare a documentation and verification of conclusions in a form of presentation, workshop, conference, objection, etc. Final presentation of the results should characterize company's current status objectively, selection of processes dispread for change and should provide sufficient amount of information for solution proposal – synthesis.
- And finally it is needed to formalize conclusions and proposals from the analysis.

SWOT Analysis

It is a type of qualitative analysis resulting in knowledge, trend, development as well as quantitative expression in according to other competitive subjects.

Likewise at system analysis, SWOT analysis focuses on either outer position of companies in logistic chains (material, financial, information) or on inner factors, or combined.

The title of this method has its origin in English: Strengths, Weaknesses, Opportunities, and Threats. And seriously, the principle of this method base on determination of strong and weak features in compare to the competition (products, individuals) and of possibilities and chances and risks raising from the environment and strong feature of particular subjects (company, product, …) [79].

SWOT analysis is a method used during appraisal of potential risk in upcoming period. This method can be used for appraisal of company's chances, products, services or personnel.

Sequences of Steps for SWOT Analysis.

(a) First step is determination of an objective based on which we proceed the analysis. It is simply not possible to perform an analysis of potential success or risk without determination of success criteria (objectives are defined by criteria). Possible objectives of SWOT analysis is find out whether:

- company is economically successful.
- company is successful in a long term.
- product lifetime look like.
- company apply the scientific and technical knowledge in its area.
- particular product can be successful on market.
- the flexibility of supplies are in compares with the competition.
- find out whether particular person can succeed on particular position.
- some activities and processes influence economical results of a company the most, and many others.

(b) Second step is definition of factors and variables influencing stated objectives:

- Stage of products sales, market demand.

- Accounts payable, loans and credits.
- Real cash-flow.
- Launching of a new product on market, etc.

Each of these factors could be S, W, O or T.

(c) *Third step* is gathering of information about particular factors. In case of making analysis of potential company risk of abortion it is needed to find out information about our company and about competing companies as well. In case of making analysis of eventual market success and of a risk of product abortion, it is needed to gather information about competing products and market trends.

Strong and weak feature from company's objectives point of views get identified by the analysis and potential opportunities and risks are concluded based on the market status.

The SWOT analysis sequences of steps are illustrated on a picture below:

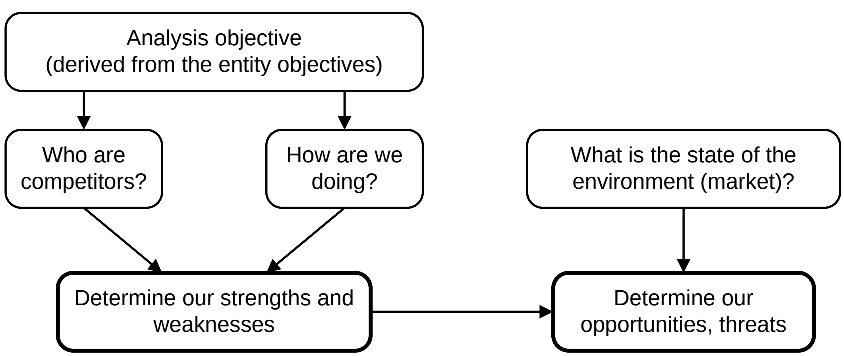


Fig. 39. *SWOT analysis sequences of steps.*

Analysis can be carried out also in a form of a table, where strong and weak feature together with opportunities and risks are quotes.

Strong features	Evolving from comparison with the competition.
Weak features	Evolving from comparison with the competition.
Opportunities	Evolving from the environment and the subject.
Threats	Evolving from the environment and the subject.

The analysis result can also state that the opportunities are low and risks are high. In that case a decision about change of a subject can be made (about a company or a product). Change of the objectives should be made so the features of the subject (its parameters) would become its strong features. E.g.:

- A company has its own research development team with laboratories. This fact will appear among the strong features in the criterion of scientific and technical knowledge. On the other hand, could be a weak feature in case we focus on the financial effects of this year.
- Weak feature is also the technical quality and strong one is a high capacity of products with low expenses. Change of company's objective: we will become a producer of products from lower price category. From this point of view, our parameters are a strong feature compared to the competition.
- The thread is that the production is low and prices too high because our products have specific quality. Change of a company's objective: we will specialize on order production with custom made products and seasonable prices. From this point of view, company's characteristics are strong features in compare to its competition.
- Your employee wants to become the head of a team, of which he is a member of. His strong feature is his education and knowledge, weak feature is his ability influencing other people. The risk could be that he won't be able to handle people. Recommended change of the objective: he will orient towards an expert career and based on this his personal characteristics will become his strong features.

Objective changes are illustrated on a picture:

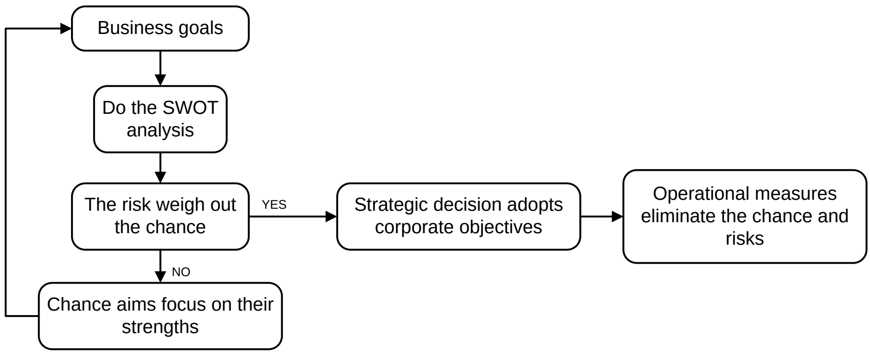


Fig. 40. *A change of subject objectives based on SWOT analysis.*

It is obvious that SWOT analysis enables determine subject objectives according its characteristics and that increase its chances and eliminates the risks of achieving success – to determine the development strategy.

A creation of a table with strong and weak features, opportunities and risks from the first phase of the analysis could be only the first, preliminary result. There is a possibility for jump one more step further or continue in creation of strategic decisions.

(d) Potential strategies of SWOT analysis.

Strategic schema as the SWOT analysis results:

Strategy SW / **Strategy OT**	***S* – strong features strengths**	***W* – weak features weaknesses**
O – opportunities	Strategy *SO*	Strategy *WO*
T – threats	Strategy *ST*	Strategy WT

- *SO* – to use strengths for achieving competitive advantage.
- *WO* – overcome weaknesses by using opportunities.
- *SW* – to use strengths to face the risks.

- *WT* – minimize expenses and face the treats.
- *OT* – strengthen and used the opportunities and avoid or get rid of treats.
- *SW* – strengthen strengths and eliminate weaknesses.

Analysis of Opportunities and Treats – O-T.

O – T analysis enables divide attractive opportunities hidden on market and which can bring advantage to a company. At the same time, focusing on company problems might be struggle with.

Company must follow important powers of the macro environment (demographic, economic, technological, political, legislative, social and cultural) and also members of the micro environment which influence the ability to achieve profit (customers, competitors, suppliers, distributors).

Analysis of the Strength and Weaknesses – S-W Analysis.

Emphasis of outer factors evaluation, executed with the aim to determine company's objectives must be supplemented by an analysis of internal factors. Several companies know the opportunities the market offers them but they miss the ability to use them. With the analysis of its strength and weaknesses a company is able to find out what is reasonable to conduct according to the current and expected situation.

Main features of a competitive advantage on market are: high market ratio, consumption basis and loyalty, concentration on the fastest rising market segment, strongly preferred product, costs advantage, profits above standard, technological and innovative capability.

Important features of competitive disadvantage are: loss of market position, profit below standard, non sufficient financial resources, decreasing repute among customers, low product quality.

(e) Operative objectives of SWOT analysis.

Next step of the SWOT analysis could be a phase of operative decisions formulated as concrete objectives ready to be presented in front of working teams. Situation is illustrated on previous figure (Fig. 40). Operative objectives should focus on execution of the opportunities and risk elimination.

SWOT analysis could be finalized by stating of operative objectives. Let's determine criteria of a well defined objective. Operative objective should be:

- Achievable (by using available resources and in planned time table).
- Measurable (so the achievement could be controlled).
- Time based (so the achievement deadline could be stated).
- Emotionally attractive (so motivation factors could be used).

(f) SWOT analysis conclusions.

SWOT strategy and operative objective indicate the orientation of logistic system synthesis.

If we continue with "model approach", then it is necessary to determine particular S, W, O, T factors and carry out a detailed analysis.

If the next step would be according to a case study, then we search for adequate strategy recommended by SWOT and particular factors will be evaluated as case studies.

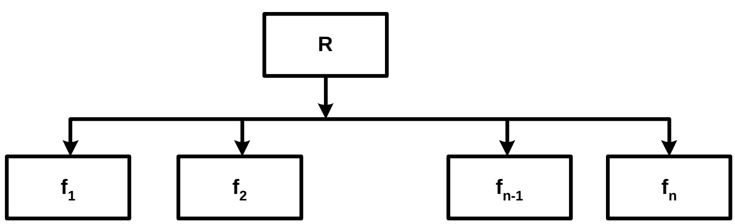
Multi-Criterion Analysis

Multi-criterion analysis is a method of quantitative evaluation – of an analysis when the analysis result should also include the overall evaluation of the status and comparison with several alternatives. It can be used in the phase of an analysis and synthesis and in a sequence of SWOT analysis, respectively system analysis (as the second analytical phase).

Method is applied also in cases when analyzed problem depends on several factors (stochastic, deterministic, business, manufacturing, personal, social). To put all these factors on one platform for comparison and evaluation is very challenging.

Analysis is initiated by defining factors F_1, F_2, … F_n. particular problem depends on these factors.

Factors can be on the same importance level but can be also hierarchically divided.



(a) One-level factor structure (Ratio-index method).

(b) multilevel factor structure (AHP – method).

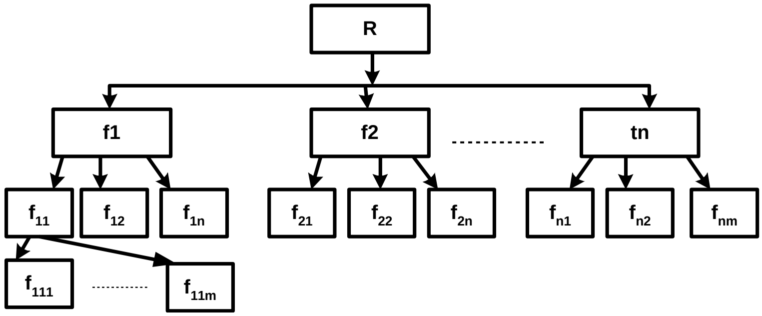


Fig. 41. *a). one-level factor structure (Ratio-index method);*
b) multilevel factor structure (AHP – method).

Same level of factors is used in ratio-index method [7], hierarchical division of factors is used in AHP method.

Both methods use expert approach (e.g. for factor selection or weight definition, etc.). This means that these types of decisions are performed by a group of experts, selected workers.

a) Ratio-index Method

In case we want to concentrate all factors or criteria into one decision – into one indicator, we use this method:

- Factors have different character from quantification and casualness point of view.
- Factors are from different areas – business, manufacturing, distribution, etc.
- They have different significance related to the analysis objective.
- Factor is on the one hierarchic level.

E.g. in case of selection and evaluation of suppliers, evaluation of new market potential, allocation of a new division, selection of a manager into an important position, etc.

Algorithm of such method follows:

(a) Factor and criteria selection for the evaluation $F_1 \ldots F_n$.

(b) Evaluation of important factors contributing to a fulfilment of the main objective – assigning of factors' weights w_i. It is advised to select the factors and define the weights by an expert. Weights w_i express factor's importance but at the same time they express the proportion of significance among the factors. From a practical point of view it is advised to make the sum of weights equal to number 1. (It is related to a visual dividing of a "unit circle cake").

$$\sum_{i=1}^{n} w_i = 1$$

In case this is not valid, factors are normalized.

$$w_{i\,j} = \frac{w_i}{\sum_{i=1}^{n} w_i}, \text{ i = 1, 2, … n,}$$

And the sum is $\sum_{i=1}^{n} w_{ii} = 1$.

(c) Particular variants V_j are evaluated with the help of selected factors (HV_j – variant evaluation V_j).

We evaluate particular factors F_i – (HF_{ij}) for each variant V_j:

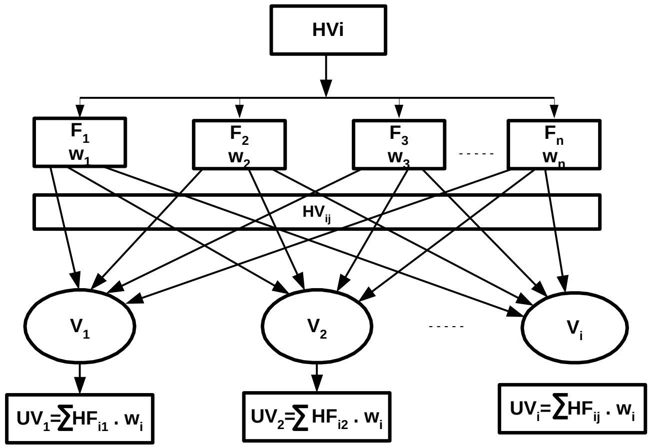


Fig. 42. *Evaluation according Ratio-index method.*

Factors are evaluated according to a pre-defined interval, so called potency rate – K.

$$HF_{ij} \in \langle 1, K \rangle$$

Potency rate value means evaluation interval and defines sensitivity of the method. The bigger the amount of variants and factors is the larger interval and higher potency rate becomes.

Variant evaluation:

$$HV_j = \sum_{i=1}^{n} HF_{ij} * w_i$$

Analysis can be defined by minimization, meaning that the smaller evaluation HF_{ij} is the better, respectively vice versa by maximization. The higher HF_{ij} is the better and the same is valid for the weights w.

The solution then is:

$$V_j(optim) = \min_j \langle HV_j \rangle$$

In case of a company analysis and evaluation, then we are talking about evaluation of only one variant.

It is necessary to formulate both negative and positive factors in one form so they will become the same – either positive or negative. E.g. in case of evaluation of suppliers: e.g.

- F_1 – amount of distribution per month (the bigger the better).
- F_2 – time from the order till delivery (the smaller the better).

In case e.g. F_1 will be re-formulated – intervals between distribution (the smaller the better) in case of a minimization task.

From a practical point of view it is necessary to create following evaluation table:

Tab. 1. *Table for multicriteria evaluation by Ratio-index method.*

Title of factor i	**Factor I weight**	**Variant 1**		**Variant 2**			**… Variant j**	
F_1	w_1	HF_{11}	$HF_{11}.w_1$	HF_{21}	$HF_{21}.w_1$		HF_{j1}	$HF_{j1}.w_1$
F_2	w_2	$HF_{1\,2}$	$HF_{12}.w_2$	HF_{22}	$HF_{22}.w_2$	…	HF_{j2}	$HF_{j2}.w_2$
F_3	w_3							
F_4								
.			.		.			.
.			.		.	…		.
.			.		.			.
F_n	w_n	HF_{1n}	$HF_{1n}.w_n$	HF_{2n}	$HF_{2n}.w_n$		HF_{jn}	$HF_{jn}.w_n$
Total variant evaluation			HV_1		HV_2			HV_j

b) Analysis of Hierarchical Processes – AHP

This analysis is a method where it is necessary to create a hierarchy of at least 2 levels for factor evaluation.

E.g. productivity depends on following criteria:

- Technology

- Management
- Marketing
- Trade
- Personnel, etc.

Within technology there could be:

- machine utilization.
- machine performance.
- skills of the personnel.
- failure rate.
- quality assurance as a sub-criterion, etc. and there is a possibility to incorporate other criteria – factors.

This method can be used also in case we do not want only one total evaluation but evaluations in particular areas - criteria.

For evaluation of criteria – factors, following methods are used: comparative evaluation, connoisseur's judgement, descriptive analysis, qualitative analysis, quantitative data classified by simple statistics [21] Analytical hierarchical process (AHP) is used as empirical analytical method of an analysis. AHP is a multi-criterion decision tool enabling quantitative and qualitative measurements and detection of relations between them. AHP focuses on integration of different measurements and evaluation into one total package for classification of alternatives according to equal comparative criteria.

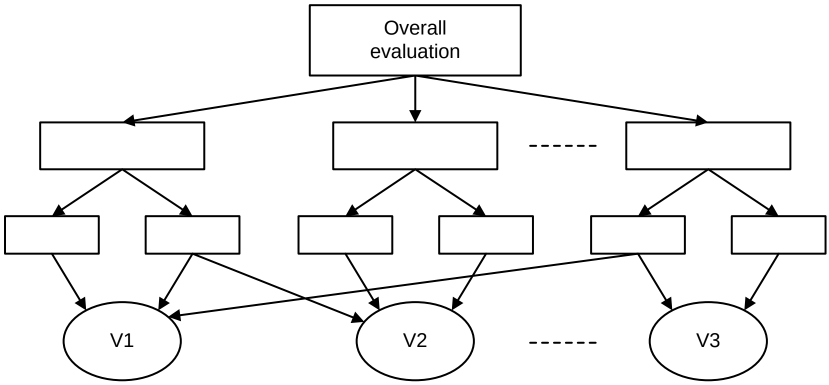


Fig. 43. *Hierarchical structure of the analysis process.*

Usage of AHP includes 4 phases.

First phase – creation of problem hierarchical structure. The total problem is rated by criteria (factors). These criteria are divided into sub-criteria. Solution alternatives are finally connected by evaluation based on sub-criteria. Fig. 43 shows this type of hierarchy.

Second phase is related to determination of criteria and sub-criteria importance. This is performed by comparison of all criteria by matching.

Then this must be valid:

$$\sum_{i=1}^{n} w_i = 1;$$

and at the same time within each criteria, the sum of sub-criteria weights is:

$$\sum_{j=1}^{nj} w_{ij} = 1; \ \mathrm{i} = 1, 2, \ldots \mathrm{n}$$

Weights w_i are defined by expert means. It is necessary to control their equilibrium for factors by a matching matrix.

Tab. 2. *Ratio weight table.*

	F₁₁	**F₁₂**	**F₁₃**	**…**	**Fₙₘ**
F_{11}	*1*	$P_{11/12}$	$P_{11/13}$	…	$P_{11/m}$
F_{12}	$P_{12/11}$	*1*	…	…	$P_{12/m}$
F_{13}	$P_{13/11}$	…	*1*	…	$P_{13/m}$
F_{21}	$P_{21/11}$	…	…	…	$P_{21/m}$
F_{22}	$P_{22/11}$	…	$P_{22/13}$	…	$P_{22/m}$
F_{23}	$P_{23/11}$	…	…	…	$P_{23/m}$
⋮	⋮	⋮	⋮	⋮	⋮
F_{nm}	$P_{n/11}$	$P_{n/12}$	$P_{n/13}$	…	$P_{nm/nm}=1$

Legend:
$P_{11/12}$ - weight matching w_{11}/w_{12}
e.g.:
$P_{11/12} = w_{11}/w_{12}$

Comparison of the results from this matrix and from the maximal values defined by the experts leads to weight optimization. The weights could be optimized also by a method of DMSPM [15][16].

Factor's *i* final value is calculated from the evaluation and sub-factors' weights HF_{ij} and w_{ij}.

$$HF_i = \sqrt{HF_{i1}^{w_{i1}}} * HF_{i2}^{w_{i2}} x...xHF_{in}^{w_{in}}$$

Total variant evaluation is $CHV = \sqrt{HF_1^{w_1}} * HF_2^{w_2} x...HF_n^{w_n}$

Each criteria and sub-criteria has a numerical value – priority (weight comparison) after the second phase.

Third phase calculates the value of alternatives – variants $m_{ij} = \sum_{i=1}^{n} HF_{i,j}.w_{ij}$

In the fourth phase, these alternatives are put according to the evaluation – CHV. In case of using AHP method for decision making, following 4 axioms need to be fulfilled:

(a) Inverse axiom: when *A* alternative is *n*-times preferred than *B*, then alternative *B* is 1/*n*-times preferred than *A*.

(b) Homogeneous axiom: comparison by matching is essential only if elements are comparable.

(c) Depending axiom: comparison on a lower level (sub-criteria) depends on an element on a higher level (on higher criterion).

(d) Anticipatory axiom: in case that some criteria in the hierarchy get changed, new evaluation of such new hierarchy is required.

To be able to rate the plausibility of gained results, it is needed to calculate a *consistence index* (CI) and *sufficiency ratio* (CR).

CI defines aberration of comparison matrix from rational matrix (evaluation by experts) and CR is a value where CI is divided by *criterion's value*. Matrixes with CR=0,1 and less can be used for selection of reliable division.

Formula 1 represents the calculation of CI. To make it simple we can say that the higher the value of CI the less consistent is the hierarchy and its compared pairs.

(1) $CI = \frac{\lambda_{max} - n}{n - 1}$ where:

λ_{max} – average difference of valued preferences

n – factor amount [15]

$$CR_i = \frac{CI_i}{RI_i}$$

RI_i – index of casualness

i – matrix rank

CI_i – consistence index

CR_i – sufficiency ratio

Implementation indexes (IMPL) are used for usability rating of results from AHP estimation. Implementation index determines importance and pressure evolving in improvement. It is created to increase the aberration sensitivity in competing environment. This index is raised by division of standard aberration into values stating the priority (importance). Ability to compare particular attributes is improved. The smaller is the value the higher is the chance of development (improvement). [21]

Tab. 3. *Table of implementation indexes [Saaty, 1996] [57].*

MATRIX SCALE (RANK)	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
INDEX CASUALNESS	0	0,52	0,89	1,11	1,25	1,35	1,4	1,45

Emphasized implementation index expresses also the importance and pressure leading to an improvement. The competition and development tendency also influence customers' satisfaction and loyalty. This IMPL is emphasized by a competition index and development tendency index. Emphasized implementation index uses divisions which equal the sums of answers used for competition and development tendency. The smaller these values are the bigger occurs is needed in attribute improvements.

(2.) Competitive index = | (w % - b %)/100 - 1|

Compared with the competition			*Development tendency*		
Worse	The same	Better	Worse	The same	Better
16%	35%	49%	34%	43%	23%

(3.) Index of development tendency = | (w % - b %)/100 - 1|

(4.) Emphasized IMPL = $\dfrac{\text{Standard aberration}}{\text{weight} \times \text{competitive index} \times \text{index of development tendency}}$

Following table is used for total evaluation:

Tab. 4. *Table for the evaluation by AHP.*

Main factors	Main factors' weights	Sub-factors	Sub-factors' weights	Sub-factors' evaluation	w_{ij}. HF_{ij}
F1	w_1	F_{11}	w_{11}	HF_{11}	w_{11}. HF_{11}
		F_{12}	$w1_2$	HF_{12}	:
		:			:
		F_{1n1}	w_{1n1}	HF_{1n1}	
F2	w_2	F_{21}	w_{21}	HF_{21}	:
		F_{22}	w22	HF_{22}	:
		:			:
		F_{2n2}	w_{2n2}	HF_{2n2}	
Fn	w_n	$F_{n,1}$	$w_{n,1}$		
		$F_{n,2}$	$w_{n,2}$		
		$F_{2n,nn}$	$w_{n,mn}$		
Total evaluation				$\sum w_{ij}.HF_{ij}$	

In case of more attributes, table is drawn the same way as in ratio-index method.

Multi-criterion approach for evaluation of competitiveness and company's development

Company's quality is defined by two basic attributes:

- competitiveness.
- direction – development dynamics.

Multi-criterion evaluation can be used for company's quality evaluation according following methodology.

A questionnaire for customers and experts is prepared:

Tab. 5. *Evaluation of competition indexes and indexes of development tendency.*

Element (attribute) Operation, factor i	Expectation /min. status/	Reality /current status /	Comparison with the competition			Development tendency		
			H	R	L	HS	RS	LS
attribute 1								
attribute 2								
:								
:								
attribute n								

where: H – worse, R – the same, L – better.
HS, RS, LS – worse, the same, better development tendency.

Attributes of operations, processes and factors characterize the company. This method can be applied as well as a consecutive analysis, e.g. after a year.

A questionnaire is filled into a table:

Tab. 6. *Questionaire evaluation table.*

Attribute	w_i	**Average values of expectations**	**Standard aberration**	**Average values of experience**	**Standard aberration**	**Comparison with the competition (%)**			**Development tendency (%)**		
						H	**R**	**L**	**H**	**R**	**L**
Attribute 1											
Attribute 2											
:											
:											
Attribute n											

wi – weights, attribute's priority

Based on the values in a table, we calculate

$$\text{Competitive index} = \left| \frac{H\% - L\%}{100} - 1 \right|$$

H% - percentage of asked people evaluating competitiveness as worse

L% - percentage of asked people evaluating competitiveness as better

$$\text{Development tendency index} = \left| \frac{HS\% - LS\%}{100} - 1 \right|$$

An emphasized implementation index is calculated from these coefficients. It determines the importance of an improvement.

$$\text{Emphasized IMPL} = \frac{\text{Standard aberration}}{\text{weight * competitive index * development tendency index}}$$

Weight optimization or evaluation of particular factors can be performed by *Matching=ratio weight matrix.*

Tab. 7. *Ratio-weight matrix.*

w_i \ w_j	**w_1**	**w_2**	**w_3**	**…**	**w_j**	**w_n**	$\sum_j p_{ij}$
w_1	$p_{11}=1$	p_{12}	p_{13}		p_{ij}	p_{1n}	$\sum_j p_{1j}$
w_2	p_{21}	$p_{22}=1$					
w_3							$\sum_j p_{3j}$
w_i					p_{ij}		
w_n						$p_{nn}=1$	
							$\sum_j p_{ij}$

Rational weights can be compared one to another by creation of a matrix of processes p_{ij}, where $p_{ij} = p_i / p_j$. If rational weights (added to factors) and weight power expressed by ration to other weights is approximately the same, then the appraisal of a rational weight was correct (e.g. $\Delta w_i = {}_{pi} - w_i \leq 0{,}1$). If differences are bigger, then rational weights need to be corrected.

$$wp_i = \sum_j pij \Big/ \sum_i \sum_j pij$$

If $\Delta w_p \leq 0{,}1$ then weights are designed correctly not only in their absolute (numerical) value but also in compare to weights of other factors.

Analysis for Heuristic Model Design

Creation of a heuristic model as the basis for a synthesis requires a precise analysis.

Due to the fact that heuristic is defined as a method for mental activities modelling carried out by human activities, the biggest amount of synthesis applications is in the management processes.

Particularly in logistics, it is mostly in processes of:

- prognosis.

- operative planning.
- production scheduling.
- supplier selection.
- design of distribution network structure, etc.

This means, that it's mostly used there, where the essence of such activity or a process is decision.

Heuristic analysis should create outlet for heuristic model synthesis. An outlet for decision is a collection – database of information and rules. When we have the input information for such decision process (e.g. heuristic basis of data about product sales), by executing an analysis we will be able to describe algorithms, sequences of steps and rules as executed by a man during decision making.

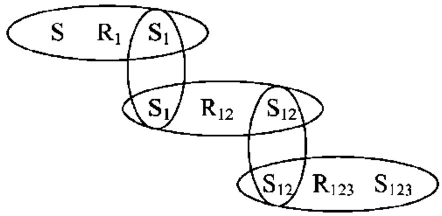
An analysis for heuristic model creation and LS synthesis according such model is executed on an existing systems respectively on analogical – gauge system. This method is suited for innovation projects, where productivity and process efficiency by automation and informatization of control activities need to be improved. This improvement is carried out by system optimization (with applied principles of optimization during heuristic model creation), and flexibility increase.

Heuristic analysis comprises principles of:

1. Theory of elementary information processes – system / process breakdown into such small processes that could be modelled and solved:

$$
\begin{tikzcd}
S(t,\alpha(t)) \arrow[r] \arrow[dr] \arrow[ddr] & R_1 \arrow[r] & S_1(t_1,\alpha(t_1)) \arrow[r, dash] \arrow[dr, dash] & R_{11} \arrow[r] & S_{11}(t_{11},\alpha(t_{11})) \\
& R_2 \arrow[r] & S_2(t_2,\alpha(t_2)) & R_{12} \arrow[r] & S_{12}(t_{12},\alpha(t_{12})) \\
& \vdots & & & \\
& R_n \arrow[r] & S_n(t_n,\alpha(t_n)) & &
\end{tikzcd}
$$

2. Decision tree breakdown into triads and cascades:



3. As seen from 1), to be able to analyse a problem, it is necessary to know:

- group of rules $\bar{R}_i \ldots \bar{R}_{ij}, \ldots$
- group of following situations $\bar{S}_i \ \ldots \ \bar{S}_{ij} \ \ldots$

To perform an analysis means to create a defined structure (1), more precisely define situations and rules.

4. For structure definition (1), it is sufficient to know the initial situation S (t, α (t)).

   (Situation S in time t, with features, parameters α (t)) and group of rules $\bar{R}_i$.

5. *Definition of heuristics.*

Analogy – induction

Decision rules $\bar{R}$ bring to heuristic models, experiences, praxis, intuition because these are expressed in concrete techniques, steps, decisions, situation reactions, etc. that is why the analysis for rule definition initiates from:

- Knowing how people do it.

- Why do they do it.
- What rules do they apply for particular activity?

Repeated activity execution (during plan preparation) and fact that praxis has verified correctness and success of it means achieving a suitable tool for future control.

These conclusions base on repeated analogy and abductive and inductive decision making.

If particular rule R_i was valid for situation S_1, S_2 … S_n and provided suitable solution y_i, then if situation S_{n+1} is analogical to situations S_1, S_2 … S_n, tule R_i is also suitable for its solution.

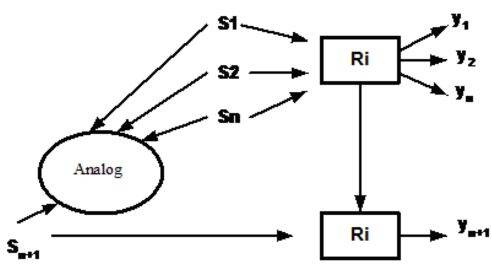


Fig. 44. *The induction principle.*

Heuristic rules are created by induction according to repeated analogy. It is difficult to divide the phase of analysis from synthesis especially in case of heuristic approach. This is a model approach and it has its own specifications.

6. Definition of further rules:

Several other rules need to be defined besides the group of heuristics $\bar{H}$:

- *TP – technological rule,* are rules are defined by technological regularity, e.g. duration of slab movement in pusher furnace cannot exceed 120 minutes, if we load it in cold phase, because its inner material structure would be disturbed.

- slabs on steel will get rolled from the widest to the narrowest due to cylinder depreciation.
- $\bar{O}$ - *constraints*, rolling temperature of slabs at the entry to the rolling path cannot be less than 1200 ℃.
- $\bar{E}$ - *expert rules*, defined particular activities decided to keep in charge of a person – planners, logistic manager, dispatcher because:
  - Those activities are not suitable for modelling – and for automation.
  - We don't want to model them due to "user friendly" purposes and person's participation is requested.
- *KO – optimization criteria.* Innovation, re-engineering of LS has a defined goal implicitly and explicitly – process of system optimization as an entity. LS optimization always leads to a multi-criterion problem. In analysis we have to define main optimization criterion. In synthesis it is necessary to e.g.
  - maximize machine capacity utilization.
  - minimize energy consumption.
  - determine the order – sequence of product manufacturing.
  - optimize production progression from chemical consistence point of view, dimensions, etc.
  - optimize smoothness of parameter changes.
  - minimize distribution path.

The main criterion is always the criterion of consumptive because each of the above-mentioned criteria is directly or indirectly translated into expenses.

By analysis we can define rules, formulas and algorithms for calculation of these criteria and their relations either mathematically, logically.

From the practical point of view, analysis is performed by any possible means, such as internet, company's materials, theory, research but mostly by a detail exploration of people, their intellectual activity during decision making and managing, by algorithms, verbal description.

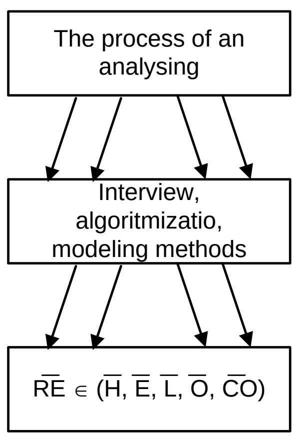


Fig. 45. *Principle of rule definition.*

3.4 Synthesis of a LS

Synthesis of a LS aims in:

- designing effectively functioning LS with less expenses or.
- designing a new system according a detailed analysis of a previous system or.

- defining and designing the creation of a new LS based on theoretical knowledge and methods.

In general, synthesis includes these basic steps:

- Specified definition of LS goals (after analysis).
- Conceptual design (design of a LS structure and behaving, its parameters, elements – subsystems, their relations and connections to other systems).
- Function and process design (in a form of steps, algorithms, input and outputs).
- Method of design, optimization (know-how) of the system and its functions.
- Technical solution.
- Information solution.
- Schedule plan for realization and verification.

Final synthesis is completed with:

- Conceptual project (Preliminary study).
- Technical project.
- Executive project.

In some cases the solution conception can appear in the preliminary study.

Analysis should provide sufficient amount of information, data and knowledge for *designing* the structure, behaving, functions and processes of such new LS – for synthesis

Synthesis = The process of creation LS

Synthesis has 2 phases:

1st – how to do it – proposal for methods, rules, algorithms and techniques (know- how),

2nd – to do it – creation of particular system on the base proposal methods (know-how) and inputs, parameters and conditions gathers during the analysis.

Synthesis of a LS differs according to a project type:

(a) *Routine project* – always looked for *analogy* of a problem with a problem solved in the past. Synthesis is bases on the correct defined conditions of similarity.

(b) *Innovation project,* where know-how exists and is applied on new conditions of a new problem. This is not a change of philosophy, solution principles or systemic change but this is an adaptation and innovation of functions and processes.

(c) *Creative project* – when a new systems is created or re-structured. Its structure from previous system into a new one is created. For these purposes new know-how and new system must be generated

3.4.1 Selection of Synthesis Method

Definition of a problem and solution objectives, selection of paradigm and analysis results predefine the selection of a method for synthesis.

Simulation model, respectively heuristic model is used for LS synthesis when there is none analytical model capable to solve the situation or we are not able to create such analytical model.

Simulation models are used when searched parameters and structure cannot be calculated analytically, e.g. a manufacturing process with several operating machines. The range of goods is wide and each product has different production method, different operation times and we want to e.g. localize buffers, calculate the machines' capacity utilization, find the optimal lay out, etc. In this case mathematical calculation for bulk service is very complex and non-realistic.

Heuristic models are applied in cases when people can solve particular problem but mathematics and operation analysis can't. Then we model their behaving during particular problem solving – create heuristic model.

Benchmarking is used when we are able to find the problem solution in analogical case.

If we choose a paradigm:

Case study – based on analysis results (flash, problem oriented or SWOT analysis) a method for a synthesis is chosen according *analogy*.

Synthesis principle for case study is analogy

Two cases, situations or problems are analogical

(a) If they have the same structure and the same element features

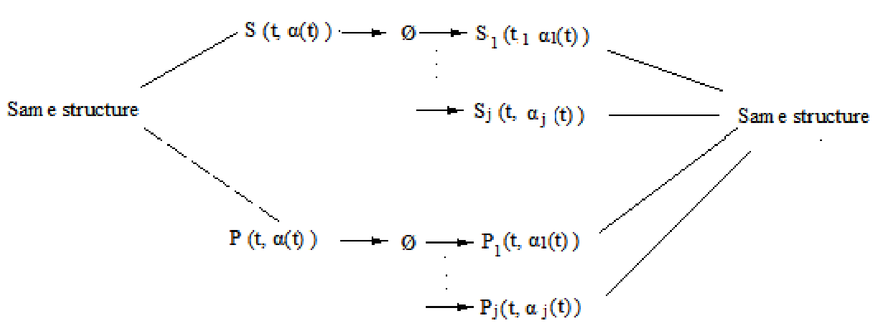


Fig. 46. *Principle of analogy.*

This principle is used either directly – analogical solution is looked for when solving particular problem (e.g. storage of particular material), or in case of a more complex situation. E.g. design of company's LS where method of multi-parameter analogy – *benchmarking* will be used.

In case of study approach, new methods, techniques and solutions are not created by used and applied a solution from analogy case.

However, there might be cases when problem - case or situation necessary to be solved is relatively isolated but solution requires a creation of a model – heuristic, simulation, analytical. Borders between individual paradigms and approaches are not strictly defined (black and white) but in many case they are blurred (grey).

Application of a model approaches in synthesis is through:

(a) Analytical model.

(b) Simulation model.

(c) Heuristic model.

Analytical models applied for LS are mostly models of operation analysis and manufacturing process modelling e.g.:

- models for calculation of capacity and machine configuration.
- models of bulk service.
- Markov chain.
- network methods.
- sequential methods.
- linear optimization (simplex models).
- dynamic optimization (dynamic, programming, calculus of variations).

- allocation and lay out methods.
- neuron networks.
- forecasting methods (quantitative and qualitative) etc.

Each of these analytical models is suitable for a solution of a concrete problem, e.g.:

- If we need to solve localization of machines or size of stores, we apply a model of capacity calculation.
- If we need to design a project of an operative maintenance management, network analysis CPM and PERT are applied.
- If we need to find an optimal product sequence, sequential methods Branch and Bound or an enumeration method is used.

All these models have defined usage in their application for LS synthesis and all are problem-oriented.

Synthesis bases on a creation of model for particular problem according known method. A little bit more specifications are include in simulation and heuristic models, that is why they are described separately.

Re-engineering depends on the size, amount and type of re-engineering tasks. In case re-engineering is done under outer pressure (economic or time) then re-engineering tasks are solved as individual case studies and all rule for case study solutions are valid also for synthesis.

In case re-engineering is executed as part of a plan, there is enough time, equipment and capacities, and then we apply systemic – model approach. In most cases combination of case studies and model approach are used.

3.4.2 Application of Simulation Models in LS Synthesis

System can be analyzed and explored:

(a) on a real object.

(b) on a physical model.

(c) on mathematical model.

(d) on simulation model.

Simulation is a synthesis method where designed LS is replaced by a simulation model, with help of which all experiments are carried out with the aim of achieving parameters that are later on applied back on examined and designed LS.

Simulation is one of the last and most expensive alternatives for LS synthesis. Due to the complexity, stochastic and variety of processes; simulation is most of the time the only option for LS synthesis.

E.g. in case of a very complicated crossing:

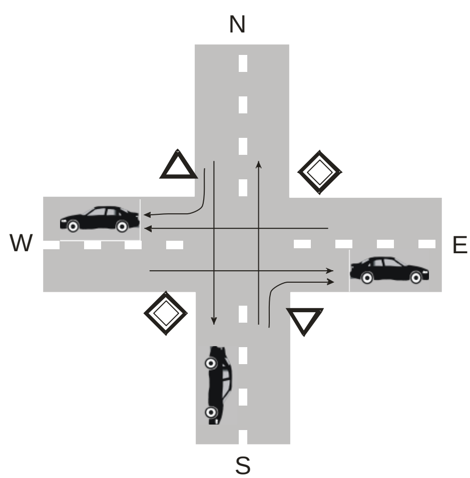


Fig. 47. *A crossing as LS.*

E.g. if an objective and task is defined: to find an optimal lengths of green lights in all directions so that cumulative cars waiting time of at the crossing as short as possible and so that the crossing has the maximal operating efficiency.

Density and conveyance flows are different during the peak, during night of weekends, during holidays or during different seasons. Particular crossing could be observed and set directly on the real crossing but that would be unrealistic.

However the crossing can be modelled – we create a physical model with cars and lights, which is a possible task but only visionary for calculation of essential parameters (τ_n, τ_s, τ_e, τ_w – times of green lights from the north, south, east and west).

This is a possibility to create a mathematical model based on systems for bulk service. The task is feasible but a model of four or six systems for bulk service interactively excluding each other activities is extremely complicated.

In this case simulation would be the only solution. A simulation model for particular crossing will be created and on this model, experiments will be performed (different lengths of green lights). Status of each of the cases will be carefully monitored. From several variants the only one – optimal will be selected and applied to the real crossing.

Nowadays only computer simulation models play an important role in the real praxis.

Simulation models are *functional models* which copy the functions, activities and processes of real LS. In our case we are not modelling a crossing but its functions, e.g. cars *come* to a crossing, if there is a red light, they *wait*, if there is a green light, they *pass*, etc. Such creation of a simulation model requires a specific analysis described during creation of simulation model.

Simulation models of LS are mostly discrete, respectively can be defined as discrete systems.

Sequence of simulation model synthesis:

1. *Problem definition* is e.g. wrong function fulfilment; low performance of a shipping system, long waiting duration at the crossings, violation of delivery dates, overload of intermediate operation buffers, etc. Objective definition follows the problem definition. E.g. to find an optimal length of green light at the crossing, to find the bottle-neck of a manufacturing process, design optimal capacity of intermediate operation buffers, etc.

2. If particular object (a company, crossing, conveyance system) exists, we *define a system* on it (the LS) on which we would like to verify a topology, elements parameters, transmittance, capacity utilization – variables: times, position, capacity.

3. If a real system doesn't exist, we have to conclude from its project, design, meaning *simulation model assumes the existence of projected system in real or project form.*

4. Definition of variables for simulated model, what characterize particular LS (τ_s, τ_j, τ_v, τ_z, – time durations from the north, south, east and west), P – transmittance, etc.

5. Synthesis assignment is a transformation of *defined LS into a system of bulk service* respectively other formalized system we are able to model by particular simulation tool (language, system). E.g. a crossing is pictured as six simple bulk services of which two or three can work simultaneously. The others are interlocked. E.g. a crossing is transitive in directions S→ N and N→S, other directions are interlocked.

6. *Selection of simulation tool – a system for model creation.* It can be – universal language e.g. Pascal, C++, however a creation of simulation model is more complicated; or it could be one of block-oriented simulation languages e.g. GPSS, SIMAN, or one of iconic languages SIMFACTORY, EXTEND, which are necessary to be skilled in but a model creation is significantly easier. This is the only disadvantage of simulation model synthesis, because the designer must be skilled in at least one of the simulation languages or other tools.

7. *Creation of global simulation model* – conceptual simulation model – which element of a real system will be modelled by what element or tool of simulation language, e.g. arrival of cars to the crossing will be modelled by generating random numbers in GPSS represented by GENERATE block, in SIMANE by CREATE block; machine operation will be modelled in GPSS by orders:

- SEAZE TROJ.
- ADVANCE T_1, T_2 (processing time, processing time dispersion).
- RELEASE STROJ.

Such modelling will be carried out by other blocks in SIMFACTORY, and others in SIMANE etc.

Steps 5 and 6 are the most creative, they are the centre of the synthesis and require abstract, creative way of thinking, knowledge in philosophy of object programming.

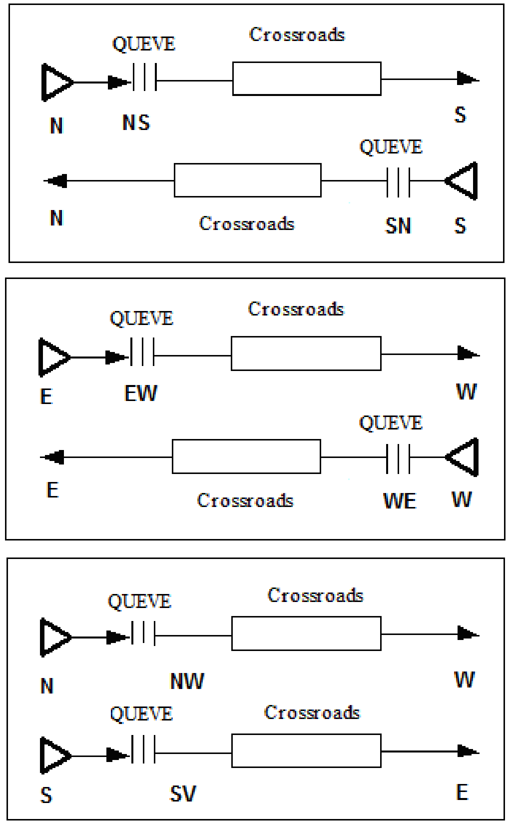


Fig. 48. *Formal model of a crossing as guening (QS) Crossroads Series.*

1. Creation of models, elementary processes and definition of parameters, functions and blocks:

- Division of a model into elementary components – inputs, array, machines, buffers, dividing, cumulation, quality control, etc.
- Generating of random numbers (modelling of inputs, orders, break downs).
- Process synchronization.
- Time control in simulation model (TIMER).

- Gathering and evidence of results in the model.
- Output definition – variables and their functioning.

2. Transcribing of model into command of simulation language – creation of simulation model (according language type).

3. Verification of simulation model:

- From a logistic point of view – if processes in the real system perform the same way as in the model, if model truly reproduce the behaving and functions of the real system.
- From the formal point of view – if syntax of used language is ensures
- Till the logistical correctness must be controlled by particular controlling steps by a designed (e.g. model flows control, their directions and capacity), formal point of view is controlled by selected language compiler – simulation system.

4. *Simulation time* is time that passes by during the model experiments or duration of simulation model compared to the real time. The essential question is how long is it required to simulate a real system so that results (proceed statistically) can be approved as valid for a designed LS. Due to the complexity of LS relations, very often there is no possibility to define a simulation time. But the more precise results we want to achieve, the longer simulation time is required. There is a one simple rule. Simulation is performed till

$$\left| x_i - x_{i+n} \right| \leq p$$

This means, that the difference of variable x_i values during i experiments and $i + n$ experiments is smaller than defined precision – p. If required precision was achieved during experiments, simulation can be finalized.

5. Evaluation and result calculation.

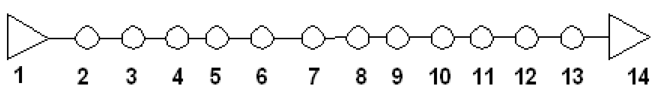
6. Experiments for another variant.

7. Variant evaluation and selection of optimal solution.

8. Application of a solution to a real system.

Evolution of simulation tools, languages and systems leads to a creation of client-oriented simulation systems.

When all processes during analysis and synthesis of simulation models are assembled



E.g.

1) By applying PASCAL, FORTRAN a person executed all 14 activities.

2) By applying GPSS a designer executes (1, 2, 4, 5, 6, 8, 9, 11, 12, 13, 14). (Block-oriented language).

3) By using SIMAN (1, 2, 4, 5, 6, 13, 14) (Interactive language) 7, 11, 8, 9 partially.

4) By applying EXTEND – object-oriented language (1, 2, 5, 13, 14) 6, 9, 11 partially.

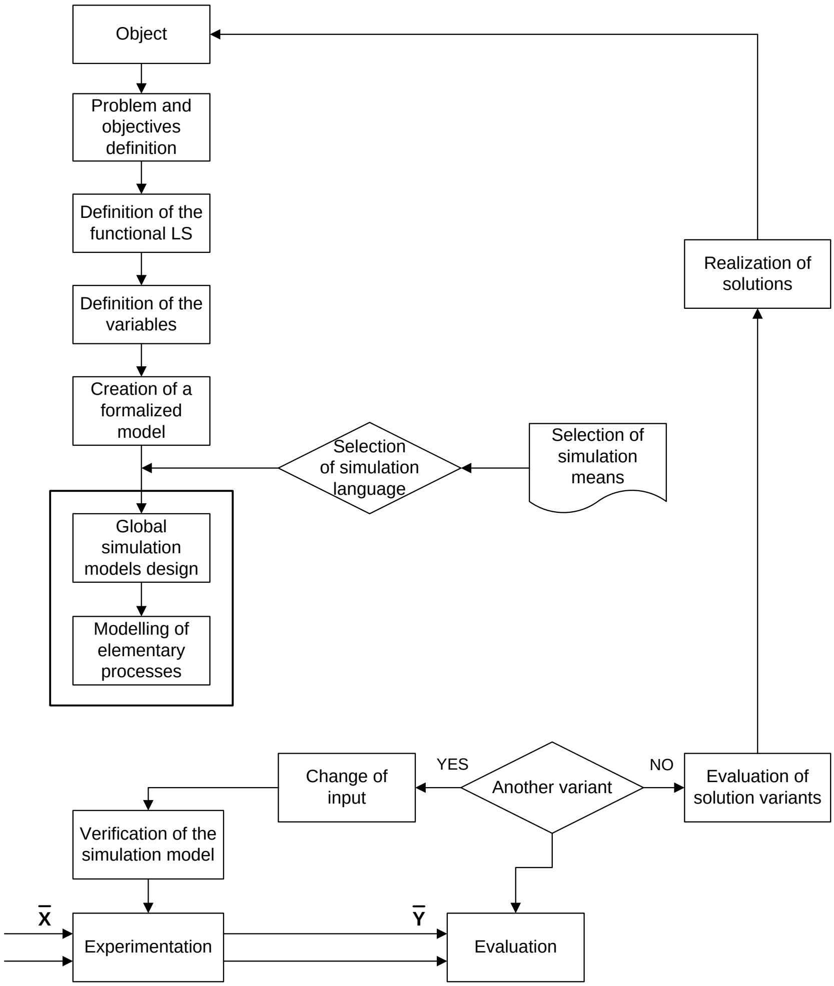


__Fig. 49.__ Sequence of steps during LS synthesis according SM.

3.4.3 Benchmarking

Main aim for improvement of logistic processes in the companies is the acquirement of strategic competitive advantages on the market. One of the options for LS creation is benchmarking. Nowadays, benchmarking method is applied in several areas and that is why there are many definitions for it:

- Benchmarking is continual and systematic comparison of own performance in the productivity, quality and manufacturing process with other companies and organizations with the best performances.

- Benchmarking is systematic and continual comparison of products, services, practices and characteristics of organizational units which ensure company's international competitiveness.

- Benchmarking is usage of systematic methods for comparing with others and finding of better paths and ways how to do the job.

- Benchmarking is observation of the others with the aim of learning from them.

Benchmarking is a technique where processes and methods of company's functions are compared and differences of efficiency are discovered. Reasons for found differences are investigated and improvements are identified. Usage of benchmarking in logistic processes means process oriented way of thinking where value added logistic processes of designed LS $\bar{x}_i(P)$ and matching logistic processes in gauge form $\bar{x}_i(E)$ are compared and their differences Δx_i are analyzed.

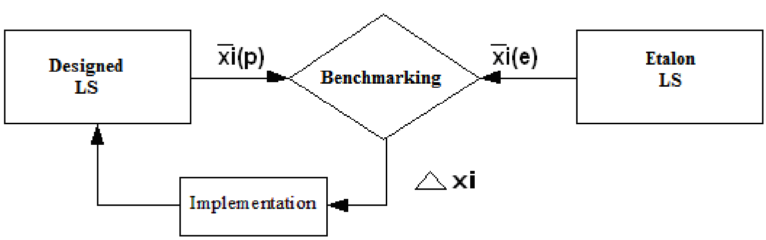


Fig. 50. *Principle of benchmarking.*

Problem is to find the etalon company. Such company must be similar and in that case it is from a group of competitors. To be able to gather information means to make the same analysis also in the gauge company, which means to gather information from it as well. This company is not motivated to provide their own information such benchmarking purposes.

Benchmarking aim is not only compare variables but also compare different types of problems and success factors. E.g.:

- Analysis of differences in values of logistic process variables and conclusion of concrete actions for improvement.
- Continuous comparison and ambition for further improvement of logistic processes. A creation of benchmarking team can strongly support these tasks.
- Restriction of requirements put on investigated logistic processes from the customer point of view (internal and external customers).
- A project can get to a stage when it wants to achieve even higher and better level by itself based on the gathered possibilities for new logistic systems and acceptance of new practices.

From all above mentioned, the benchmarking object can be whatever, what needs to be improved, e.g. service, product, process, resource – human, material, financial, qualitative, etc. continuous search for the best and comparison with it brings several advantages to the company. It enables the top management to realize realistic capabilities and disadvantages and opens the way to changes in logistic processes.

Benchmarking Methodology.

It is necessary to divide the benchmarking processes methodologically into particular sequential steps (phases). The advantages of such phase conceptions are:

- Creation of terminated and clear parts.

- Reduction of interruption risks.
- Flexibility – good adjustability to various conditions.
- Stepwise reduction of uncertainty and inaccuracy.

Common discussions with partners can serve the needs for the transfer from one phase to another. The aim of these discussions is presentation of own results from each phase, interactive exchange of experiences and final evaluation of potential improvements.

Usually following division into 5 phases is used.

1st Phase: Definition and Planning.

(a) Definition of objectives for benchmarking project.

(b) Creation of project team and organizational planning.

(c) Schematic presentation of the final process and its documentation.

(d) Determination of methods for internal data gathering.

(e) Identification of potential benchmarking partners.

2nd Phase: Internal / External Analysis.

(a) Gathering of basic data.

(b) Researched process specifications.

  - Process modelling and analysis.
  - Adding of relevant values.
  - Gathering of further data.
  - Observing of logistic processes in designed and gauge system + process selection.

3rd Phase: Comparison and Analysis /Identification of Potential Improvements.

(a) Comparison of basic evaluating parameters.

(b) Selection of suitable parameters for benchmarking process.

(c) Data gathering from benchmarking partners.

(d) Comparison and evaluation.

(e) Identification of strong features – potential improvement.

(f) Own result interpretation.

4th Phase: Proceeding Plan / Preparation for Implementation.

(a) Internal presentation of results.

(b) Determination of realistic aims and priorities.

(c) Elaboration of improvement strategy.

(d) project elaboration and application of changes.

5th Phase: Realization of Improvement Implementations

(a) Realization and management of particular actions and proceedings.

(b) Realization verification (achieved aims control).

(c) Internal presentation of results / project finalization.

(d) Evaluation and documentation of project results.

3.4.4 LS Synthesis on the Basis of Heuristic Model

Heuristic approach assumes modelling of process principles as processing of information carried out by a person on various phases of his/her activities and while solving various tasks. This approach then bases on a principle of *heuristic model* creation.

Sequences of steps during creation of such heuristic model:

(a) Definition of initial situation (problem definition).

(b) Creation of possible variants for further situations (possible solutions).

(c) Rule creation – criteria for solution selection.

(d) Heuristic model synthesis.

(e) Heuristic model verification.

The sequences of steps for creation of such heuristic model are illustrated on a fig. 51. Definition of rule group is performed as the result of analysis, technological processes, machines, equipment, organization and manufacturing process management, economy, capacity and optimality criterion.

Particular process, e.g. planning, has particular entry file of orders and by its analysis the rules were defined, which need to be fulfilled by the planning process.

The synthesis objective is to create an algorithm or model from these rules and from the definition of entry files structure.

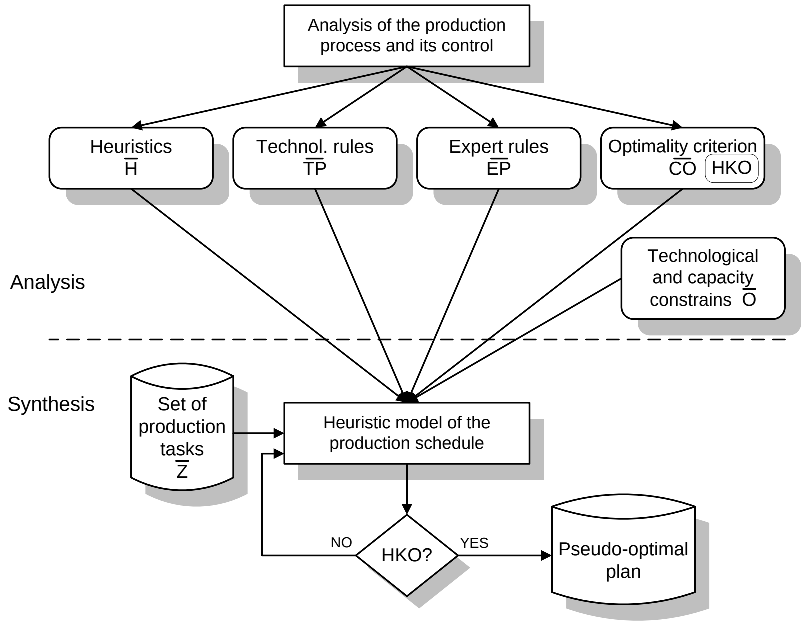


Fig. 51. *Creation of heuristic model.*

$$\{\overline{R}\} \in \{\overline{\mathrm{H}}, \overline{\mathrm{T}P}, \ \overline{EP}, \ \overline{O}, \overline{CO}\}$$

Group of rules comprise of following groups:

- Heuristic - $\overline{H}$.
- Technological rules - $\overline{TP}$.
- Expert rules - $\overline{EP}$.
- Restrictions - $\overline{O}$.
- Optimality criteria - $\overline{CO}$.

If we draw the solutions in a form of decision tree, then group of inputs (e.g. orders – for order control, group of manufacturing tasks – for operative planning and production scheduling, group of suppliers - for supplier selection, group of customers and resources for design of distribution system structure, etc.). Each group of inputs is different and must follow criteria $\overline{R}$ defined in previous analysis. If the amount of criteria is "*n*", then on a group "$\overline{Z}$ "we are able to apply these criteria in various orders. Theoretically there are *n!* rule sequences. That would mean to create *n* tree structures (because we can start with any of the n rules).

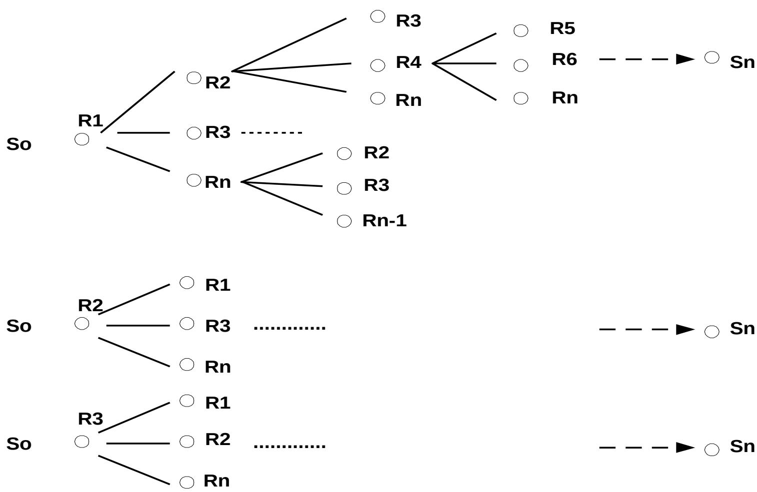


Fig. 52. *Labyrinth of tree structures presenting solutions of heuristic model.*

To create a model or an algorithm means to apply on $\overline{Z}$ (initial stage S_o) sequence of rules and get to stage S_n (final stage). Sequence of cascades creates a model, algorithm, progression:

$$S_o \quad R_1 \quad S_1$$

$$S_1 \quad R_2 \quad S_2$$

$$\vdots$$

$$S_{n-1} \quad R_n - S_n$$

The essential question is which of the *n*! sequences is the right one, the correct one, suitable and optimal? Who can we find it the in the shortest time?

There are two strategies we are able to follow during synthesis:

(a) *Inductive-deductive strategy*, from $S_o \rightarrow S_k$, when we don't know the final form of the model or the process or if we look for the way how to get there by knowing the initial stage S_o and rule vector $\overline{R}_i$.

(b) *Abductive-inductive strategy*, when we know the final stage S_k – final form, content and we continue from back to the front.

$$S_k \rightarrow S_n \rightarrow S_{n-1}$$

$$S_{n-1} \rightarrow R_{n-1} \rightarrow S_{n-2}$$

$$\vdots$$

$$S_1 \; R_1 \; S_o$$

Situation is complicated by a fact that we are not aiming in finding just "some" solution but an optimal solution by solving a heuristic model. That is why one part of heuristic model synthesis is also optimization task. LS must fulfil several criteria, e.g. minimize expenses, maximize machine utilization, minimize energy consumption, etc. – optimization problem is multi-criteria problem.

To find an optimal way – path in decision labyrinth means to create an optimal model.

Heuristic methods of path searching in a tree can be divided into:

a) *Metaheuristic – one step*, which ensure the movement in the decision tree one step after another – on one triad.

$$S_i \; R_{i+1} \; S_{i+1}$$

In case of a successful step – (according selected criterion) movement continues.

One step methods are:

a1) Neighbourhood search – (next step, rule R are generated as random number), if a step is successful -> continues, if not -> back to stage S_i.

a2) Neighbourhood search with tabu – unsuccessful tries are saved to a memory – tabu so they are not repeated.

a3) Hill climbing – criteria with maximal gradient are selected.

a4) Genetic algorithms base on generation of two codes where sum of them is a random number – rule (similar to Monte-Carlo principle).

b) *Two-step methods:*

b1) Simulation analysis applies the idea of returning from an unsuccessful step is not on the same path as during forward direction.

b2) Method of branch and bound applies criteria till the next unsuccessful step. In case of an unsuccessful step it is returning back to point where the step was still successful and continues in the path that has not been tried yet (tabu principle).

c) *Path methods*:

c1) Method of sequential application of criteria. This method bases on findings of an optimal sequence of rules outside the decision tree.

This method rises from the conclusion that rules are not independent, many interactions and relation exist among them and are connected to the same process. They create a network.

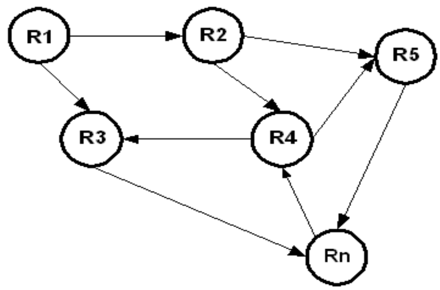
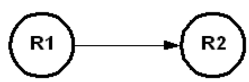


Fig. 53. *Criteria network.*

Relations among them are quantitative – we are able to express them in numeric or relation form, respectively qualitatively. Relation direction expresses the dependencies, e.g. rule R_2 depends of rule R_1 and direction expresses also subsidiary (reference, subordination).



Some information is coded in such network graph which can be used during definition of "suitable – optimal rule sequence".

Because it is necessary to solve a problem of multi-criterion optimization, it is possible to solve it by selecting one of the rules $\overline{R_i}$ as the main criterion for HKO optimization. Other criteria as a rule will be applied implicitly during creation of heuristic model.

A principle of "fishing net" is applied on such rule network. If we catch this fishing net by one knot - rule defined as HKO, then particular net will be arranged according the relations to HKO. For illustration, let us used HKO – R_n

By pulling HKO a net will get transformed into pseudo-tree and then it is clear that rules R_i are arranged into levels.

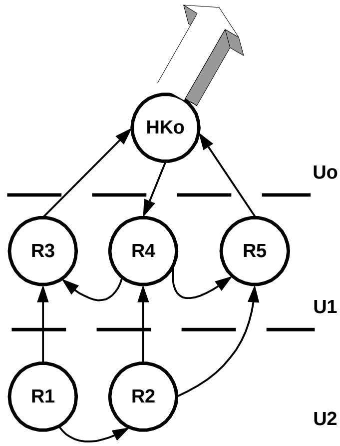


Fig. 54. *Criteria pseudo-tree.*

Relation of rules to HKO determines their importance in particular process and their priority while application to $\overline{Z}$. This way a "pseudo-tree" was created.

Next step is the change pseudo-tree of rules into a "chain" – rule sequence.

Rule order in the chain will be according levels:

$$\{U_o\} \to \{U_1\} \to \{U_2\}$$

It is necessary to create the order at each level. Once again subsidiary relation to the superior criterion will be used.

Second criterion will be from U_1 – either R_3 or R_5. Both criteria influence the value of HKO. Criterion that HKO will react most sensitively will become the most important, that is why it will appear as the second one in the chain. For illustration, let's say such criterion will be R_5.

Then the order will look like this:

$$HKO \to R_5 \to R_3 \to R_4 \to R_2 \to R_1$$

This pseudo-optimal sequence will be applied to $\bar{Z}$ and an algorithm will be created. This creates the basis for heuristic model creation for LS synthesis.

c2) second option would be the usage of Monte-Carlo method. This means to generate the whole sequence – criteria sequence. When an algorithm is created (=suitable model), this model can be used.

3.4.5 Synthesis Conclusions

LS synthesis is a process of creation of new innovated LS. Development of synthesis methods directs to unified type systems, partially valid and well algorithm (finance, transport, purchase). Though just as difficult it is to find two same companies, it is also difficult to find two same manufacturing processes, distribution networks, planning systems, etc. That is why for parts like procurement, manufacturing, distribution, transport, main material flow, etc we have to create "at-hoc" tailored made logistic systems. And there are approximate synthesis methods applied through:

- Case studies – analogy.
- Heuristic models – induction.
- Simulation models – imitation.
- Benchmarking – multi-analogy.

All these synthesis methods can be applied only by a designer who knows sufficient scheme of mathematical methods, information technologies and tricks of operative analysis and has satisfactory experiences and praxis because all these skills and knowledge create the background for simulation, heuristic model and for case studies.

Without achieving:

- suitable level of knowledge saturation.
- courage to create and be opened to new ideas.
- solutions of a big amount of concrete problems.
- awareness of solvability of each and every case, situation.
- creativity and synthesis of logistic or other systems is not possible.

3.5 Information Systems in Logistics

The information system is a computer program system, a tool that is used to integrate data from multiple sources are distinguished by identifiers in the specified stream information[1]. Information systems consist out such elements as:

1. *Equipment*- now mainly computers and:

- devices for storing data.
- devices for communication between the hardware components of the system.
- devices for communication between humans and computers.
- devices for receiving data from the external world.
- devices to influence the information systems to the outside world - elements (for example, computer-controlled motors).
- devices for non-data processing computers.

[1] M. Fertsch, K. Grzybowska, A. Stachowiak, *Logistyka i zarządzanie produkcją: narzędzia, techniki, metody, modele, systemy*, Politechnika Poznańska - Instytut Inżynierii Zarządzania, Poznań 2008, s. 231 -233.

2. Software.

3. Personal resources - people.

4. Organizational elements - the procedures for using the system, work instructions, etc.

5. Information elements; database, which is used in the system - for example, in the case of accounting manual accounting system.

Once we have defined what it is you can write a computer system, what is the information system in the general literature information system is defined as a part of the system and is designed and used in the enterprise workflow, based on the flow of information and the sharing of information managers. Nowadays we have many different systems used in enterprises. The first of these were introduced in the late 50 - 60's. Here will be described the best known of this group include systems such as:

1. *MRP* (Material Requirement Planning) –one of the earliest business computer applications, is based on calculating the aggregate demand for materials and semi-finished products based on the structures of stored products, standards of consumption and demand for its products.

2. *MRP II* - This is Manufacturing Resource Planning, is a response to the growing needs of users, due to the small capacity of the MRP; consists of scheduling the production on the basis of stored processes and production capacity.

3. *ERP* - This extensive functional category of information systems, the method comprising the MRP II and enriched with the support of financial resources and personnel over controlling and many others.

4. *CRP* (Capacity Requirement Planning) – “Part” of an ERP system is responsible for calculating the burden associated with planning capacity.

5. *CMR* (Customer Relationship Management) - category often independent systems, used for customer relationship management.

6. *WMS* (Warehouse Management Systems) - category of information systems used to manage warehouse processes.

Contemporary management of a company operating in the areas of logistics cannot be realized without the support of more or less sophisticated computerized technique. Management must be based on actual data, otherwise it is not worth much.

3.5.1 History of SAP

In 1972, five programmers and system analysts left IBM and founded his own company called Systemanalyse und programment wicklung (system analysis and software development) in Mannheim in Germany. The company introduced financial and accounting program operating on an integrated enterprise data in real time. Basics of the software implemented observed functional requirements of companies with similar business profile. A year later, the company switched Material Management System (materials management system), then the Purchasing modules (shopping), Inventor Management (asset management), Invoice Verification (invoice verification). In accordance with the determined direction of the module have the data module MM FI make available in real time, which of course associated with measurable benefits.

The company changed its name after the first successes for Systeme, Anwendungen, product in der Detenverarbeitung (Systems, Applications, Products in data processing) and moved its offices from Mannheim to Walldorf.

The market appeared Accounting Assets module (fixed assets accounting). SAP has also gained in 1977, the first foreign customer in Austria. Stwirzibe was the French version of the accounting module. From that moment on SAP products have become known internationally. A year later, SAP introduced its first true solution for the entire enterprise - R/2 On the market has been introduced module Cost Accounting (cost accounting).

At the end of the seventies followed by progressive centralization in the enterprise: SAP began to self- Siemens Server 7738, for the first time in its history. Until then, development activities of its employees have been provided by regional data centres ICI customers, Thermal, Knoll, Grünzweig + Hartmann and Freudenberg. The company continues to evolve, founded the first SAP data centre located in leased buildings. But soon after the first successes started the construction of its own premises. Followed also further improve the system and technological changes. The rivalry with IBM and construct similar databases and dialog control system by the American company makes SAP quickly rethink their actions in the field of software development, paving the way for SAP R/2, even more innovative.

In 1980, SAP's products were at 50 on the list of the 100 best in Germany. Four years later he became the first customer of SAP concerned control and production planning. Work has begun on modules Personnel Management (Personnel Management) and Plant Maintenance (Plant Maintenance). SAP has also noted its presence in many European countries and began efforts to overseas markets: especially when it comes to Canada, USA, South Africa, India, South America and Kuwait.

In 1986, SAP was first presented their product R/2 at the largest IT fair - CeBIT. The main German competitor IBM introduced the System Application Architecture (SAA - System architecture application) implementing the concept of a multi-level architecture of different types of software, this has led to the use of platform- independent applications, graphical user interfaces (GUI) and a standard database management systems (DBMG). This approach has much in common with that shown in the beginning of the 80s the OSI model, on open computer networks. SAP has used the idea of SAA as a skeleton for the created then R/3 SAP decided to create all business applications in an ABAP / 4. Highly successful was the transformation in 1988 of SAP in a joint stock company. In Walldorf was opened to international training centre.

The company's revenue in 1989 reached a level of DM 831 million, half of which was established outside Germany. During this time, the R/2 was already available in 14 languages, including Russian. SAP has launched the R/3 for the UNIX platform - a system of client - server architecture designed to support the entire enterprise. It was one of the major achievements in the history of the company, which resulted in a huge increase in its revenues.

In 1993, SAP and Microsoft started working on the integration of applications such as Word, Excel, Project and Access of business software, SAP. In parallel, SAP and Microsoft have moved the R/3 on Windows NT platform. SAP America opened a development centre in Forester City - one of the cities in Silicon Valley. SAP presented Kanji version of R/3 1994. SAP already had more than 1,000 customers using R/3. The development process of the SAP R / 3 has received ISO 9000 certification. On the market was introduced version 2.2 of SAP R / 3, in which the main emphasis was placed on the logistics.

In 1995 he had 2000 SAP customers R/2 to 4,000 customers and R/3 in the world. Presented a new version 3.0 of SAP R/3 was a huge leap functional, especially visible in the module Production Planning (production planning). SAP R/3 has been ported to the IBM AS/400. SAP presented the information and process solution for enterprises, inter-real, the chemical industry, the pharmaceutical, the food and brewing. SAP also presented Application Link Enabling (ALE - enabling applications to connect), a solution that allows applications running on different computers can connect to each other. But it also allowed the SAP system to maintain a strategy of integrated applications even in client-server environment with asynchronous message - based, combination in fact distributed, but still integrated applications on different computers. To support the work of the project implementation of SAP has launched a complete environment consisting of implementing the R/3 Reference Model, R/3 Business Navigator, Procedure Model and Implementation Guide. The centre was opened Walldorf service and technical support.

The second half of the nineties was very successful for SAP, business architecture diagram, whose main goal was to speed up and facilitate the process of introducing new functionality to the system. Thanks to SAP's products have become even more flexible and open. SAP introduced web applications, presented a methodology to quickly implement the Accelerated SAP (ASAP), which was based on the experience gained during hundreds of SAP implementation projects. The German company has finally undisputed leader on the list of manufacturers of complex solutions for the industry. Within a month were coming at that time an average of 750 new customers of SAP. Presented as a result of these successes, the novelty Team SAP. Cooperation with the mobile market has led to the fact that Motorola has implemented SAP HR for 25 000 users.

In 1998, SAP map coincides with the 19 key industries. On the market was introduced SAP R/3 version 4.0. SAP also presented Enjoy SAP, which was make the SAP system will be even easier to learn, use, and adapt to individual needs. Company management announced New Dimension Initiatives (initiative a new dimension) such as SAP Customer Relationship Management Initiative (SAP initiative management of interfaces with customers), SAP Business Intelligence Initiative (SAP smart business), SAP supply Chain Management Initiative

(Initiative of SAP Supply Chain Management) SAP advanced Planner and Optimizer (advanced Planner and Optimizer SAP), management cockpit, SAP strategic Enterprise management (strategic management of the company), SAP Business information Warehouse (Warehouse business data) and Enjoy SAP (SAP enjoy - I).

In the last year of the second millennium, SAP launched mySAP.com, thereby performing a shift towards the Internet market. Introduced lateral program is related to outsourcing services and application sharing. SAP has released special flexible licenses, so that they can be shaped according to specific needs. SAP does not have to wait long to welcome its first customers for mySAP.com (these were, among others. Football club FC Bayern Munich financial services provider MLP and others). Later work also established Hewlett -Packard, Ford Visteon and pharmaceutical group Hoechst Marion Roussel[2].

In the new millennium, SAP has become a leading provider of software solutions for e-business, integrate processes within and between companies in the world[3]. The company was also the third largest seller of software on the planet. Already employed at that time were more than 24,000 employees in more than 50 countries and generated revenue increased by 23% compared to 1999. There are new campaigns and the introduction of other innovations as well when it comes to selling products and advertising. In 2001, SAP has added to its portfolio a number of corporate portals through acquisition, among others. Top Tier, a leader in the Israeli market. From revolution to evolution, is another well-known campaign of SAP, which expanded mySAP.com, allowing appeared on the market a comprehensive technology for business applications. He maintained a steady

[2] V. Kale, *SAP R/3: Przewodnik dla menadżerów,* Wydawnictwo Helion, Gliwice 2001.

[3] http://www.sap.com/index.html.

growth of the company's revenue, customer faith in SAP was still indomitable, which resulted in an increase in revenue once again by 17%.

Thirty years after his assumption of SAP was the third -largest independent software manufacturer in the world and the flagship of the German economy. Brands SAP meant high quality software. In 2002, there was a dedication of a new building in the shape of a star, which was a directly adjacent seat at SAP headquarters in Walldorf. Another great success is a new product released by the company - NetWeaver. This technology has allowed SAP to offer fast, open and flexible applications that handle business processes to the end - regardless of whether they were based on systems from SAP and other vendors.

Research conducted on behalf of identified SAP enterprise Germany “best employer 2005” among other companies employing 5,000 employees or more. In February of this year, SAP officially opened a new R&D facility in the Hungarian capital, Budapest. The company's revenue from sales of software licenses increased by 18%, with particularly high growth rates were at that time in the Americas. More than 35,800 SAP employees worldwide generated total revenues of € 8.5 billion. In 2006, SAP and Microsoft have introduced “Duet”, the first product of the two companies formed the joint efforts for the development, operation, sales and marketing. This software will allow users to quickly and easily integrate Microsoft Office and business processes supported by SAP. Both partners have sold 200,000 licenses only in the first three months of sales.

The effects of the global financial crisis, which in 2008 reached serious dimensions also affected SAP. The company initiated the personnel cuts and other austerity measures. SAP supported its customers with special programs to help them recover from the crisis and to succeed. In this year's New York office, SAP presented its SAP Business Suite 7, which was designed to help companies optimize their performance and reduce costs.

In 2010, SAP announced its intention to purchase California Sybase for about 5.8 billion U.S. dollars. Sybase was the largest software company and IT service provider. SAP has always allowed the optimal management of the company - has chosen them over before 80,000 small and medium-sized enterprises.

SAP software is:

- Offered at an affordable price to small and medium-sized enterprises.
- Each company is unique by SAP, because it offers a full range of business management software and business intelligence solutions that fit your budget consumer and business method.
- •Designed for business every entrepreneur.
- SAP solutions for small and medium-sized enterprises have been developed as a comprehensive offer that includes a wide range of functions supporting the management of the company. The software is easy to use - for fast implementation of a small number of training. Is also characterized by flexibility - solutions are scalable and can be customized as your business grows. All our solutions are based on best practices developed from over 35 years of SAP experience and collaboration of the best-managed companies.
- Easy systems to implement and maintain.
- The offer includes both affordable solutions implemented locally, as well as on-demand solutions with a monthly subscription - the software can be implemented within a few weeks by SAP and its wide network of qualified partners.

3.5.2 The Flow of Information in the Logistic System

In the logistic system in parallel with all the flows of goods flowing information which is necessary for the efficient and proper conducts of the transaction. Although commodity always flows from the sender to the recipient, the associated information runs bidirectional (Fig. 55).

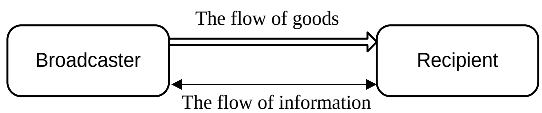


Fig. 55. *Flow of information and goods between the parties to the transaction in the logistics chain. Source: own.*

Information flows in the sphere of logistics are central to the creation of efficient supply chains. In external relations create customer relationships - supplier, and in terms of integrating internal business operations from sourcing, through production, through to distribution. They form the “nervous system” of the company used for efficient resource management and control activities in the field of manufacture, storage and transport. As a “catalyst management” it determines its effectiveness. It is a factor of production posed on a par with land, capital, labour force and entrepreneurship.

In general, information flows can be divided into those with a decision-making or executive. However, do not belittle those that include communication within the company, because they are the basis for information systems and thus help manage and optimize all activities in the supply chain.

Today, a growing number of information transmitted in the distribution channels, it is forced by the globalization of markets, the growing range of manufactured goods and the dispersal of production tasks in terms of territory and technology.

In order to clear the area of management of goods, has introduced new channels of communication. They are used to transfer the enormity of information through modern telecommunications and information technology. The processes of data processing are fully automated and fully man in them a supervisory role. Therefore, systems have become indispensable to the functioning of logistics systems and are now an integral part of them.

Information measures are used for the following functions of logistics:

- planning of logistics processes.
- coordinating operations and events.
- monitoring of the tasks.
- Process control.

These functions are performed by all cells of the logistics system along the entire chain of goods.

AI Systems and EDI.

Reaching to the early applications of information technology in logistics, you can find a system of automatic identification of goods (AI). It allows the identification and control flow of huge quantities of various goods in the channels of the logistics system. The simplest example of such a system, noticeable in everyday life, is the system of EPOS (Electronic Point of Sale) at the supermarket. Based on barcodes and product database using the reader to easily identify the goods along with prices and adds them to the shopping list. Barcode is nothing but a particular combination of linearly arranged black and white lines of different widths, representing a string of well-defined characters that can be read by means of the integrated system.

Identification systems based on barcodes enjoy far the most popular, but you should mention other identification methods, such as radio waves, magnetic path, the method of character recognition, or image.

Automatic identification of goods in computer systems was inseparably accompanied by electronic data interchange (EDI Electronic Data Interchange). Correlating these techniques allows just after placing your order, complete shipment and issue the relevant documents on the basis of data from the packaging read reader and immediately send it to the recipient. Upon receipt, the recipient scans each batch and compares the read data with a complex system order. After obtaining compliance is generated delivery confirmation that the EDI send to the sender. This paperless exchange formatted documents, allows communication between computerized systems contractors, without undue interference employees. Electronically exchanged data counterparts purchase orders, invoices, etc., and therefore are called documents. The basis of EDI technology is e-mail. Experience has indicated that the combination of systems of two entities in the network is not sufficient for data exchange. It was necessary to first adjust the documents received via e-mail, to force the company standard.

EDI is an international standard, platform-independent software and hardware. Sending documents within the EDI takes place via electronic links between computers, rather than using the standard media. Of course, this type of media, you can also capture standard EDI data and transfer it between computers, but we lose the time and we need to better involve the employee.

The use of EDI requires the use of available and reliable network transmission equipment. The base system is the transfer of standard messages that are unified commercial documents. They provide a specific set of words and grammatical rules taking into account the needs of users in different countries. This system is applicable in all levels of the market, trading companies, manufacturing, service, as well as banks and insurance companies. Suitable software enables the implementation of EDI and the following functions: export / import data and their conversion, receiving and transmitting messages, control and management of marketing documents.

For communication between the partners in the EDI system, uses a public telephone networks and web sites (technology WebEDI). In implementing the system, the company significantly improve the functioning of the supply chain and increase the level of customer service[4]. Shorten the cycle of orders, sales, invoicing, delivery and payment, resulting in reduced inventory levels, release working capital and reduce storage costs. Currently, communication cycle in the logistics chain is done electronically. Today, making purchases on the Internet in "virtual stores", the client automatically becomes a link in an integrated logistics system.

3.5.3 Types of Information Systems in Logistics

The rapid development of computer technology has made computing more three decades ago, hardly pretending to being a scientific discipline today is widely recognized as a distinct science. By moving its benefits in the realities of business logistics system, we get the ability to generate and collect data, and then the processing and analysis, the results of which also can be presented using the techniques, methods, tools and technologies. All these processes together form a computer system.

Among the most famous of the logistics management information systems, we can mention:

[4] M. Sołtysik, *Zarządzanie logistyczne*, Wydawnictwo Uczelniane Akademii Ekonomicznej w Katowicach, Katowice 2003, s. 14.

- MRP - Materials Requirement Planning, that is, material requirements planning system.
- MRP II - Manufacturing Resources Planning, or manufacturing resource planning system.
- DRP - Distribution Resources Planning, or distribution resource planning system.
- ERP - Enterprise Resource Planning, or enterprise resource management system.
- ECR - Efficient Customer Response, which is a system of effective consumer service.
- SCM - Supply Chain Management, or supply chain management system.
- WMS - Warehouse Management System, a warehouse management system.
- CRM - Consumer Relationship Management is a scheme of customer relationship management.

The role, structure and systems that comprise the Logistics Information System.

MRP - this is a strategic planning system integrated in a closed, which is used for the management of materials.

MRP system is divided into three components:

- Primary production schedule.
- The complex structure of the components forming the article.
- Statement of changes in inventories.

The main tasks of MRP include:

- ensuring the required quantities of materials, products and components for the planned production, or delivery to the customer.
- optimization of inventory levels.
- production planning, purchasing and supply.

MRP II - is an extension of MRP. It combines a whole set of processes needed to manage the production, enriched with cells derived from other functional departments of the company. It also has a greater sensitivity to changes in demand, which allows you to reduce inventory costs and downtime of the production line. This also translates to more efficient and better delivery of customer contact.

Overall:

MRP II includes:

- planning projects.
- planning of production.
- Material Requirements Planning – MRP.
- Capacity Planning - CRP.

DRP - is a system that defines the demand for stocks of all company distribution centres. After collecting data on the subject it sends them into the material and production. This action allows you to specify when the recipient requesting them the product at point of sale and create a matching time schedules requests for said product in a specific cell distribution.

The benefits of DRP module are:

- improve customer service.

- reduce the risk of stocks are exhausted.
- reducing the level of stocks of finished products.
- reduction of transportation costs.
- improving the efficiency of the distribution centres.

ERP - this type of systems is addressed primarily to manufacturing companies. It is used to optimize internal processes and resources of the company[5].

It also allows control of market linkages and greater range of control of the supply chain outside the company.

ERP successfully integrates:

- Business processes - applies modelling and process management and data flow.
- Information systems - applies to automate the flow of data and mapping, as well as functions between systems.
- Platforms - is the integration of technology infrastructure.

In subsequent years, the ERP system was developed for standard ERP II, enriching it mainly functions to enable seamless communication with business partners[6].

ECR - a kind of management strategies used in the supply chain of goods frequently purchase. The system integrates together all the cell distribution, or retailer, distributor and manufacturer so that faster, better and more effectively meet the needs of the customer. This choice of the consumer demand and

[5] J. Auksztol, P. Balwierz, M. Chomuszko, *SAP. Zrozumieć system ERP*, Wydawnictwo Naukowe PWN, Warszawa 2011, s. 15-17.

[6] E. Gołembska, M. Szymczak, *Informatyzacja w logistyce przedsiębiorstw,* PWN, Warszawa 1997, s. 28.

generate his needs become a reference point in the chain of action in its entirety. Information travels from the point of sale by all levels of distribution until the manufacturer, starting production at the right time.

Basic processes on which the ECR are:

- effective replenishment of products.
- assortment of shop floor management.
- promotion.
- the introduction of new products.

SCM - a system that allows the development of clear principles of co-operation between co-operatives throughout the distribution chain. It allows you to optimize the efficiency of the production and distribution of a particular product, as well as its distribution channel or supply of materials. The condition for the implementation of SCM is an early implementation of the ERP system, so mastering the internal resources of the company. With the introduction of SCM is treated in detail the issue of planning and supply chain execution. SCM gives you the opportunity to create a model of the entire supply network with all its limitations, then the appropriate synchronization operations, and planning the flow of goods throughout the supply chain. All these features together provide a new quality of flow processes, different from that which offers ERP[7].

WMS - is a specialized system for the general improvement of processes in warehouses. WMS due to its specificity is very often a technological support for ERP management system. It provides accurate information about inventory and deployment individual batches or even individual items. The most important

[7] https://www.sap.com/poland/pc/bp/erp.html.

function of this system is the planning of shipments from the warehouse to optimize the use of available transport resources.

CRM - the infrastructure for specifying clients in terms of value, the selection of appropriate and motivating for subsequent purchases and loyalty to the company.

The main features of this system include:

- The collection and processing of archival data dealing with customers.
- Automate the organization and management of sales.
- Collating orders on request.
- Preparation of tenders.
- Finding the necessary data.
- The preparation of forecasts and analyzes of sales and marketing.
- Generating a list of clients.
- Care of the acquired customer.
- Communication with the market.
- Administrative tasks concerning the organization of tasks within days.

3.5.4 MRP and Other Logistics Systems

MRP is an abbreviation of the English words: “Material Requirements Planning” and is translated as material requirements planning (raw materials, components). This is the method that is used for planning and control of production and inventory management system. Majority of the MRP method is based on special software computer, or if this is not possible based on the planning manual. In 1964, Joseph Orličky developed a system of MRP. Company

Black & Decker Dick Alban as the leader of the project very quickly took advantage of the new system and has achieved commercial success. In 1975, a new method was already so good that it respected the approximately 150 companies. In subsequent years, thanks to the spread of computers, MRP was implemented in about 9 thousand companies.

Processes occurring in the MRP:

- Checking the availability of materials.
- The demand for the material is the balance sheets of deliveries that are to come, or are in the process of production, in order to determine the availability of the material at the desired time.
- Balancing the execution time.
- On the basis of material requirements and time information necessary for their implementation, shall be the date when the order should be issued.
- Develop product structure.
- The process of making scheduled to release orders for the parent item will produce in timely orders for each of the sub-items.

Before MRP has the task of how to calculate the exact amount of materials and delivery schedule in such a way as to meet the ever evolving demand for individual products. These techniques are often supported by relevant systems.

Objectives of MRP:

- reduction of inventory.
- precise time of supply of raw materials and semi-finished.
- accurate determination of the cost – production.
- better use of existing infrastructure (warehouses, production capacity).

- respond more quickly to changes in the environment.
- control the various stages of production.

MRP II system is an integrated, multi-user system designed to support the management of a manufacturing company. The main functions of the MRP II are:

- demand management.
- planning of sales.
- production planning.
- material requirements planning.
- specifications of the products.
- transactions flux material.
- control orders.
- control of the production workshop.
- capacity planning.
- control of the workstation.
- purchases of materials and passive cooperation.
- distribution resource planning.

ERP (Enterprise Resource Planning) is a term class information systems supporting company management or interaction group of cooperating enterprises, the collection of data and to enable operations on the data collected.

DRP (Distribution Requirements Planning) is an important part of planning the logistics of distribution. Distribution planning is to determine when the part of recipients there is a demand for the final product to create a point of sale and time-oriented scheduling demands on the product distribution in each cell.

CRM infrastructure to identify and increase customer value, and adequate measures for which help motivate the best customer loyalty, or repeat purchases. CRM is much more than mere knowledge of customer management and monitoring of their behaviour[8].

WMS (Warehouse Management System) is a highly specialized system, streamlining all the processes in warehouses enterprise logistics operators, who in their terminals and warehouses support a very large number of different items. The logistics companies WMS is often the technology supporting activities of ERP management system. It should provide information on inventory, as well as enable the efficient location of each lot and each individual shipment. The system allows control of quantity and assortment of goods adopted.

SCM is a supply chain management (SCM) is an application that allows to establish closer and wider cooperation of all operators in the production and sales and the removal of unnecessary loss and interference.

Electronic Data Interchange (EDI) means business transfer transaction information from computer to computer using standard, accepted message formats. The purpose of EDI is to eliminate multiple data output and increase the speed and accuracy of the flow of information through a combination of relevant computer applications between companies participating in the exchange. The use of EDI allows improving the temporal availability of information logistics, expanding and refining the data, and reducing labour intensity of the process. To take full advantage of EDI, logistics channel members should communicate via computer. In other words, the effective implementation of EDI requires direct communication between computer systems, both buyers and sellers of the product.

[8] http://www.sap.com/pc/bp/customer-relationship-management.html.

GPS (Global Positioning System) is one of the fundamental solutions to support the monitoring of shipments. It allows positioning of objects moving through satellite navigation.

The development of assistive technology to send information (Information Technologies - IT), such as EDI, as well as the rapid development of the Internet in the past few years, on the one hand facilitate the work of shippers, on the other hand has increased customer expectations for service quality. It is not far for purchases made on - line, which contributed to the increase in the value retail and what the associated increase in demand for shipping services. More important are the changes in the way companies present on the market - transport services. Thanks to the Internet as possible has become faster and cheaper transfer of information between shippers and their contractors. However, there is always the provider of logistics services is able to meet the growing expectations of our customers and constantly adapt themselves by using the software to changes in the company.

3.5.5 Framework for the Creation of Logistic Systems

The framework conditions for the development of international logistics systems can be divided into the general and specific to the individual states, as opposed to the development of national logistics systems. The general framework conditions, characterizing international logistics processes include:

- transport distances - distances to defeat international logistics systems are larger, which results in the same conditions, longer delivery or re- supply, greater uncertainty in the case of forecast demand and higher inventory. Erroneous decisions logistics will be a greater impact on both the service and the costs than the national logistics systems.

- means of transport - in international transport logistics systems must often organized as intermodal transport. For the creation of international transport chains must be combined transport with very different technical characteristics. Due to their different technical characteristics, the structure of the cost of transport is also very diverse and different are also capacity. Their knowledge is a prerequisite for rational decision-making.

- institutions - the planning, implementation and control of international logistics processes is involved larger number of institutions. This applies both to the physical flow of goods and imposing on him the flow of information. In addition, the supply or distribution of the international monetary flow is often closely associated with the logistical flow of information and goods. International logistics systems require better coordination, better communication and greater control.

- documents - the diversity of institutions involved in international logistics processes results in the existence of an even greater variety of documents that are exchanged between them. Canadian Studies show that for a typical shipment specified 46 different documents, including a 360 copies. Individual documents are each adapted to the demand for information by the relevant institutions. Their existence is often conditioned historically and they differ in their form, as they contain the same information. In any case, a variety of documents hinders communication and results in higher operating costs orders.

- Information - closely related to the document is to collect, transfer and of the processing of the necessary information, but they do not exist in the same form in all institutions involved in the logistics process. Missing, incorrect or late information impair the operation or increase the cost of logistics. Barriers to the flow of information depend largely on the different framework conditions specific to different countries.

For a specific framework conditions of different countries understood to be different in different countries and conditions of logistics processes. They include:

- The legal framework - in different countries have their roots in a diverse approach to the functioning of competition in the markets in which there is a supply and demand for services. To facilitate the exchange of goods includes the bilateral and multilateral agreements in order to agree on regulations in force in each country.
- Administrative framework - they characterize the mode of application of the legislation and the organization of processes and information flows of goods in international trade and are the result of existing administrative structures and procedures in different countries.
- Technical framework - are partly the result of different legal regimes concerning the dimensions and weights used consumables. However, they may also result from differences in the investment policy institutions involved in logistics processes.
- Infrastructure and geographical framework - mainly due to the topographical conditions in different countries. Is the result of addition carried out in these countries policy towards road transport and communication networks? Only recently has the infrastructure is oriented in the context of the larger economic areas, such as the European Union. Particularly important framework for infrastructure at border crossings, where limited clearance disrupts international logistics processes.

- Cultural framework - different mentality, education systems and languages in different countries are a significant barrier to international organizations logistics systems. As a result, communication is difficult. In turn, the differences in labour productivity of logistics personnel in various countries make it workable logistic system of one country can't be taken over by other countries.

3.5.6 Ratings and Measures of Logistics Systems

Assessment of logistics companies is necessary for the proper development of their business and the efficiency of logistics processes. Study the effects of implementation of logistics systems assessment processes are needed to monitor, control and improve their performance.

For efficient evaluation of logistics systems are indicated adequately planned evaluation systems that have high quality content specialists in statistics, informatics and quality assurance, as well as the appropriate equipment.

Each logistics system is characterized by a combination of parameters in terms of spatial, temporal, technical, organizational, and economic, as well as a set of measurable features heavily (irrational). For these parameters, you can qualify for appropriate measures to investigate the quantity and value of both input and output of the logistics system[9].

These meters show the comparison of the results of the logistics activities with the objectives that have been brought to various logistics functions within the company and are associated with:

- costs.

[9] R. Kozłowski, A. Sikorski, *Nowoczesne rozwiązania w logistyce*, Oficyna Wolters Kluwer business, Kraków 2009, s. 40- 42.

- performance.
- service.

J. Twaróg distinguishes the following evaluation criteria:

(a) The criteria for evaluation of the cost may be the cost per unit of weight for the shipment or order, compile the cost of implementation here given the logistics process with the objectives set and, if necessary, amended as necessary correction. The most important should be shipping the product.

(b) The criteria for assessing the performance of present value to investment results. They express the format of the company's production per unit of effort, or the ratio obtained effects of the investment. Measures of performance results can be: the number of completed orders, the weight of goods loaded, the weight of cargo shipped, delivered or the number of shipments. While expenditures are measured in hours of operation, according to the number of employees or the means of transport, as well as in the cells used plane storage.

(c) The criteria for assessing service quality of logistics services specify which is more and more important in today's competitive global markets. Can be defined in such categories as time consistency, accuracy and the number of cases of damage to the goods[10].

Gauges and indicators Logistics is a set of analytical tools for measuring and assessing the effectiveness of processes and logistics systems. Their most important task is relevant and reliable reflect actual form. Distinguished:

- meters.

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[10] J. Twaróg, *Mierniki i wskaźniki logistyczne*, Instytut Logistyki i Magazynowania, Poznań 2003, s. 21 i n.

- indicators.

The measure is the number characterizing a phenomenon, giving the measure, which allows to compare them with other phenomena.

The meter is understood as an economic category and logistics reflect events and facts in the management of the company, as well as in its surroundings, which are expressed in the correct units of measurement. There are the following measures:

- simple, expressed mostly in the measures of natural.
- composite (aggregated) - include in the expression of value the different components, allowing a synthetic evaluation of performance.

In order to name the rationality of logistics data are necessary for logistics processes, logistics performance measurement (to measure what it wants to control) the variation of efficiency, effectiveness and economy. The test event logistics can be conducted in both the short - and long-term.

The indicator will call the number expressing the relative combined ratio ranges undeniable statistics, such as product price index.

The index is an economic concept that reflects the events, as well as the facts of the flow of materials and related information in the logistics enterprise and supply chain. Indicators can be used only to format equivalent, are used to evaluate the actions and effects of logistics systems companies, as well as combinations thereof. Show the experimentally observed and measurable form of actual, which is not the worst properly describe the purpose or aspirations logistics system. They are treated as tools of economic logistics, and logistics impacts, including indirect instruments of traffic management of raw materials and finished products. They are used to:

- measuring the effectiveness of logistics systems.
- determining quantitatively formulated goals.
- the achievement of the logistics activities of the company.
- the satisfaction of customer needs.

Indicators are needed for logistics planning and control, process control and logistics. Logistics is focused on the circulation of material information.

When creating indicators should adhere to the following requirements:

(a) the adequacy - the indicator should adequately represent the actual reality in the enterprise, as well as the evaluation of the implementation process from the point of view of the customer supplier and the manufacturer.

(b) timeliness - the assessment must be the most current and must recognize the long-term effects of current activities.

(c) materiality - the indicators should provide essential information for decision-making.

(d) accuracy - indicators need to create a foundation for decision-making and directly be associated with the program companies.

(e) extent - rate must cover a lot of real states surveyed enterprise and as soon as possible to signal emerging problems.

(f) completeness - an indicator must allow for the complete recognition system implementation and evaluation of all processes from the beginning to the end of the operation, for a complete description of the need to create a large number of parameters.

(g) Comparability - indicators must be close at different times within a company, between companies, as well as links in the supply chain.

(h) the unification of units, categories or brands - must describe a similar rate as in all organizational units of the enterprise and beyond, it allows comparative lists in order to debug the broader enterprise.

(i) intelligibility - indicators should be constructed of measurement understandable by both the evaluators as well as the participants, entities which are subject to assessment and managers.

(j) compatibility - the information must be available to existing enterprise information system, and enable the creation of construction indicators.

(k) the costs and benefits - the creation of indicators must be effective, and the costs of measuring and creating indices correlated with the interests of the function that defines the tasks.

We conclude that the purpose of the application of modern information technology, including integrated management systems in enterprises is to use them competitive advantages resulting from better control of internal and external processes, better information and improve the operation of the organization.

Management systems will have for a long time will be the main source of information in enterprises, both in Poland and in the world. The emergence of new technologies and management methods will influence the development of IT solutions for businesses and today it is difficult to predict how they will look like support systems for 10 or 20 years.

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4

Design of Logistic System – Applications

4.1 Design of the Logistic Strategy

This study based on transformational leadership, which underlines the value of managerial behaviour supporting subordinates capabilities and motivation to develop them, increase their self-worth, work towards the benefit of a group, and build base for learning which helps a person to evolve and transform toward new level of capabilities.

Burns (1978) differentiated with transaction and transformational leadership, transnational leaders lead through social exchange, like politicians lead by exchanging one thing for another; jobs for votes, etc. Transformational leaders are those who stimulate and inspire followers to both achieve extraordinary outcomes and develop their own leadership capacity.

Bass (1985) defined four main "*I*"s as cornerstones of transformational leadership: idealized influence, inspirational motivation, intellectual stimulation and individual consideration [1]. The theoretical frame is based on transformational leadership, Bass' Directions of outputs [3].

A holistic but simple model of a human being (profile) from resource allocations to behaviour and finally to outcome directions and outcomes has been built basing on psychic, social, functional, organizational and structural factors [12] and put together according to the Sand cone model (Takala et al MD'2005, Takala IJMTM'2002, Ferdows et al 1990) and decision maker's outcomes in transformational leadership [11,13]. A reactor is stable on a very limited area, and adaptively monitor and react to the change in the environment in a systematic and effective way [11, 13].

The mathematical calculations are based on information collection by Analytical Hierarchy Process where qualitative objects are converted to quantitative values [9].

4.1.1 Methodology

Research Strategy and Methods

1. With the theoretical frame of reference we measure empirically by deduction profiles for transformational leadership by using Analytic Hierarchy (AHP) questionnaires. Questionnaires were distributed to 2 cases institution, one in china where 10 managers were interviewed, the other in Slovakia where 5 managers were interviewed. The Chinese case institution is a Public health administrative organization, which in charge of public health propaganda and coordination of the city. Questionnaire was distributed to 10 main principal within the organization.

2. Statistical tests will be made to find out the logic in the leadership profiles to increase the accuracy, statistically analytical models will be built and tested to measure leadership skills by leadership indexes from resource utilization to leadership behaviour and finally to outcome directions and outcomes.

3. Finally models are built to measure the effectiveness of leadership within different areas of outcomes. We try to find out the correlation between these outcomes and leadership indexes in a forecasting way.

Definition and Formula

1) Prospector

Oriented for future and extra effort, The people in the prospector group are looking further future and are willing to make some sacrifices at present to reach the goal set in the future.

$$1-(1-(EE^{1/3}) * (1-EF) * (1-S) * Std^{(1/3)} \quad EE>0.43,\ EF,\ A\leq 0.57$$

2) Analyzer

Oriented between prospector and defender, Analyzers are balanced between these two groups mentioned earlier.

$$1-(1-(S^{1/3}) * 1-(Std^{1/3}) \quad SA>0.43,\ EE,\ EF\leq 0.57$$

3) Defender

Oriented for effective use of existing resources at present, Defenders are conversely making good results currently and putting less effort to the future.

$$1-(1-(EF^{(1/3)})) * (1-EE) * (1-S) * (Std^{(1/3)}) \quad EF>0.43,\ EE,\ SA\leq 0.57$$

4) Reactor

All the rest of the leaders' categories. Earlier literature defines Reactors as unstable and inconsistent with their leadership style by having mixed characteristics of all the other categories. On the contrary, we claim according to the analyzed new research data that "Reactors" can be characterized as highly adaptive, effective and systematic. Reactors are strongly self directed and confident to make quick decisions. Due to lack of resources Reactors have learned to rely on their skills and abilities to succeed as a leader. In this paper, according to the definition, based on the value of EE, EF and SA, interview results of two managers from Chinese case institution can be classified as reactor, one lies between analyzer and prospector, the other lies between defender and prospector. We will use the simply average to calculate reactor:

1/2(Analyzer+Prospector) OR 1/2(Defender+Prospector)

Others

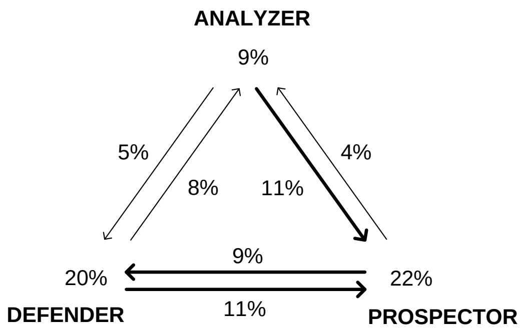


Fig. 56. *Change in outcome direction of different leadership group.*

('EF') = Effectiveness; how to meet or even exceed the objectives on results and performance.

('S') = Satisfaction; to the leader.

('EE') = Extra effort; to create entrepreneurship.

('Std') = std deviation in E, S and EE.

4.1.2 Results

Tab. 8. *Different index of Chinese case company.*

	RI	LI	OI	TL	ICR	STD
Interviewee 1	0.214	0.270	0.981	0.057	0.084	0.145
Interviewee 2	0.316	0.046	0.165	0.002	0.172	0.342
Interviewee 3	0.250	0.545	0.973	0.132	0.116	0.306
Interviewee 4	0.302	0.385	0.575	0.067	0.114	0.077
Interviewee 5	0.618	0.242	0.939	0.140	0.066	0.330
Interviewee 6	0.475	0.151	0.990	0.071	0.126	0.077
Interviewee 7	0.143	0.194	0.978	0.027	0.064	0.191
Interviewee 8	0.215	0.138	0.971	0.029	0.150	0.194
Interviewee 9	0.415	0.260	0.155	0.017	0.136	0.412
Interviewee10	0.427	0.473	0.120	0.024	0.464	0.291

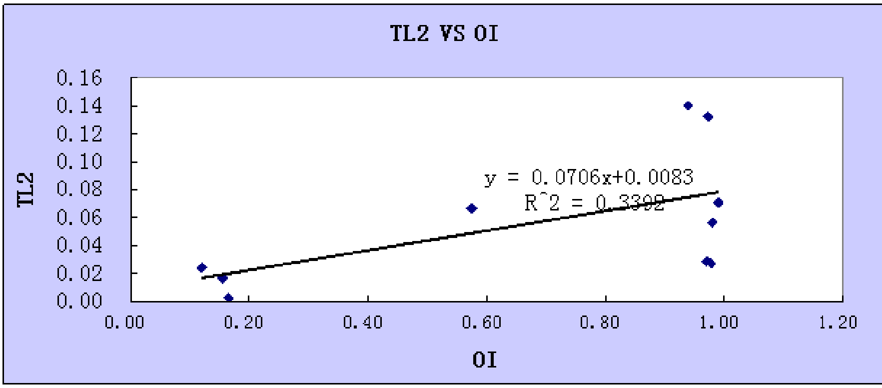


Fig. 57. *Total leadership index VS Outcome index of Chinese case company.*

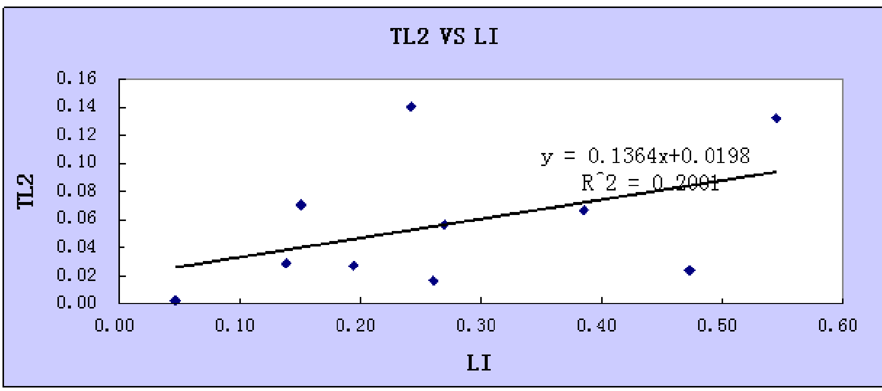


Fig. 58. *Total leadership index VS leadership index of Chinese case company.*

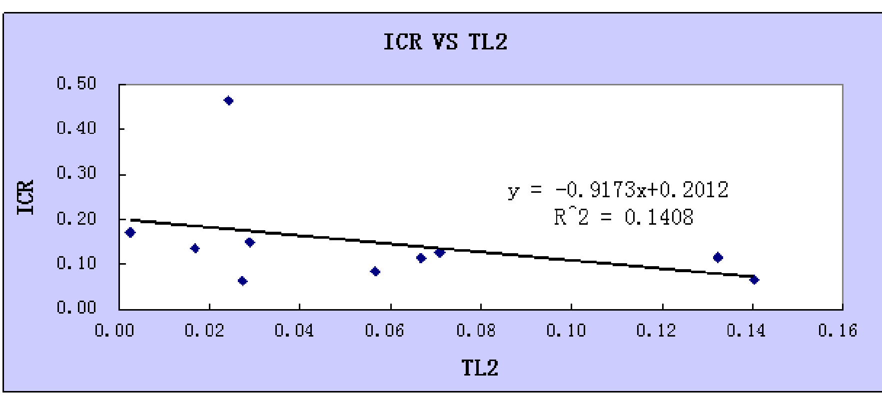


Fig. 59. *ICR VS Total leadership index of Chinese case company.*

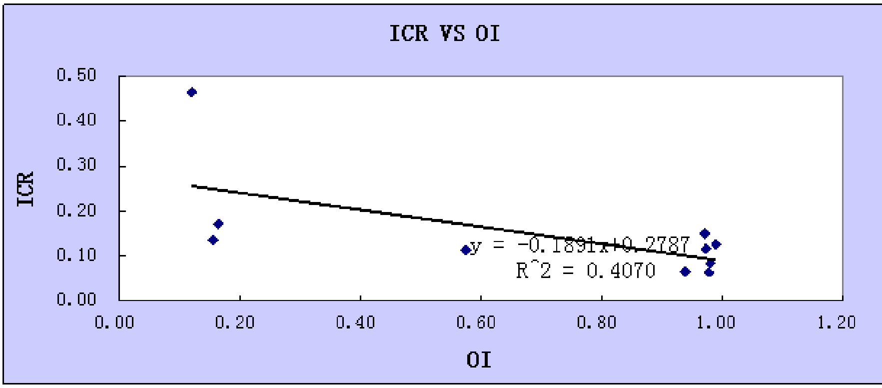


Fig. 60. *ICR VS OI of Chinese case company.*

Tab. 9. *Different index of Slovakia case company.*

	RI	LI	OI	TL	STD
Interviewee1	0.103	0.292	0.931	0.028	0.363
Interviewee2	0.090	0.239	0.957	0.021	0.265
Interviewee3	0.277	0.347	0.979	0.094	0.144
Interviewee4	0.331	0.133	0.982	0.043	0.180
Interviewee5	0.106	0.143	0.978	0.015	0.251

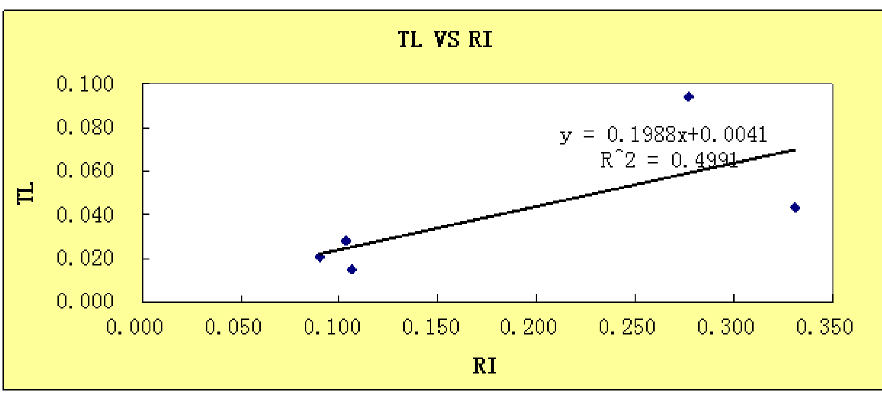


Fig. 61. *Total leadership index VS resource index of Slovakia case company.*

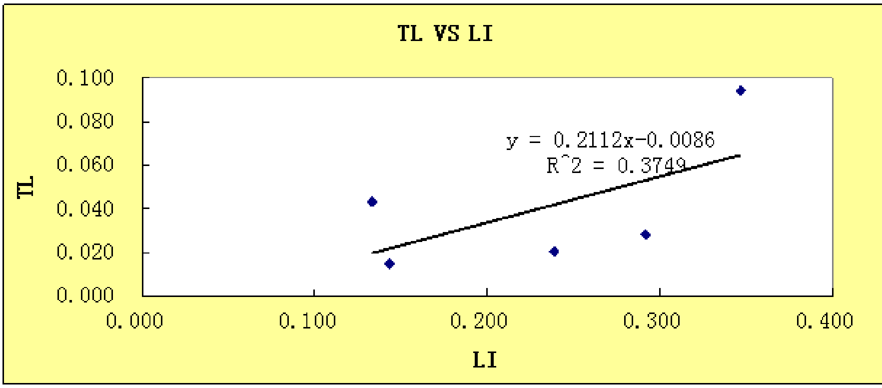


Fig. 62. *Total leadership index VS leadership index of Slovakia case company.*

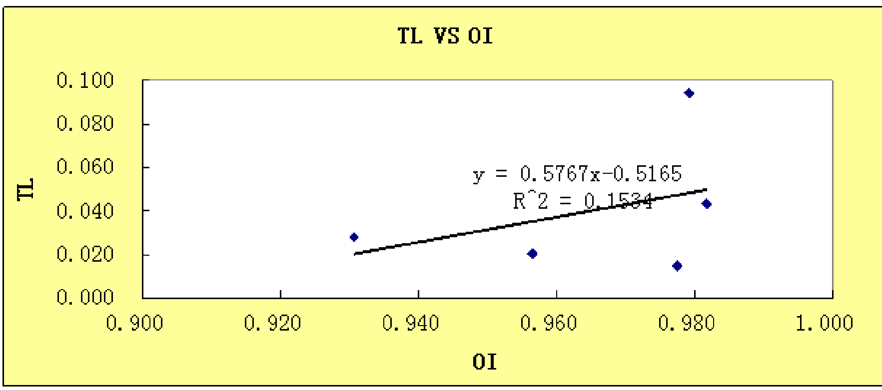


Fig. 63. *Total leadership index VS Outcome index of Slovakia case company.*

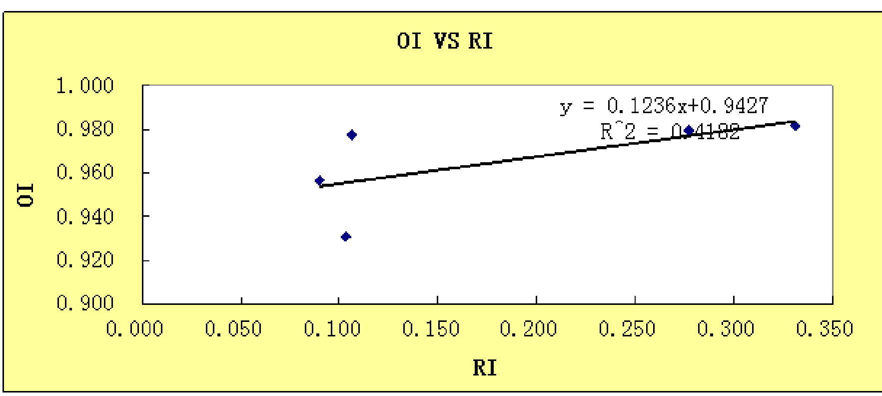


Fig. 64. *Outcome index VS resource index of Slovakia case company.*

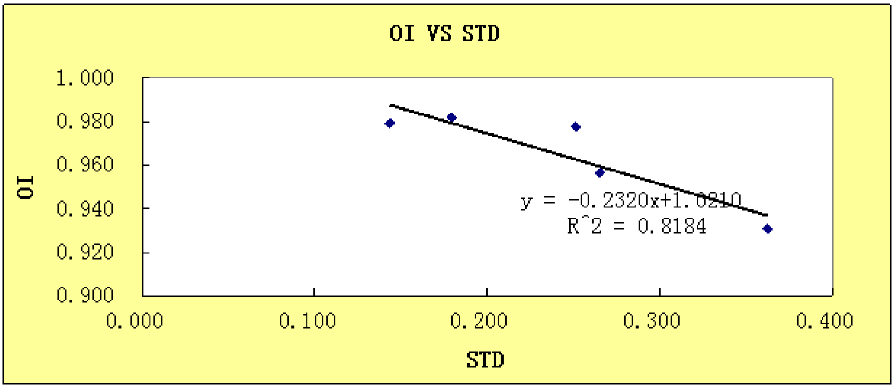


__Fig. 65.__ Outcome index VS Std of Slovakia case company.

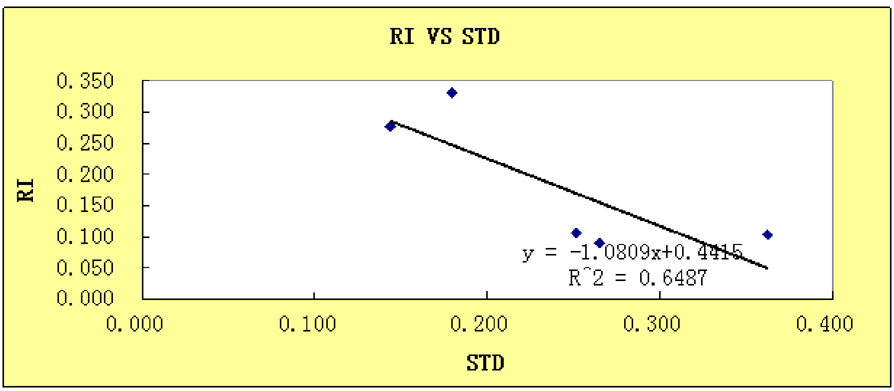


__Fig. 66.__ Resource index VS Std Slovakia case company.

4.1.3 Findings and Discussions

For Case Institution from China

1. Compared with other index, Outcome index plays the most significant effect on total leadership index, the relationship between outcome index and total leadership index is positive, which implies that the director of outcome plays the most important role in deciding the total leadership performance of this institution.

2. Leadership index also has some effect on total leadership index, but not as significant as outcome index. The effect of resource index on total leadership index is very limited

3. Inconsistent ratio has negative effect on total leadership index, which shows that a poor understanding toward transformational leadership will affect the performance of total leadership. Inconsistent ratio has negative effect on outcome direction index, which shows that a poor understanding toward transformational leadership will affect the direction of transformation leadership.

4. All the regression results are not significant enough.

For Case Institution from Slovakia

a) Analysis of SEZ Krompachy company

Company Profile: SEZ Krompachy a. s. is a company with more than 60 years of tradition in producing low and high voltage electrical appliances. It was established in 1948. In 1992, it was transformed to a private shareholding company.

SEZ Krompachy a. s. has its seat in the town of Krompachy in the eastern part of Slovakia, about 400 km eastwards from the capital city Bratislava, with 70 km to the Hungarian border, 100 km to the Polish border, 160 km to the Ukrainian border and 240 km to the border with the Czech republic.

Principal company processes include development, production, assembly and sales of electro-technical products and systems, engineering products, in particular tools and moulds and plastic mouldings.

State-of-the art development trends are applied in production activities to produce technically and qualitatively leading products.

The enterprise has its own development department and cooperates closely with the Technical University in Košice, ensuring continuous innovation and development of new products. The products are developed and designed in compliance with international IEC standards and tested and compared in our own test room as well as in independent national and international laboratories and testing and certification authorities, indicating high technical standard and user safety of our products [15].

In 1994, the company was awarded the *ISO 9002 Quality Certificate an ISO 9001/2000 Certificate in 2002*.

Its quality management system was verified and the certificate was granted by SGS Yersley (UK). The company developed a programme of increasing qualifications of workers within the whole range of technology structure, starting from manual workers up to top managers.

The production programme includes:

(a) Circuit breakers, current protectors, modular appliances (LV - low voltage).

(b) Cam switches (LV).

(c) Household insulation materials (LV).

(d) Switchboards and racks (LV).

(e) High and low voltage (HV and LV) circuit breakers.

(f) High voltage disconnectors.

(g) Tools, moulds and models for plastics moulding (EP – engineering production).

(h) Plastic mouldings (P – Plastics).

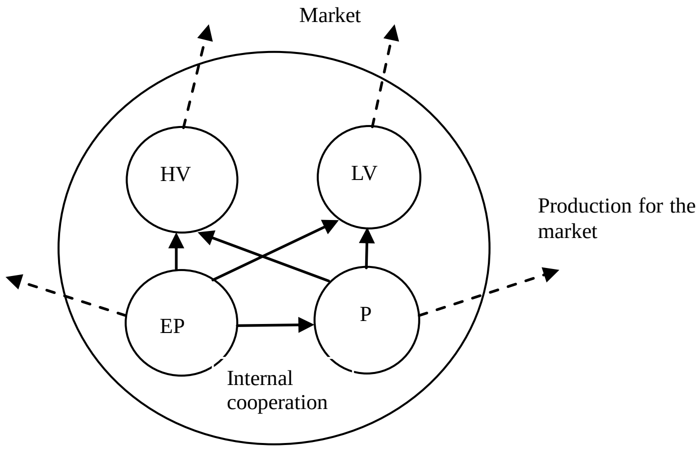


Fig. 67. *Product flows in SEZ Krompachy, a.s.*

The production is divided into four parts – low voltage appliances LV, high voltage devices HV, engineering production represented by the tool shop (EP) and plastics production to produce mouldings on injection presses. The LV and HV programme focuses on external markets; EP fulfils tasks needed for inter-company cooperation, LV and HV programme and plastics production; production of plastic mouldings (P) is intended for needs of the LV and HV programme, too.

Market and Clients: Products made by SEZ Krompachy have a strong position especially in the Central European Countries, Czech Republic, Ukraine, Poland, Hungary, Bulgaria and Russia, but over the years they are getting established on markets of the Western and Southern Europe, Southern America and Asia.

The tools and moulds are used by many renowned companies, such as GEC, VA Tech Rezlodle – UK, Schupa, Siemens Kramp – Germany, Whirlpool Poprad etc.

In the last 5 years, production volumes have been increasing on a year-to-year basis since 2004 until 2008 (in SKK mil.)

2004	2005	2006	2007	2008
450	470	500	514	540

SEZ Krompachy a.s. has been generating profit all the time during its existence. In the last two years 2007 and 2008, the company invested significant resources into technical innovations in particular.

b) Conclusion of the Analysis

1. RI, LI and OI have positive relationship with TL. Resource index plays the most significant role on total leadership index. While regression relationship of outcome index on total leadership index is not significant, which shows that outcome index has limited effect on total leadership index. The importance of leadership index on total leadership index lies between resource index and outcome index.

2. Empirical findings show that there is interactive relationship between OI and RI, this is a very important finding. It shows that resource index has positive effect on outcome index. This interactive relationship between outcome index and resource index may affect the calculation of total leadership index as well. It is a direction for further studies.

3. The regression relationship between OI and ICR, RI and ICR are both significant negative. It implies that a poor understanding toward outcome direction and resource will affect the efficiency of transformational leadership. These finding also confirm the above interactive relationship between outcome index and resource index.

4. There is no reactor group in Slovakia case.

4.1.4 Conclusion and Future Studies

Discussion and studies on Reactor are brand new and limited, more detail and deeper researches on the definition, calculation and application of Reactor group in transformational leadership is essential and meaningful. As the concept of Reactor group is based on the first three strategies, namely prospector, analyzer and defender, any change on other strategies will have effect on reactor group as well. Calculation of leadership index under reactor group is not unit, it depends on the understanding toward its definition from leadership group. Some assumption may be made before calculation.

4.2 Design of Manufacturing Logistics System

Each company is original from the point of production processes. Application of standard enterprise information system (SAP, proAlpha, etc.) need difficult adaptation especially for conditions of small or medium enterprises (SMEs) and the price of that system is relatively high. Therefore, the proposed model of capacity planning is much more suitable for the conditions, requires and demands of SMEs [17, 18, 19]. Specifics of production processes of RS Ltd. are combinations of discrete and continuous processes and the fact that this small company is connected to a supply chain (KANBAN) with its mother company, which defines the level of some chosen products in the expedition warehouse by the end of a month [23].

For the above mentioned reason it had to be designed the new original production logistic system. This system starts with order evidence, it includes the model of capacity planning, which respects KANBAN and model for production scheduling and operation evidence after the finishing of manufacturing [20, 22]. Both models are created on the heuristic approach i.e. there were analysed rules and limitations, which were applied to algorithms of the models. By this approach applied in the model there were included all activities, knowhow, experience, knowledge of the experts and people, who works in the company for a long time [19, 23]. Design of the logistic system of RS Ltd. can be also applied in any SME, in the area of machinery industry connected to supply chain system with another company.

4.2.1 System Analysis for the RS Ltd

The enterprise RS Ltd. is producer of stator and rotors for industrial ventilation and air conditioning system and is conformed to the German mother company. The basic production process starts at cutting of dynamo plates and their welding or riveting (PP1), its casting to aluminium alloys (PP2), finishing (PP3) and surface treatment (PP4), see figure 1.

Production process management starts with order evidence and the process of planning in the enterprise of RS Ltd. starts at the purchasing and sale manager, who collects continuously incoming orders. The term of delivering of all filed orders is 20th day in a month to a planner (if the day is weekend, then this file is delivered obviously sooner). The file with orders contents is in the status as they were delivered without any editing. The file content date of receiving, date of production (due date), article number and name, quantity, and customer (standard customer is mother company). The term, when the plans should be ready for supervisors of production division and to general manager is 25th day.

The file of recorded orders (FRO) is continuously actualised by adding new incoming orders, while planner can open the file anytime but on mentioned date he will receive the file through e-mail. By this step the actualisation of this file is finished and it is ready for planner to create new production plans.

The plan is created separately for these divisions:

- for cutting (CNC machines).
- for casting.
- for finishing (CNC machines), however this is not detailed plan given to a supervisor but it is a list of products and due dates and delivery dates.

The first set of information input is in-process production itself, which was planned in previous periods "N-1" for present period "N" (e.g. cut dynamo plates are not already casted in to aluminium body, casted are not finished and finished are not surfaced etc.)

The second set of information input is store levels of finished products, so called "KANBAN", where the certain levels are need to be kept (levels represent quantity) by the end of a month. The decree, from the mother company which defined the certain levels of finished products, is actualised regularly, sometimes also when there is unexpected increase of orders of standard (often ordered) products. KANBAN is a kind of flexible reserve between the planning and fulfilling store levels, when the planning is not strictly fixed on term but for managing of store levels. It is also a kind of buffer in a peak ordering while incoming of many orders of many products to one due date. Ordered assortment is firstly fulfilled according the KANBAN levels in a store and then the missing items are planned first as a priority.

Some of the semi-products (e.g. riveted stators and welded rotors) are not produced in this enterprise but they have to be ordered. This idea is used as a flexible item in capacity planning model. These purchased semi-products are also a reserve for smoothing of material flow especially between cutting and casting (Fig. 68). The second task of purchased semi-products is a capacity balance of production process. The capacity calculation is done first with all incoming unproduced orders. Then it shows the “bottle neck” (usually it is welding and riveting) of the process by its calculation which also shows the ratio of possible and impossible produced orders and thus it is possible to enlarge capacity of welding and riveting by purchasing of these semi-products.

Purchased semi-products represent standard products, which are parts of best selling products. They are even with better quality and in many cases cheaper in comparing with self-produced semi-products.

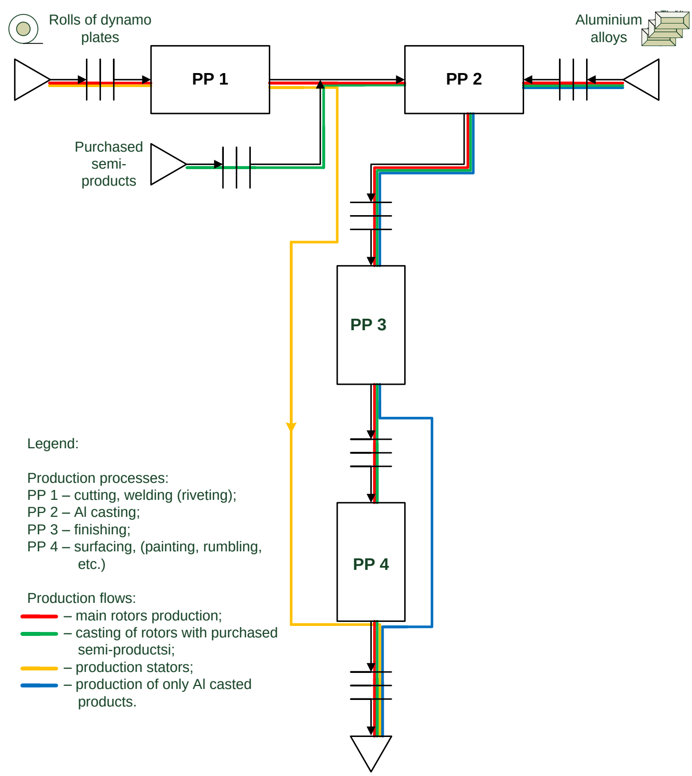


Fig. 68. *Basic production processes and flows of RS Ltd. enterprise.*

Capacity planning: Source of input information is the file of all orders. Each order has the certain quantity of ordered assortment and due dates. Present capacity planning consists of planning of all orders backwards from due date to first operation. There are calculated latest times of beginning of production and capacity need of each machine by this way, supposed that all income orders are put into production. Next, there is calculated in-process production and purchasing of semi-products, which can relieve capacity need at PP 1. In each production company, including RS Ltd., the capacity calculation have to include unexpected influences (lost times) i.e. breakdowns, increased time of setting etc., which is 10 – 15% of all times. That is why the machines are planned at about between 85 – 90% of their capacity, so this created a kind of time reserve.

The calculation of capacity needs is done each month - month forward. There is always done the balance of produced assortment by taking products from KANBAN levels first, it shows: how many products can be taken from the warehouse, how many need to be produced, how many need to be bought, etc. Two situations can be occurred after the KANBAN application:

- capacity needs (CP) are higher than capacity possibilities (CP), (CN > CP):
    - One possibility is to buy semi-products. It can happen that even everything is bought there are still not enough sufficient capacity possibilities e.g. casting has to be provided inside the enterprise, it cannot be replaced. In this case there it is need to contact customer by phone and discuss with him about priority of ordered products, which are urgent for him, that means the sequence by which the products will be produced or to discuss about partial shipment, the part will be produced on time, the rest later or to discuss about backup date. All customers (however the mother company has majority of all orders) are considered as equivalent.
- capacity needs are lower than capacity possibilities (CN < CP):
    - All levels of KANBAN are filled at first. While filling the standard assortment (very often demanded) there are created over-KANBAN

levels. When this is done and the capacity needs are still low, the machines maintenance is planned and also the all-company holiday can be determined.

The standard bottle neck in RS Ltd. is welding at PP 1. Welding is slower as the next process – casting. The actual principle is that the whole batch of material is welded first and then the whole batch is moved to casting. While welding of brakes all the following production, the purchased semi-products are used. Thus the purchasing is a kind of regulative item.

This bottle neck should not be bottle neck, because it is relatively cheap and simple equipment. In the proposal it is proposed to enlarge the capacity of this place by buying other welding machine and adding the servicing person or automating this place [21].

4.2.2 Proposal of New Conception of Production Logistics

The new proposal has to fulfil some specific targets:

- completion of orders in required quantity and quality in priority to mother company.
- flexibility and stability, minimization of operative changes.
- increasing of technological and logistic discipline, keeping of a production plan and dates of delivery.
- increasing of regularity (smoothness) – production tact.
- consecutiveness order changing and minimizing of stores (buffers).
- minimizing of production costs.

The proposal of the production logistic system (SYVYLO) is described in the (Fig. 69). The production logistics means managing, ensuring and providing of material flows in the RS Ltd. company, which are provided through these basic activities:

1. annual planning of trade and production.
2. order logistics:
    - processing of workload (from incoming orders) into planning periods.
    - technological, material and economic order appraisal, material balance.
    - capacity planning.
    - cumulations and creation of internal work orders.
3. preparation of production scheduling for machines and equipments.
4. shift managing of operative production plans.
5. operative evidence of production.

SYVYLO is only the “core” of the production logistic system and does not include:

- annual planning of trade and production.
- warehousing management and material ordering, reality and material order assurance will be confirmed by a supplier.
- preparation and recording of new technological descriptions for new products or changing in technological descriptions will be added into proposals manually through prepared interfaces.

- operative evidence will not be automated (e.g. by bar codes) but will be entered through the terminals of information systems located in production area by production supervisors and also into KANBAN cards.

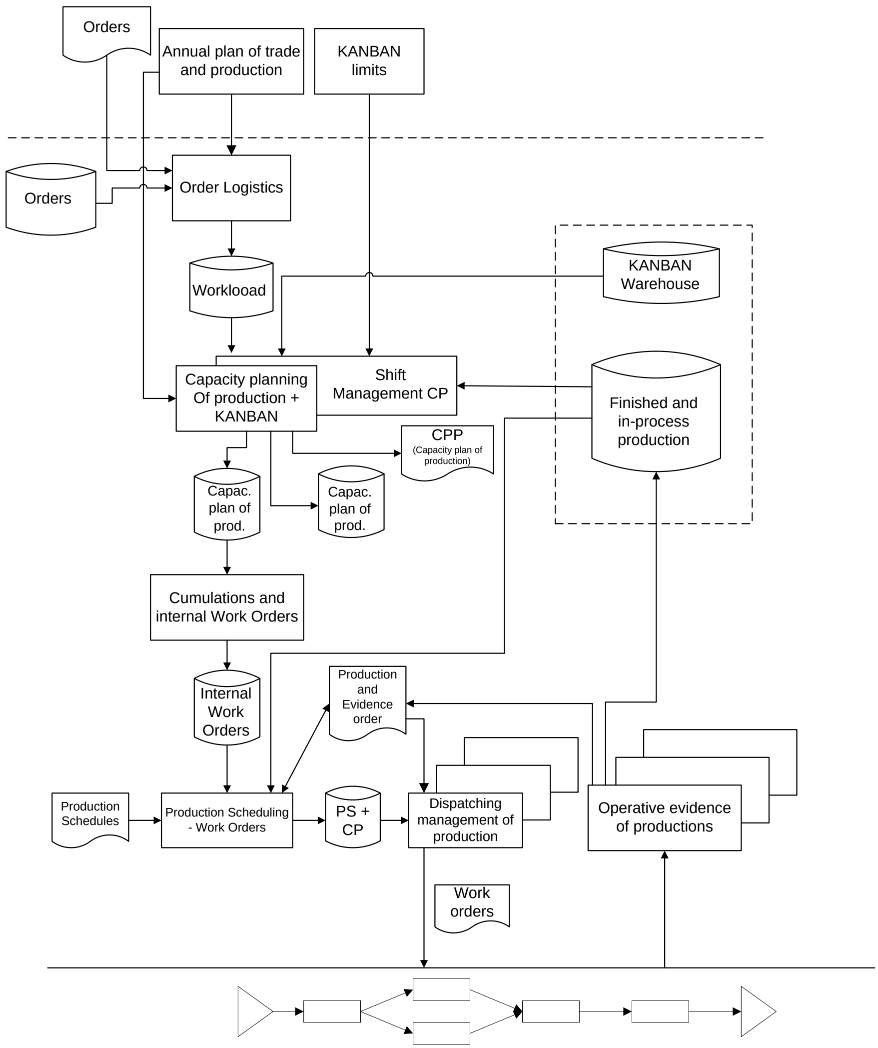


Fig. 69. *The structure of production logistics system (SYVYLO) in RS Ltd.*

4.2.3 Proposal of Capacity Planning Model

The capacity planning comes out from known workload – orders to certain planning period. Its aim is to choose orders from the aggregated orders (file of incoming orders) and to put them into a production plan, into a certain planning period by keeping the following:

- to fulfil required ordered quantities and due-dates for customers.
- to give in balance capacity demands to machines, equipments, workplaces with their capacity possibilities.
- to keep the prescribed store level limits of products in KANBAN warehouse.
- to purchase material, semi-products or sub-deliveries based on capacity plan of production.
- to have the capacity plan as a basis for creation production scheduling, in this there is no need to take care about capacity.

Parameters and criteria for capacity planning:

1. The capacity plan is created for all company and it is divided to:
   - U1 – cutting, welding, riveting.
   - U2 – casting and production of aluminium (Al) alloys.
   - U3 – surfacing, finishing and other finalising.
2. Planning period will be at minimum 8 weeks. Planning point is between 10:00am – 12:00pm on Thursday.

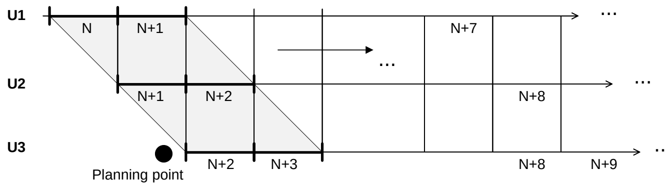


Fig. 70. *Planning periods of defined divisions (U_1 - U_3).*

3. There is used the principle of sliding planning, which is performed each Thursday at noon (12.00 o'clock).

4. There is a different obligation in weeks (1st week is definite, 2nd week is preliminary – set at approx. 80%, 3rd week – 8th week is forecasted). The exact authorisation of doing changes have to be defined, e.g. changes for 1st week – only general director can provide changes, for 2nd week – only delegated production supervisors or planner can provide changes, other weeks planner and other entitled persons can provide changes.

5. Planning by PULL system – it means from the end to beginning.

6. The products will have priorities "B" – ordinary, "S" – urgent, "SS" – super urgent.

7. Closed system of capacity planning (phase production) besides the products with priority "S" and "SS" (defined by general director) will be kept, i.e. what is produced at U1 in week N will be processed at U2 in week N+1 and at U3 in week N+2. It results to defined production time, which for "B" products is three weeks, for "S" products two weeks and for "SS" products is one week or orders are completed from KANBAN.

8. The capacity plan will be created at 90% of maximum capacity (10% is left for unexpected, unaware changes and interactions).

9. Initial variant of plan is created in the way that:

   - Inputting “S” and “SS” orders into weeks according to DD_I to division U3.

   - New “B” orders are assorted by: LRT – Longest Remaining Time, i.e. maximum time to their production is:

$$\sum_J MN_I * t_{I,J} = \max ,$$

     respectively according to DD_I to division U3.

     Orders are inserted to certain weeks from the end of U3 through U2 up to U1.

   - The capacity calculation is provided and there are calculated CN_J (capacity needs) in certain periods of weeks N+1 - N+8, but planning dead times, compulsory maintenance and in-process production have to be taken into calculation.

10. Calculation of bottle-neck.

11. Solution of bottle-neck through KANBAN stock levels, and point 10 is again repeated.

12. Calculation of sub-deliveries of welded and riveted parts and point 10 is again repeated.

13. The capacity smoothing is possible to reach:

   - By using KAIZEN.
   - By moving forward.

By dividing one big order to 2, 3 smaller batches (internal work orders) and moving two, three batches a period back.

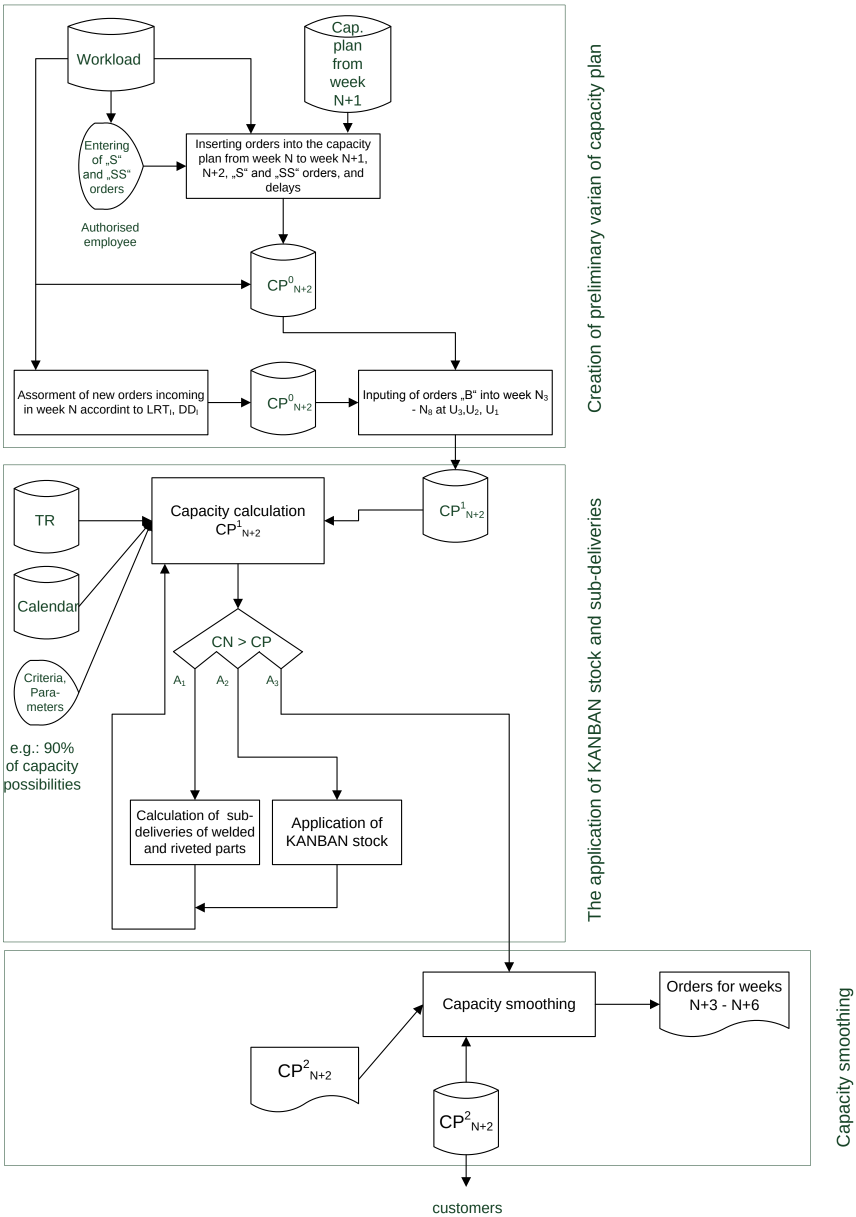


Fig. 71. *Algorithm of the capacity planning model.*

4.2.4 Conclusion

The real system for the company RS Ltd. is not only the model for capacity planning itself. It was also created the model cumulation of orders and production scheduling with the evidence of work in progress and finished products for the each machine. The system, in this state, is already similar to the professional information systems for production management, with the difference, that there are integrated all the features and tools they really need and will use them as it is required from their production practice. Description of such a system would have far exceeded scope of this article and further description of this model is omitted.

The proposed model of capacity planning itself is a key activity of the whole system, because in this model it is created a file of possible workload that is possible to process, in the certain week with the given capacity potential of machines. This file is important for the operation of the further model of cumulation of orders and production schedules preparation and faults in that file would cause malfunction of the system.

4.3 Design of Model for Creation of Basic Foil Manufacturing Plan in Chemosvit Fólie a.s.

The department of manufacturing of basic foils is the first step in the whole manufacturing process. For better illustration of the position of the manufacturing of basic foils follows (Fig. 72).

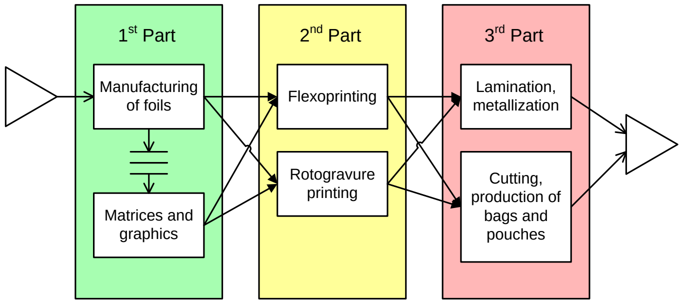


Fig. 72. *Three-tact manufacturing process.[32]*

The company, from the point of capacity planning is divided into three parts. The 1st tact includes basic foils manufacturing and purchasing, in the 2nd there is the printing and in the 3rd tact there are laminating, cutting, slitting and shipping (Fig. 72). [29, 30]

The assortment of manufactured products in the company Chemosvit fólie a.s. represents basic polyethylene - PE and polypropylene - PP foils, flexo and rotogravure foil printing, lamination and manufacture of bags and pockets. The company has its own graphic studio and preparation of printing forms for flexo-printing and rotogravure printing.

The assortment of products can be divided into two basic groups:

- Product type of monofoils.
- Product type of laminates (further classified into large range of the assortment). [26, 27, 32].

The basic division of foils:

- *Blown* (3 layers foils).
- *Casted* (2 - 5 layers foils).

The basic division of the assortment:

- Barrier foils - polymer (impermeable of certain types of gases): 3 – layers, 5 – layers.
- Polypropylene (so called - the bread foils, suitable for food use): combination of homopolymer and copolymer, pure homopolymer (homo), pure copolymer (copo), twist foil. [28, 32].

Technology of basic foils manufacturing.

Manufacturing of basic foils is currently provided on four extruders i.e. blown foils and cast foil technology, i.e. casted foils. The overview of different maximal widths, the number of worms (layers) in the manifold nozzle and manifold nozzle sizes are listed in Tab. 10.

Tab. 10. *The overview of width (winding), the number of worms in the nozzle and nozzle dimensions of the technology.*

	Technologies			
	Macchi	**Varex 1**	**Varex 2**	**Alpine**
Max. width	2200	2600	2600	2000
Number of worms	5	3	3	3
Manifold nozzle size	500	500	500	400

The mixture of granules is prepared by an operator according to the recipe in the technology tab. The granules are melted in the worms (max. number of layers of a foil = number of worms), homogenized and transported to the extrusion tool (manifold nozzle), where the melt is co-extruded and blown through the nozzle slit to circular cross-section in the form of foil sleeve. Then the process follows this procedure:

1. blowing and stabilization of a bubble – adjustment of the thickness, width by the calibration basket.

2. cooling IBC (internal bubble cooling) and also EBC (external bubble cooling).

3. flattening (by a flattening device).

4. pulling and foil reservation.

5. winding (cutting of a hose to desired foil size).

6. coiling up a roll as a final product, which goes either on sale directly or as a semi-product for further cooperating departments (flexo-printing, lamination, confection and cutting). [31].

4.3.1 Definition of Model Creation Principles

Determination of Main and Alternative Technologies.

Every product has determined main (most efficient) and alternate technology, where it can be also produced, but with lower efficiency. Example of technology determination is given in the Tab. 11.

Tab. 11. *The example of technology determination.*

The assortment – chemical composition	Macchi	Varex 1	Varex 2	Alpine
H2	H2			
H1S	H1S			
H701 RS	H701RS			
	- main technology		- alternate technology	

The Assortment Changeover.

Changeover is a state, where it is necessary to change one type of material (chemical composition) to another, while it is created a downtime and a waste is produced. A waste is represented by a cleaning of a machine between the manufacturing of two products of different chemical composition. The changeover involves also the exchange of the nozzle. Changeovers respectively changes of assortments are done under the certain rules to these technologies and are explicitly expressed by e.g. the changeover matrix (Tab. 12).

The criteria for the efficient operation of technology are: a minimum number of changeovers, the minimum number of nozzles exchanges.

The Colours of the Assortment Changeover.

Similar like in the previous case, here are also rules which are explicitly expressed, e.g. network diagrams at extruder Varex 1. (Fig. 75).

The Cumulation of Orders and its Rules.

The cumulation follows these listed rules:

1. The same quality i.e. the same assortment (chemical composition), type.
2. The same thickness.
3. Different widths, if they can be fit into the coiler.

There are necessary to be kept the following parameters for the required width of an order:

- Blown ratio – equation (1) for standard foils: 1,7 – 3.
- Consideration of a half circle circuit: 1,58 (π/2).

It means that it is possible to produce a min. and max. width from the nozzle 500 mm (taking into account the tolerance):

- Minimal width: 500 x 1,7 x 1,58 = 1343 mm.
- Maximal width: 500 x 3 x 1,58 = 2370 mm.

Thickness is independently controllable variable and has nothing to do with blowing ratio.

$$Blown\ ratio \in \frac{\dfrac{width\ of\ \ foil\ \ for\ an\ order \times number of\ coils}{nozzle}}{\dfrac{\pi}{2}}$$

Blown ratio influences the properties of foils, a foil structure is oriented through that nozzle, i.e. for a given speed and temperature there are oriented polyethylene, chains are oriented and a foil acquires its properties.

4.3.2 Proposal of the Operational Planning Model

The conception is based on the analysis, which confirmed the suitability of the present way of capacity planning and production scheduling for particular extruders (technologies). The current way is sophisticated, there were created procedures during a long-term application, which create the appropriate variants of manufacture planning of foils. It is therefore appropriate to apply the heuristic approach that is based on defined and explicit described rules and procedures used at the actual creation of plans by a logistician, to put these rules into the sequence and to draw them into the algorithms (models) for the plans creation. The principle of Synchro-MRP was applied as another strategic principle (Fig. 73), and thus it reduces overall manufacturing time of an order execution and increases flexibility. [25], [33]

The levels of foil stocks (in the “turning point” S) were defined based on the analysis of the frequency and volume of contracts over the past two years. “S” means the buffer store of the basic foils at two-week supply of the standard foils.

Then there was applied rule that orders for the manufacturing of foils for the certain planning week *N+1*will come out of the consumption in the buffer store

“S” in the week *N*. These may be modified by the prescriptive orders entered by a production manager. The Synchro-MRP is based on the idea that the manufacturing process is divided into 2 parts in terms of planning: [25]

1. MP I - the first part of the manufacturing process, make to stock “S”, it is mainly the production of standard foils, which is similar to many products, i.e. planning is provided in the part MP I – by PUSH system, it is planned statistically or with a certain time delay, for example, one time unit (e.g. a week).

2. MP II – it is the manufacturing to order i.e., it is flexible to customers, it is planned by PULL system – make to order – i.e. manufacture of printing.

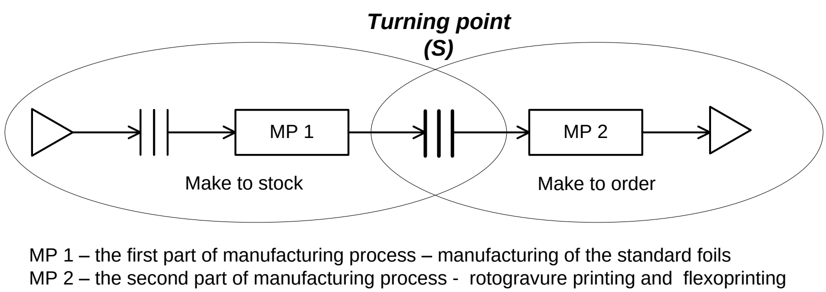


Fig. 73. *The proposal of production management scheme of basic foils in company Chemosvit fólie a.s. with the principle Synchro – MRP.*

Model of capacity planning and scheduling is created by the following activities (Fig. 74):

(a) The model for calculating of stock levels of standard foils.

(b) The calculation of virtual order content ($M_{I,\ N+1}$) – the manufacturing volume of products for week *N+1* (according to consumption from the stock “S” in week *N*).

(c) The capacity planning.

(d) The cumulating and the sequence planning.

4.3.3 The Model for Calculating of Stock Levels

The calculation of the proportion of particular foils to the manufacturing volume was quantified by using the Pareto analysis. It points out that the total production of 20% of its products in the company provides 80% of the profits. The idea of the method was used to determine the optimal portfolio of the current products composition, but with a buffer–for a risk in the future.

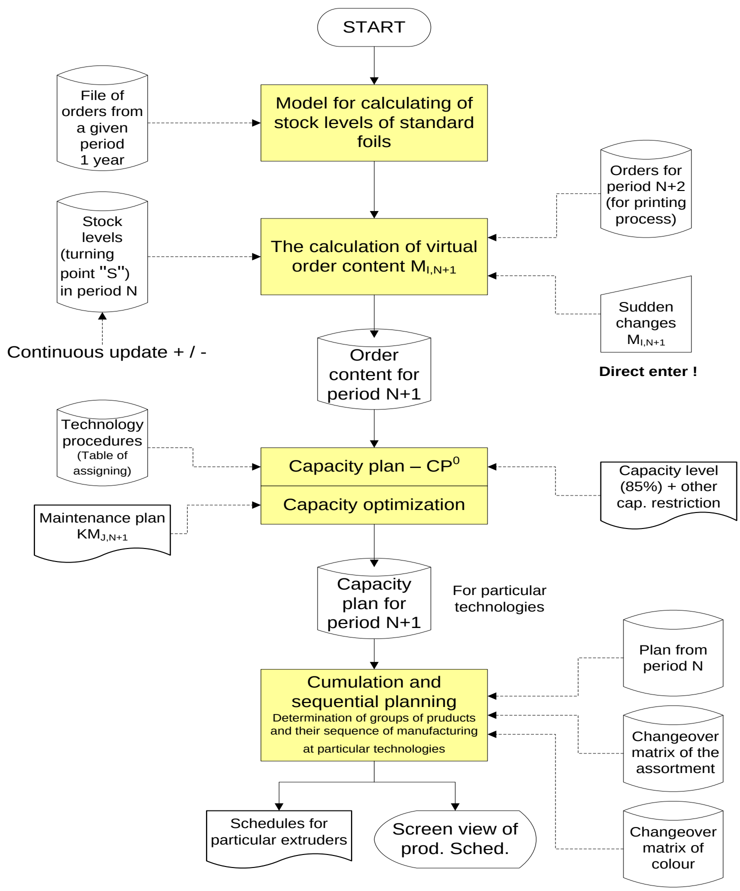


Fig. 74. *The basic algorithm of the concept of capacity planning and production scheduling solution.*

Based on the Pareto analysis of the current data file of the foils manufacturing and a small but regular repeating products it was designed to produce the standard foils and it resulted that 14,22% of all foils with the different thicknesses are involved in nearly 62,8% of total manufactured output. The remaining foils are considered as the special foils that are about 37,2% of the total manufactured foils during the given period in the company Chemosvit fólie a.s. Any other foils that were not produced in a given period or new products shall be considered as the special foils.

Two-week stock levels were calculated from the given data file according to equation:

$$Two - week\ stock\ level = \frac{Total\ volume\ of\ manufactured\ orders\ during\ given\ period}{number\ of\ weeks\ during\ given\ period} \cdot 2$$

4.3.4 The Calculation of Virtual Order Content

To add stock levels (and therefore the orders for the manufacturing of foils) for the week *N+1* can be defined according to:

1. The basis of the consumption of foils in the week *N* (if the state is below of the two-week supply), but is produced in whole economically effective batches.

2. The prescriptive enter due to expected consumption e.g. because of a sudden change in the consumption in the downstream manufacturing sections of printing.

Special foils, because they are not produced to the stock, are manufactured on the basis of the material balance of incoming orders for printing. Need foils for week *N+2* is manufactured in week N+1.

4.3.5 The Capacity Planning Model Proposal

Then the model of capacity planning continues after calculation of the order content for the individual extruders. Assignment of the order content for each technology (extruders type Macchi, Varex 2, Varex 1, Alpine) is done according to the main technology. Thus, it is created the zero level (unbalanced) capacity plan CP^0. After this step, it can be proceed the capacitive balancing – the capacity optimization.

The principle is as follows:

1. Machines are sorted to sequence Macchi, Varex 2, Varex 1, Alpine, this order is a priority for capacity optimization (ranking from the highest quality technology to less quality).
2. It begins with the first machine *J*, where the capacity is exhausted.
3. Then it is found an available technology (machine) *K* with the highest priority.
4. It is found an order with the main technology in machine *J* and alternate in the machine *K*.
5. This order is moved from the technology *J* to *K* and then there are re-calculated the capacity requirements at the technology *J* and *K*.
6. If such an order is not found, it is continued with next available technology *K+1* and the procedure is repeated from the point 4.
7. Finally it is found another machine *J*, where the capacity is exhausted.

The process is repeated until all machines are balanced. If this is not possible, the orders, which cannot be produced for capacity reasons, remain as unmanufacturable in a week *N+1* and they are entered in the file of unmanufacturable contracts.

4.3.6 The Production Scheduling Model

The production scheduling aims to arrange orders to the optimal sequence. Sequential planning is divided into two activities:

- Cumulation orders to groups.
- Sequential planning.

Cumulation

Developing algorithms for cumulation was based on the conditions that production is made to stock. It includes the following procedure:

1. Entering of so called side-runs (side-run is a part of unused width of a foil) into the system (by a logistician of production section).
2. Grouping of orders according to the quality (chemical compos.), then to the thickness.
3. The calculation of the minimum and maximum width of side-runs to each planned order based on the blown circumference.
4. Assigning of side-runs to manufactured orders:
    - Assigning of manually entered side-run into the calculated tolerance of side-run to each manufactured order.
    - Assigning of side-run as an order, if the calculated tolerance range of side-run meets some dimensions of orders from the technology and the creation of so called double-order.

- Assigning of side-run to defined storing assortment.

Sequential Planning

Criteria for sequential planning:

1. Minimizing of changeovers of chemical composition of the sconsecutive orders.

2. Exact date (time) within a week is not set, the production must be executed within one week (manufacturing is made to stock with weekly advance).

Each extruder can be considered as separate element at sequential planning because the rules are different for each extruder. Thus, each technology has different criteria. As an example there is the sequential planning for extruder Varex 1:

The situation on the technology Varex 1 is the most difficult because it produces a large range of products. It can produce almost complete range of assortment produced at all machines.

Production at this technology already includes coloured assortment of white, black and white and white-black-white. These colours are in particular layers e.g. white-black-white is made up of layers of white - black - white. Possible changeovers are shown in the (Fig. 75).

Another problem arises at the "peat – agro" assortment - AG320 and AGW320 alike at Lamiten 105 and W105, 111 and W111 or W205 and 205 etc. where it is added so-called master-batch to white colour. If there are at least two such cases in the cumulating is the procedure in the way that there are changeovers from clear to white, then the W105 and 105, what ultimately means the changeover clear - white - white - clear etc. The changeover from one type of a white assortment to a clear of another type would cause a high production of waste, because there is a different polymer composition.

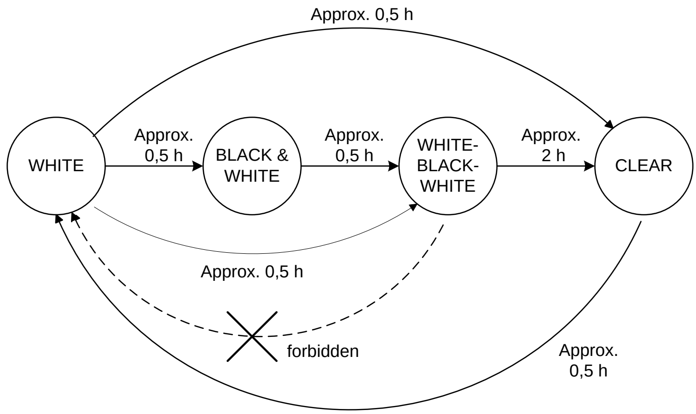


Fig. 75. *Network diagrams of colour changeovers.*

Changeover matrix of chemical composition is referred to the assortment of groups, which have a higher priority than changeover of colours (e.g. Lamiten with Lamiten is preferred against to clear with clear…) Tab. 12.

Tab. 12. *Changeover matrix of chemical composition of assortment at Varex 1.*

	HP, HPE, T09	Lami-ten.	Peat AG	X10	701	702	Milk-MLB	MLB 282S	Others
HP, HPE, T09	X			X					
Lamiten.		X		X					
Peat AG			X	X					
X10*	X	X	X	X	X	X	X	X	X
701				X	X				
702				X		X			
Milk - MLB				X			X		
MLB 282S				X				X	
Others				X					X

4.3.7 Conclusion

The proposed system is built as an autonomous information system, which will itself monitor inventory levels, set the level in stocks with directive inputs of extreme or urgent orders. Its autonomy is more advantageous as a link with the capacity planning of printing because of the effectiveness of the work.

The benefits of this planning model are:

(a) Increasing of objectivity at inclusion of orders to the plan.

(b) Increasing of variability because a person normally created only one option of the plan but this model can serve as a simulator and in a moment it can prepare several variations of the capacity plan and production schedules.

(c) Efficiency performance of orders fulfilment was improved, because in the case of obtaining orders with higher priority, the system can be restarted from any time, i.e. changes are not made at random, but they respect all the rules.

(d) The model allows establishing an advantageous variant of plan in order of optimizing because optimization criteria are directly incorporated in the model of its work.

4.4 Analytic Application of Forecasting of Orders for Printing Rollers in Chemosvit Fólie a.s.

The printing of flexible films for food and non food products uses the system based on the printing rollers, where is engraved graphic (pattern) which is printed on a film. Each colour (also specific colours) is printed by a separate roller. For common full-colour graphics, i.e. one order, approximately 6 - 7 printing rollers are needed. The number of rollers is limited because of storing capacity and costs of rollers. In case of new incoming order there are two possibilities how to cover an order by the sufficient rollers: to use totally new rollers (as a carrier of future graphics) or to use old (already used) rollers, where the old graphic will be cancelled and a new one will be created. The problem is appeared when a graphic on a stored roller is discarded for orders, which can be reordered again. It means, that the main task of the forecasting system is to mark orders connected to rollers, for which it is necessary to keep already engraved rollers, because occurrence of orders in near future (nearest months) is highly probable. The repeated preparation of graphics for certain rollers is very expensive and it takes relatively long time. That is why there is a need to predict time of probable occurrence of each recorded order in this company.

Nowadays, there are in records more than 3500 different orders and the great majority have the signs of uncertainty or irregularity and that is why each order needs to be examined by a separate approach. To eliminate a fatal error it is necessary to find out the solution, which is possible to use in such unstable dynamic processes. This article brings two possibilities of solution: a method suitable for mentioned cases and two methodologies of multi-method combinations.

4.4.1 Basic Function of CFS (Complex Forecasting System)

In the following chapter the performance and deeper study of the complex forecasting system is described. Primary information which is available, consist of the dates, when orders were received and this is the main basis of the historical data. This data need to be transformed into the periods of an order occurrence. Then, there are certain graph lines created for each recorded order and the periods of an order occurrence can be assignment to the typical models of historical data (see below). The transformation of the graph lines is described in Fig. 76. The time line at the top represents an order occurrence in last 24 months (from 1/24 to 24/24), i.e. during two-year performance. A thick line means that an order was active in this time, the number represents produced quantity, but this number is not important for transformation. There is a calculation of inactive periods between two active consecutive periods and the result is increased by 1, for better statistic interpretation later. For example between the periods 11/24 and 12/24 the result is “0” and this can cause a mathematical difficulty. This procedure creates the graph lines of each order. The axis ‘X’ represents *the number of occurrences – frequency of occurrences* and axis ‘Y’ is *the number of inactive periods – interval of occurrence* between two active consecutive periods, increased by 1. In principle, this transformation calculates that each following active period is after the calculated period (Fig. 76).

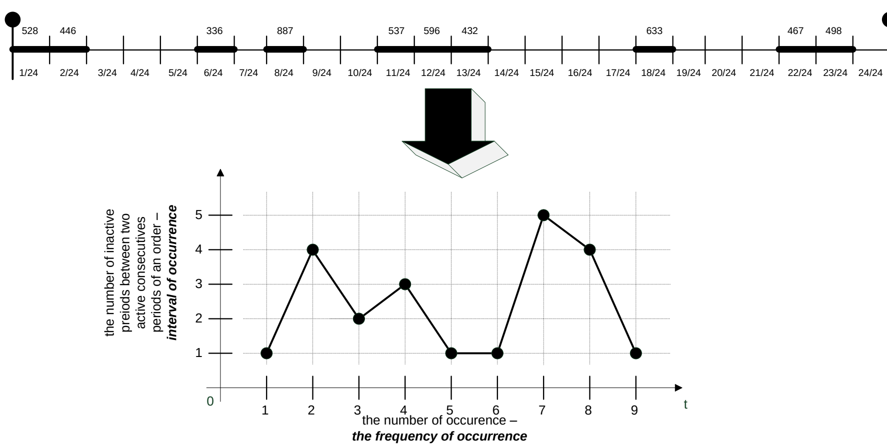


Fig. 76. *Transformation of periods of an order occurrence into the graph line (Kačmáry, Malindžák, 2010).*

After the transformation of order occurrence to graph lines, the next process of classification of the graph lines is provided. The block of classification is important for the strategy of forecasting, which method or technique should be used to create good forecasting results. There are seven basic and associated types of graph line models of historical data [34, 35, 36]:

1. "**K**" model – constant model.
2. "**T**" model – trend model.
3. "**S"** model – seasonal model.
4. "**C**" model – cyclic model.

To trend models can be associated also two sub-models:

5. "**TC**" model – trend - cyclic model.
6. "**TS**" model – trend - seasonal model.

Model time series, which do not suit with the above models:

7. "**E**" model – empiric model.

It is possible to assort any graph lines to the above mentioned models only when the frequency of occurrence is higher or equal to 6, besides model "K" and "T", where the minimum of 3 occurrences are enough. Because, three occurrences give two points to get a line and it evaluates by "K" or "T" model. At least one of the occurrences has to be within the last six months, otherwise the forecasting is skipped in this case of the application because it is considered that an order is totally inactive.

There were used only standard and generally known forecasting methods in all models besides model Nr. 7 – empiric model. This is a model, where it is not possible to determine any patterns of value occurrence so it is not possible to allocate these lines into above determined models. Thus, forecast calculation becomes very difficult with an uncertain result. The way of forecast calculation can lead through methods or methodologies suitable for stochastic, dynamic changeable processes, chaotic scatters or volatility time series. New approaches (both methods and both methodologies) described in this paper were used and were applied in CFS.

4.4.2 System Application

The application and implemented of new methods and methodologies in the proposed CFS is shown in the block algorithm (Fig. 77). For each roller set connected to recorded order is prepared forecast individually. The CFS uses standard statistical method according to models in which the time series are sorted. In case that no standard model is used, the calculation is done by the proposed methods and methodologies implemented in the last block of the algorithm – empiric model.

The example of the CFS system output with the certain order, its history and the order occurrence prediction with recommendation is in the following (Fig. 78).

The fist example had almost the sings of constant line, so the calculation was provided according to rules of the model “K”. Because the predicted time of the order occurrence was almost 2 month, the result was to keep the engraved rollers on stock for the soon occurrence of the order.

The second example has signs of stochastic behaviour of the time series, so the calculation was provided according the rules of the model “E”. There were used new approaches and it resulted to the predicted time of the order occurrence up to third month, which was also recommended by the CFS to keep the rollers on stock.

Calculation in the third and the fourth example was provided according to rules of the model “T”. Predicted time of the order occurrence of the fourth order was over the determined limit, the CFS gave recommendation to reject rollers for the order – it means, that this set of rollers can be used for another orders.

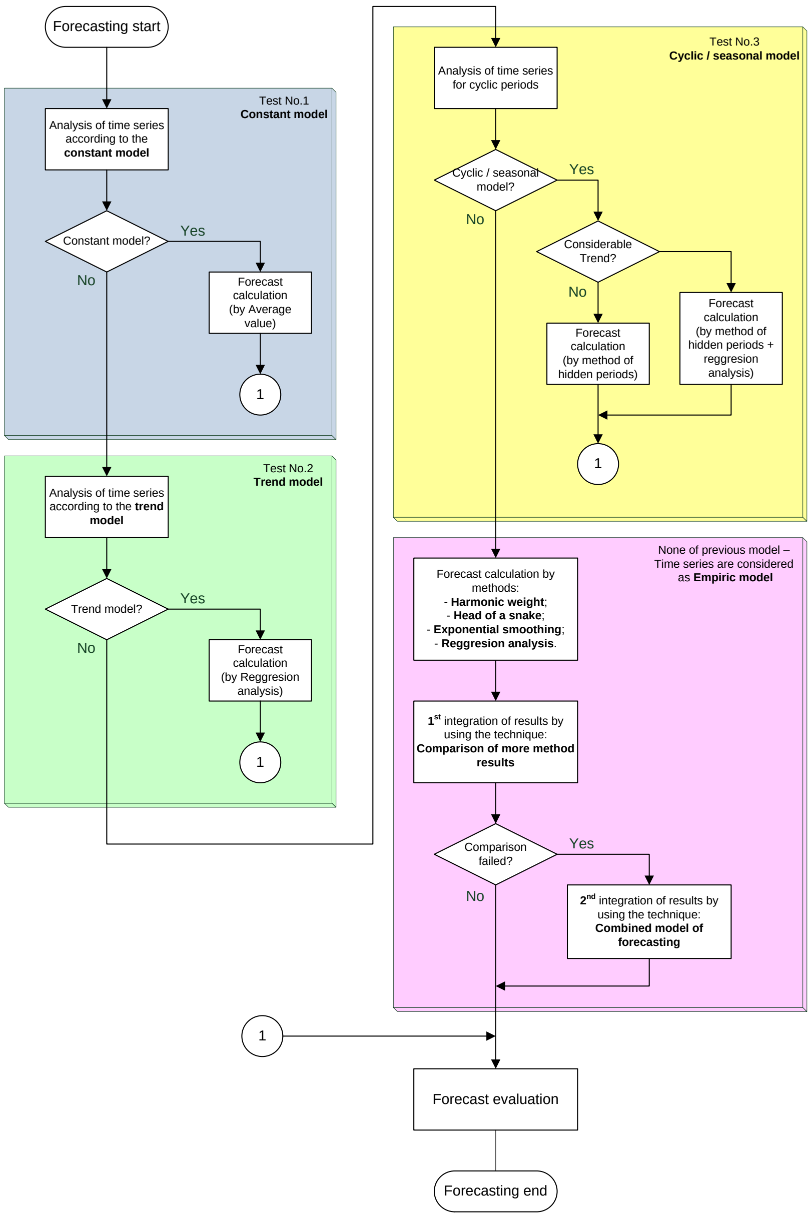
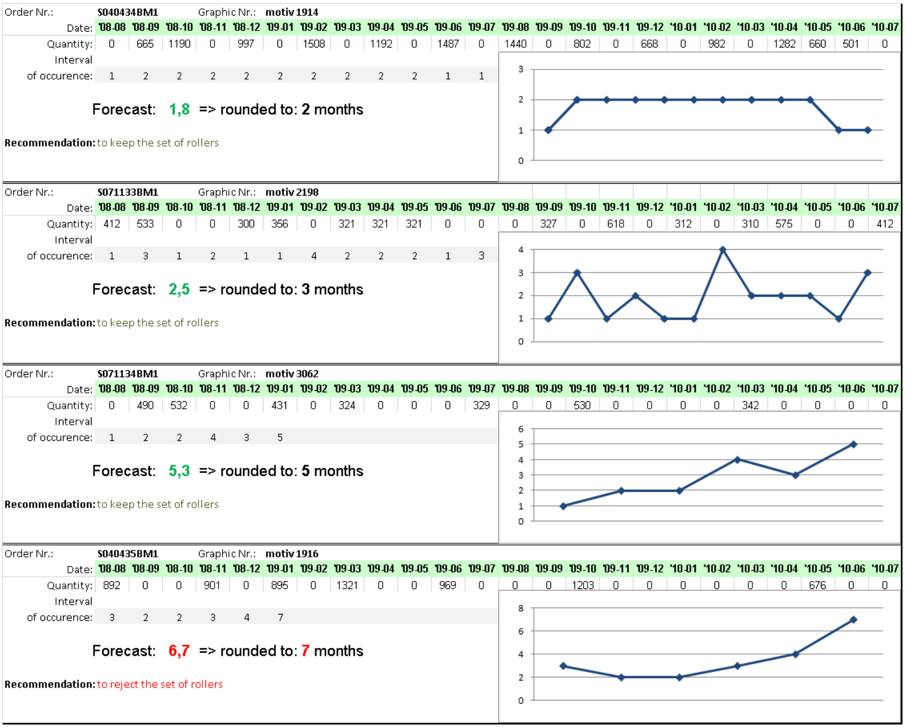


Fig. 77. *The algorithm of the Complex forecasting system progression.*



Order Nr.: **S040434BM1** Graphic Nr.: **motiv 1914**

Date:	'08-08	'08-09	'08-10	'08-11	'08-12	'09-01	'09-02	'09-03	'09-04	'09-05	'09-06	'09-07	'09-08	'09-09	'09-10	'09-11	'09-12	'10-01	'10-02	'10-03	'10-04	'10-05	'10-06	'10-07
Quantity:	0	665	1190	0	997	0	1508	0	1192	0	1487	0	1440	0	802	0	668	0	982	0	1282	660	501	0
Interval of occurence:	1	2	2	2	2	2	2	2	2	2	1	1												

Forecast: 1,8 => rounded to: 2 months

Recommendation: to keep the set of rollers

Order Nr.: **S071133BM1** Graphic Nr.: **motiv 2198**

Date:	'08-08	'08-09	'08-10	'08-11	'08-12	'09-01	'09-02	'09-03	'09-04	'09-05	'09-06	'09-07	'09-08	'09-09	'09-10	'09-11	'09-12	'10-01	'10-02	'10-03	'10-04	'10-05	'10-06	'10-07
Quantity:	412	533	0	0	300	356	0	321	321	321	0	0	0	327	0	618	0	312	0	310	575	0	0	412
Interval of occurence:	1	3	1	2	1	1	4	2	2	2	1	3												

Forecast: 2,5 => rounded to: 3 months

Recommendation: to keep the set of rollers

Order Nr.: **S071134BM1** Graphic Nr.: **motiv 3062**

Date:	'08-08	'08-09	'08-10	'08-11	'08-12	'09-01	'09-02	'09-03	'09-04	'09-05	'09-06	'09-07	'09-08	'09-09	'09-10	'09-11	'09-12	'10-01	'10-02	'10-03	'10-04	'10-05	'10-06	'10-07
Quantity:	0	490	532	0	0	431	0	324	0	0	0	329	0	0	530	0	0	0	0	342	0	0	0	0
Interval of occurence:	1	2	2	4	3	5																		

Forecast: 5,3 => rounded to: 5 months

Recommendation: to keep the set of rollers

Order Nr.: **S040435BM1** Graphic Nr.: **motiv 1916**

Date:	'08-08	'08-09	'08-10	'08-11	'08-12	'09-01	'09-02	'09-03	'09-04	'09-05	'09-06	'09-07	'09-08	'09-09	'09-10	'09-11	'09-12	'10-01	'10-02	'10-03	'10-04	'10-05	'10-06	'10-07
Quantity:	892	0	0	901	0	895	0	1321	0	0	969	0	0	0	1203	0	0	0	0	0	0	676	0	0
Interval of occurence:	3	2	2	3	4	7																		

Forecast: 6,7 => rounded to: 7 months

Recommendation: to reject the set of rollers

Fig.78. *The example of the application of the Complex forecasting system.*

4.4.3 Conclusion

There are some important reasons for prediction of incoming orders in analysed company. One of the most important reasons was the optimisation of store of archived printing rollers in a company's warehouse. The second important reason was to decide immediately which of the sets of rollers graphics can be cancelled and prepared for active uncovered orders. These facts were the foundation of the project for design and implementation of the proposed complex forecasting system. It also began to be a part of ERP system of the company.

In the company there are more than 3500 records of orders in evidence, which were ordered and were produced in history. Average number of rollers in one set for one order is approx. 6,7 pcs. Assuming, that the company wants to keep on stock all sets of rollers for each recorded order, approximately 24000 rollers with ready graphics are required. Then a huge storing space would be required because of relatively large dimensions of one printing roller. It is almost impossible to have on stock such a large number of printing rollers. That is why the company is forced to optimise this storing space and to keep on stock only these rollers, which are supposed to be often and frequently used. This is evaluated by the complex forecasting system. The system has to evaluate continuously the present situation, because the company has in disposal only approximately 7000 rollers. The CFS was created for the company, which calculates the forecast and recommends which rollers need to be kept on stock and which is possible to rework for another uncovered active order.

This Complex forecasting system is a part of multicriteria decision process concerning cancelling or keeping roller graphics for certain orders, because there are numbers of other factors, which can influence this decision process. The whole system is implemented into an ERP system of the company and it is a tool for a worker of operation planning at the division of rollers preparation.

In Figure 6 there are examples of the results of forecast calculations by the CFS using four real records of orders from the total number more than 3500 records. Each order from these 3500 records is analysed and forecasted continuously every week before the capacity planning of the manufacturing process to count required capacity for the division of rollers preparation. These four examples from 3500 records were chosen to demonstrate the outputs of the CFS, the first order represents calculation according to “K” model, second order according to “E” model, third and fourth order according to “T” model. The fourth order example also demonstrates the recommendation of rejection of printing rollers for this order, and these rollers can be used for another active order.

There are used many circumferences of rollers in the company, it varies from 550 mm up to 1000 mm. The circumference of 600 mm is most often used and in total comparison it is about 15%. Following, there are the results of optimisation process using the CFS in all orders using 600 mm rollers. Some facts are summarised in the Tab. 13:

Tab. 13. *Input information.*

Total number of orders using rollers of 600 mm circumference:	**530**
The number of orders, where the frequency of occurrence is higher or equal to 5:	94
Number of cancelation and remaking graphics for the sets of rollers connected to above mentioned orders:	633
Average number of rollers per order:	6,7

Calculation:

$$633 \text{ x } 6{,}7 \approx 4241 \text{ engraving per two years.}$$

The complex forecasting system could save approximately 4241 engravings. If the present capacity of engraving facility is 80 pieces per day, it means there can be saved 53 days of useless engraving during two years, which would definitely help to increase flexibility and money savings. To increase flexibility at their planning system is one of the main goals of the company during the years of economic crisis.

4.5 Simulation Model of Big Metallurgical Company

The content of this paper is focused oriented on data obtaining for the modelling and simulation of the production, transport and stores processes in the metallurgy, which represents system approach of LS starting from the raw material resources through mining and metallurgy processes to the customers (automobile companies, cold roll mill factories, civil engineering industry, e.g.).

This large system can be considered as a LS or logistics nets. For the research purposes this type of the system can be analyzed applying simulation models. In many cases the simulation (when parameter systems are stochastic) is only one possible solution. The goal of this paper is to describing the methodology of the simulation model design and optimization of parameters LS applying simulation models. LS consists from elements which have very complicated structure.

In the LS model this complicated units are represented as one element with its inputs and outputs. For information obtaining about each elements is necessary their depth analyses.

> *"This large system – originating its material flow from raw materials and moving towards end – customers we can understand as a logistics system or supply demand network" [47].*

To obtain the data for the simulation model design and experimentation, it was necessary to analyze all processes in the chain as well as all divisions participating in the LS. The present research study describes case studies and models to analyze processes of mining, materials processing, metallurgical, transport, warehousing, maintenance, e.g. The result of case studies are data for the simulation model design, and input data file for the simulation model experimentation [48].

4.5.1 The Methodology for Large LS Simulation Model Design

The system can be analyzed and explored [49]:

(a) on a real object.

(b) on a physical model.

(c) on a mathematical model.

(d) on a simulation model.

The simulation is analysis and synthesis method, where the designed LS is replaced by its simulation model. On this simulation model are carried out experiments with the aim to achieve parameters that are later applied back on the examined and designed LS [50, 51].

The simulation of a large LS is one of the latest and most expensive alternatives for the LS optimization. From the point of complexity, stochastic characters of operations the simulation is unique approach for the LS synthesis. *"Specific problem areas in steel production planning and scheduling include inventory management, slab, plate and cast design and melting shop, hot strip mill and finishing-line scheduling. Optimizing of each problem area independently can result in savings for a steel manufacturer. However, even greater gains can be achieved by simultaneously optimizing all of these interrelated areas."* [52].

Simulation models are functional models which simulate the functions, activities and processes of the real LS. In our case we are not modelling the real factory parts but its functions and processes, e.g. ore exploitation, storing, transport from underground, transportation of raw materials etc. The creation of a simulation model requires a specific analysis described during the simulation model creation [53].

In our case a large LS consists of discrete (transport of slabs, manipulation with coils, slabs) and continuous processes (iron and steel production, continue casting) [48]. For these types of the LS it is better to apply simulation systems which are able to model discrete and continuous processes, e.g. EXTEND.

4.5.2 Steps of Simulation Model Synthesis

1. The problem definition is e.g. wrong function fulfilment; low performance of a shipping system, long waiting time at the crossings, violation of delivery dates, and overload of intermediate operation stores, etc. The problem definition is e.g. to find the optimal length of the green light at the crossing, the right place of allocation and the layout of the manufacturing system, the design of the optimal capacity of intermediate operation buffers, etc.

2. If the object (a company, crossing, conveyance system) exists, we have to define the system on this object, which we would like to optimize e.g.: a topology, element parameters, transmittance, and capacity utilization and to define the variables: time, position, and capacity. If a real system doesn't exist, we have to conclude it from its project and design. The meaning of the simulation model assumes the existence of projected system in a real or project form [50].

3. The definition of variables for the simulated model and capture of data, which described particular LS (operational time, transport time, waiting time, transmittance, capacity, etc). Provision of data for simulation model appears from results of analyses of each works in metallurgy factory.

4. The transformation of the defined LS into a bulk service system respectively or other formalized models which are in the form useful for modelling by a particular simulation tool (a simulation language or system).

5. The selection of a simulation tool – a system for the model creation. It can be – the universal language, e.g. Pascal, C++, however a creation of the simulation model is more complicated, or it could be one of block-oriented simulation languages e.g. GPSS, SIMAN, or one of iconic languages SIMFACTORY, EXTEND, which are necessary for the model creation. In

these special simulation languages the model creation is significantly easier. There is the only disadvantage of the simulation model synthesis, the designer must be skilled in at least in one of the simulation languages or some other tools.

6. The creation of the general simulation model – is a concept of the simulation model and it defines which element of a real system will be modelled by which elements or tool of the simulation language, e.g. arrival of cars to the crossing will be modelled by generating random numbers in GPSS represented by the GENERATE block, in SIMANE by the CREATE block; the machine operation will be modelled in GPSS by orders:

   - SEIZE A
   - ADVANCE $T1$, $T2$
   - RELEASE A

   (A-name of machine, $T1$-processing time, $T2$-processing time dispersion). Such modelling will be carried out by different blocks in SIMFACTORY, and different blocks in SIMAN, EXTEND, etc. Steps 5 and 6 are the most creative. They are the core of the synthesis and require concise and creative way of thinking, knowledge of the object programming philosophy.

7. The creation of models of the elementary processes and the definition of parameters, functions and blocks:

   The parts of the model consist from elementary components – inputs, queue, machines, buffers, dividing, gathering, quality control, etc. Other parts of the model are:

   - the generation of random numbers (modelling of inputs, orders).

- the process synchronization.
- the time control in a simulation model (TIMER).
- the gathering of the simulation results.
- the output definitions of variables and their charts.

8. Transcribing of the model to simulation model using the language command – the creation of a simulation model (according to language type).

9. The verification of a simulation model:

   - From a logistic point of view – if processes in the real system are performed in the same way as in the model, if model truly reproduces the behaviour and functions of the real system.

   - From the formal point of view – if the syntax of the used language is ensured. While the logistical correctness must be controlled by particular controlling steps (e.g. model flows control, their directions and capacity), the formal point of view is controlled by a selected language compiler – simulation system.

10. The simulation time is the time that passes during model experiments. The essential question is how long it is required to simulate a real system so that results (executed statistically) can be approved as valid for a designed LS. Due to the complexity of LS relations, very often there is no possibility to define a simulation time. But the more precise results we want to achieve, the longer simulation time is required. There is one simple rule: the simulation is performed till $|x_i - x_{i+n}| \leq p$. This means, that the difference of variable *xi* values during *i* experiments and $i + n$ experiments is less than or equal to the defined precision – *p*. If the required precision is achieved during experiments, the simulation can be finalized.

11. The evaluation and result calculation. From the results which offer the standard of simulation systems we can calculate some cumulative variables, e.g. total cost, calculation of multicriteria optimization.

12. Experiment iteration with another variant. One of the big advantages the synthesis by the simulation model is a possibility to simulate many variants.

13. Variant evaluation and selection of optimal solution. By some multicriterial evaluation of variants the optimal solution of the system is calculated. Simulation model makes possible to change input parameters as variation of parallel working equipments, variation of processing time. Variations of results are subject of multicriteria classifications. Target is to select optimal solution at clearly defined data.

14. Application of a solution to a real system.

4.5.3 The Transformation of the Real Logistic System to Formalized Model

For the simulation model design of the LS we have to transform the real manufacturing, transport and storing processes to a formalized model as described above in the steps sequence of the simulation model synthesis [48].

This case study presents formalized model (from the Slovak industry) of the LS from the mine Siderit Nižná Slaná, s.r.o. (Fig. 79, 80), processing division Nižná Slaná: production of Fe pellets Nižná Slaná, transport to metallurgical company, reloading of raw materials and storing inputs, material stores, Fe production in three blast furnaces, Fe transport to steel works, continue casting works of the slabs, repairing hall and storing in the cold store, modelling of charging into the push furnaces, rolling on the wide hot rolling mill and creation the tin coils, cutting workshop. Outputs of these processes are branches to three directions:

- customers.
- cutting division.
- cold roll mill division.

Within the frame of the Mine Siderit Nižná Slaná research we concentrated on the balance model design of the production process and on the multicriteria optimization of applying reengineering methods.

For the purpose of production process analysis has to be created the next models within the frame of a metallurgical company it was mainly:

- the raw material discharging model.
- the layout of raw material optimization in the input raw materials stores.
- the blast furnaces charging model.
- the planning and scheduling models for individual aggregates.
- the models for indirect measurements.
- the products sequence optimization models for individual aggregates.
- the capacity models for the definition of the bottle neck of the metallurgical process.

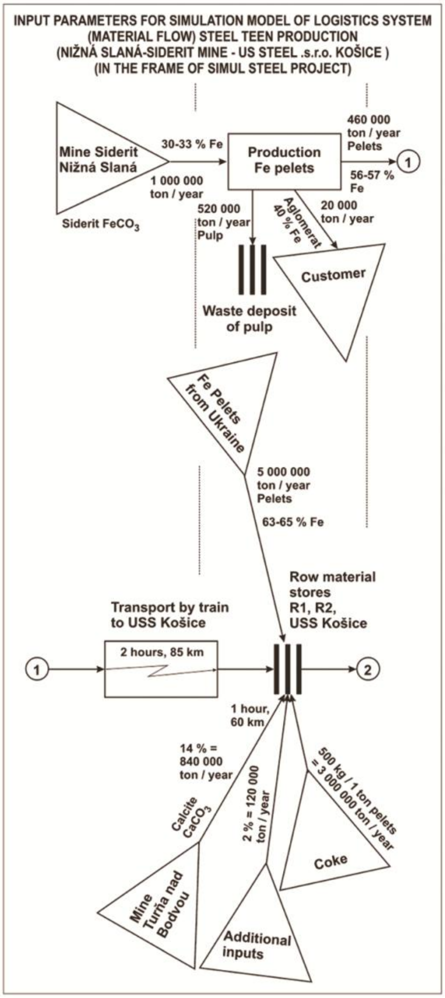


Fig. 79. *Formalized model LS, input parameters for simulation model of LS, part1 [48].*

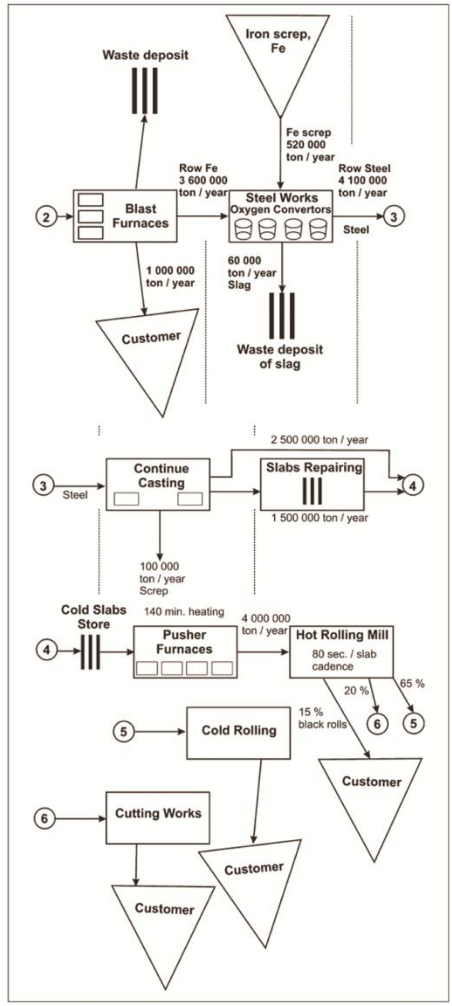


Fig. 80. *Formalized model LS, input parameters for simulation model of LS, part2 [48].*

Figure 79 and 80 displays a chart diagram of the formalized model LS in mine and metallurgy manufacturing processes described above.

The results of the analysis and case studies are data files for the design of a simulation model and experimental data for the simulation model of the LS.

Results of the analysis are the summary and aggregate data described in the chart diagram of the logistics system on Fig. 79 and 80. The logistics system is described on the principle input - output (black box) for each elements of the complex modelled chain from raw material resources though individual technological, manufacturing, transport and storing processes to consumers.

Data which contain formalized model are obtained from case studies [48, 50-56].

4.5.4 Conclusion

The present paper describes the methodology of the creation of the simulation model which is in many cases only one way of analysing and designing the large scale LS. This methodology has been applied under the condition of the mining and metallurgy manufacturing [48, 59, 61-70]. The paper describes a formalized model and data which are necessary for the simulation model design and to perform the experiments with this model.

Described methodology was applied in many factories for example VSŽ – USS Košice, the Mine Nižná Slaná, the Mine Lubeník, Steelworks Podbrezová, the Mine Nováky, and the Mine Veľký Krtíš.

4.6 Quality Evaluation of Logistic Systems

The origin of the term of quality dates back to the ancient times and philosophical sciences. For the first time it was used by Plato, who believed that judgments based on measurable (quantitative) criteria cannot fully describe phenomena and items. The real world is an imperfect representation of really existing perfect ideas. Quality of individual items means therefore the reached degree of perfection [76].

In the following centuries many authors dealt with the issue of quality, described and characterised it. E. Kindlarski gathered over a hundred definitions of quality [77]. One of them was formulated by Donkelaar:

> *"Product (service) quality is good only when with minimum costs of use it provides maximum contribution to the health and happiness of all persons who have participated in its design, production, distribution, use, protection and recycling and distinguishes itself with minimum consumption of energy and resources as well as acceptable impact on the environment and the society" [78].*

This definition expresses fully and unambiguously the essence of quality and indicates all elements that should be taken into account in designing and quality assessment of products and services. It also refers to ecological aspects and the impact of products and services on the society, which is quite important today. The history of logistics is also that long.

Quality and logistics should be closely related to each other. It is enough to compare definitions of both these terms, in which satisfying customer's needs and the level, that is the quality of provided services, are very important. On the other hand, reference books rarely and only fragmentarily refer to the issue of quality in logistics. They lack a comprehensive, complex approach encompassing all aspects of this issue.

4.6.1 Quality Assurance Methods and Systems

Quality assurance is the primary objective of quality management because not only quality alone but in fact quality assurance inspires trust in the supplier. Quality assurance implementation requires development of a quality assurance system including such components as: proper organisational structure, processes, procedures and assets [80].

Reference books in the field of quality as well as practice of production companies demonstrate that there are many various solutions and concepts of quality assurance. In a synthetic aspect, we may properly classify these solutions and present the following description perspectives [81]:

- evolutionary, presenting stages of development of the concept of quality assurance.
- proprietary, presenting achievements of selected and popular originators of quality assurance.
- regional, representing differentiated approach to quality assurance depending on local conditions of a given country or commonwealth.

These aspects overlay and are closely related to each other. However, we cannot determine accurate time frames of individual stages of quality assurance development because they started differently and their course was in each case different, depending on the country, region, branch of economy and even the company.

A. Hamrol and W. Mantura distinguish the following most typical stages and concepts of quality management development [81]:

1. Production control: It is included in the organisational structure of the company, in production units in the production or technical department. Control functions in this case refer to a work post. The subject of the control

may be the product, but also a part, unit, assembly, etc. which is obtained in the course of a production process and assessed in terms of technical quality. Therefore product orientation and acceptance function dominate. It is a control that has properties of restrictive remedial inspection. The main purpose of its results is to determine whether to accept or reject a product and remunerate or punish an employee.

2. Quality control: This type of control is based on the assumption that quality may not be forced by control, it must be developed. A more developed organisational structure occurs, closely related with quality. It mainly concerns laboratories, test and analysis units, staff units and other. Quality is taken into account not only in the technical aspect. This approach usually includes certain elements of preventive activity as well. Responsibility for quality is divided between production and management units and method of self-control is in use. Quality control in this case has features of acceptance and prevention control and uses methods of statistical quality control.

3. Quality guidance Regulating is most important, including the functions of control and correction. Elements of planning and quality stimulation are also present. Quality guidance uses a cybernetic model with feedback, therefore it is process-oriented. It is complex, so it goes beyond the quality service which has a very important place in the organisational structure of the company. Quality guidance employs self-control and systems of faultless work. Additionally, methods of statistical control of technical process are often in use.

4. Quality Management: The abovementioned concepts and stages included only certain management functions, while this concept takes into account a complete set of these functions. Growth of importance of quality management was particularly distinctive in Great Britain where BS 5750 standard

was introduced in 1979. It determined requirements for quality assurance systems. In 1987 the International Organisation for Standardisation published a series of standards referred to as ISO 9000, which specify terminology related with quality management, describe different models of quality assurance, determine functional conditions for this models as well as guidelines for quality management and elements of quality assurance systems.

The third edition of ISO 9000 was introduced in 2000. It includes four standards:

- ISO 9000:2005 (PN-EN ISO 9000:2006) Quality management systems – Fundamentals and vocabulary.
- ISO 9001:2000 (PN-EN ISO 9001:2001) Quality management systems. Requirements.
- ISO 9004:2000 (PN-EN ISO 9004:2001) Quality management systems. Guidelines.
- ISO 19011:2002 (PN-EN 19011:2003) Guidelines for auditing management systems.

The next edition of ISO 9001 standard was introduced in 2008 and since 2009 it has been in use in Poland as PN-EN ISO 9001:2009. Minor changes introduced in this edition mainly concern more specific and accurate formulation of certain terms and provisions [82].

Changes were also introduced in 2009 to ISO 9004 standard, which is Polish PN-EN ISO 9004:2010. Above all, the name was changed. The current name is: *"Quality management oriented on permanent success of an organisation. Quality management approach"* [83].

Complete, accurate and detailed implementation of the said standards in a company as well as meeting all the related requirements do not mean that the company has a comprehensive and complex management strategy. The concept that is currently referred to as the best one, including all issues related with quality management implementing all management functions and involving all employees of the company, is “Total Quality Management” (TQM).

According to S. Tkaczyk: “Total Quality Management is a people-oriented management system purpose of which it is constant increase in satisfaction of customers gained at really constantly decreasing costs. The TQM is a complex system approach (not a selected field or programme) and an integral part of the high-level strategy; this system functions horizontally, crosswise to functional sections and departments, involving all employees of the entire company; it goes in both directions beyond the company in order to incorporate the supply and distribution chains. The TQM emphasises teaching and adaptation to the process of constant changes as the key to the success of the organisation” [84].

The integrated management system is an interesting idea. More and more often in theory and practice of company management are taken actions oriented at integration of individual autonomous management subsystems. One general management system may encompass [85]:

- quality according to ISO 9001.
- environment according to ISO 14001.
- occupational safety and health according to PN-N-18001 (BS 8800).
- finances.
- logistics.

However, most often integration encompasses only quality, environment and occupational safety management systems and sometimes quality systems implemented in individual branches of industry. Logistics is treated as a separate field of management.

4.6.2 The Concept of the Logistic Process Quality Assurance System

Logistic process may be implemented with use of all of the methods and quality management systems described above. However, they do not guarantee reaching the goal of high level of customer service because they do not include all aspects of logistic process management. Furthermore, research carried out in Polish companies indicated that many quality management tools are used only to a small extent (Tab. 14).

Tab. 14. *Quality management system improvement tools being implemented (results of research of 2006 and 2007, comparison of segments depending on the number of employees and origin of the capital; percentage of indications).*

Implemented management system improvement tools	**Number of employees**						**Capital**			
	up to 50		**51 - 250**		**over 250**		**foreign**		**Polish**	
	2006 N=64	**2007 N=63**	**2006 N=112**	**2007 N=147**	**2006 N=83**	**2007 N=90**	**2006 N=73**	**2007 N=66**	**2006 N=186**	**2007 N=234**
Environmental management system	15.63	20.63	42.86	38.78	56.63	61.11	52.05	74.24	36.02	65.38
Occupational safety and health management system	20.31	3.17	24.11	14.29	55.42	28.89	43.84	31.82	29.03	11.97
Total Productive Maintenance/5S	10.94	14.29	17.86	19.73	27.71	36.67	24.66	33.33	17.20	20.94
Self-assessment/ assessment according to quality awards criteria	12.50	17.46	12.50	10.90	20.48	21.11	15.07	7.58	15.05	17.09
Lean Management	9.38	15.87	15.18	8.84	26.51	25.56	24.66	34.85	14.52	9.83
Balanced scorecard	23.44	7.94	16.07	9.52	19.28	23.33	17.81	21.21	19.35	11.11
Six Sigma	6.25	3.17	9.82	7.48	14.46	14.44	13.70	19.70	9.14	5.56

Source: Prepared on the basis of: [86].

Individual quality management methods and tools are mostly used by large companies with foreign capital. It was confirmed in independent research in companies in the automotive and aviation industry. The figure 1 shows the model, the use of which guarantees a large extent the goal. On this basis we may say that the most complex logistic process quality management system that may also be introduced in other companies has been developed and used at United Technologies Corporation.

Companies belonging to the UTC implement the system of Achieving Competitive Excellence. It is a system of continuous improvement in all fields and aspects of company functioning, in particular in terms of operational activity management and in production logistics. It enables achieving company goals through mobilisation of employees in their everyday activities [87].

The system consists of ten "tools". These are popular work and management organising methods and techniques, in particular based on Lean Management but within the framework of ACE used in a comprehensive and consistent manner. The tools are integrated, effective and may evolve depending on specific application. They encompass methods of communication and measures for monitoring of activity.

The first one is 5S + 1 method. Its objective is to simplify, improve and create safe work conditions. It reduces wasted time, visually arranges the workplace, creates friendly and safe work environment.

Use of 5S method consists in removal of useless items from the workplace, putting useful items in their specific place and keeping production department and the entire plant impeccably clean. As these activities are performed systematically and work methods are constantly improved, a firm system guaranteeing order and tidiness is created. It is not only tidying, though, it is a process of thorough changes in the company culture, based on management visualisation, standardisation of processes and teamwork. The sixth “S” is Safety, which means safe work in a safe environment.

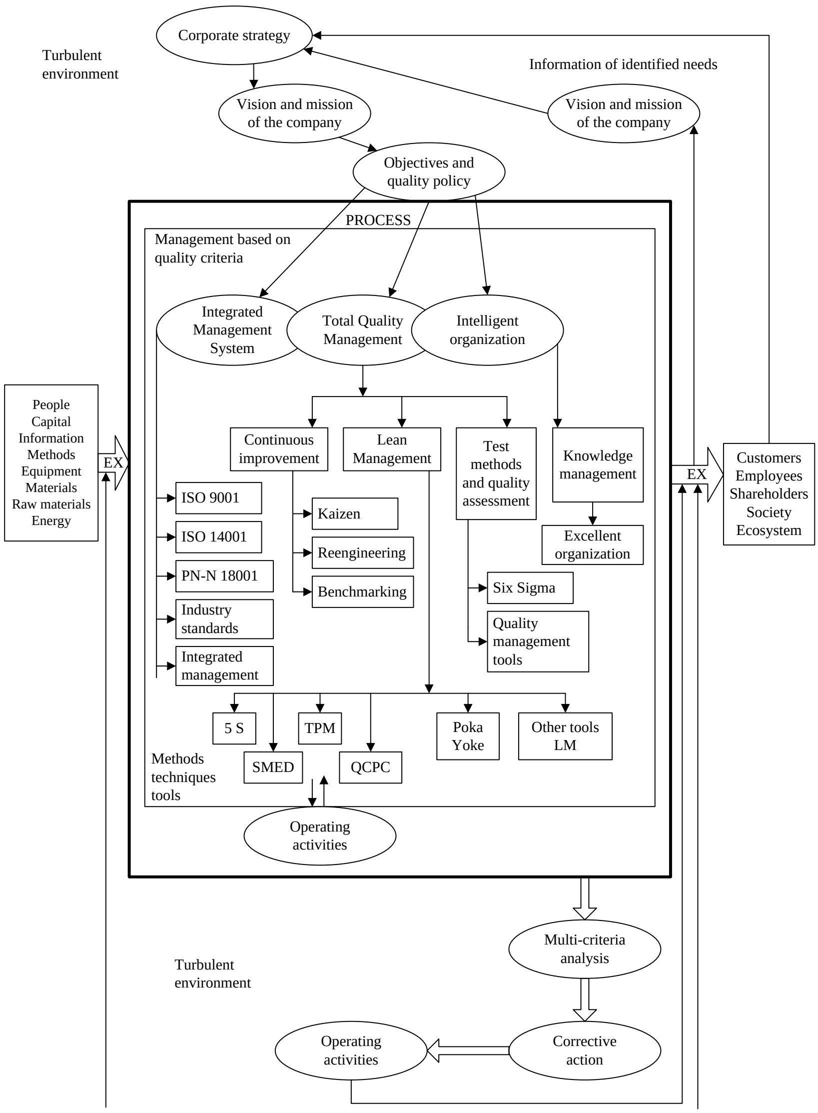


Fig. 81. *The model of the quality assurance system.*

The second tool is Single Minute Exchange of Die (SMED), it is team reduction of machine tooling exchange time. Activities are focused on reduction of down time between production of the last part of one series and starting production of the first part of another series. The positive effect is increase in machines and equipment capacity, increased work efficiency, standardisation of work methods and optimisation of series sizes.

The third tool, Total Productive Maintenance is a concept aimed at increasing productivity and efficiency of processes related with workflow maintenance through increasing creative involvement of employees participating in such processes.

The major issue related with the fourth tool of model methods is grouping similar parts in so-called families in order to standardise methods of production. This promotes elimination of activities that do not provide added value, avoiding losses and shortening of the production cycle.

The most important problem to be solved with use of the fifth tool: Quality Clinic Process Chart – QCPC, is organisation of a database system, which enables constant improvement of the process and solving quality-related problems. Each employee may present comments on their work post, describing everything that hinders reaching the required production quality in an appropriate questionnaire. Employees' remarks also refer to occupational safety and health threats.

Gathering information every day facilitates taking immediate corrective actions. Additionally, all reported issues are categorised according to their importance and suggested solution at the weekly meetings of the QCPC team. If there is a problem that cannot be solved by the team, it is passed on to the “Quality Clinic”.

The sixth tool is the RCCA method (Root Cause Corrective Action), consisted in developing standard decisions referring to specific original causes. This tool is used in order to prevent reappearance of problems.

The basic issue in the regression analysis of the market, which is the seventh tool, is to identify external and internal customers and provide feedback that will make each employee understand their needs. Data from the market and the customers, concerning quality of products must reach every work post, every employee. This will facilitate improvement of quality of products and services.

The eighth tool, error prevention (Poka Yoke) is strengthening the process against errors, which consists in active controlling of potential sources of inconsistency, so that it would be possible to identify an error before it becomes inconsistency. When the error is found, production is stopped or a proper action is taken to prevent occurrence of inconsistency as a result of such error. While monitoring potential sources of errors in each phase of the process, we may found and correct inconsistencies at their very source, which means that this tool may prevent errors through elimination of their causes.

Process validation is the ninth tool and it enables process management, understanding, controlling and monitoring deviations. Validation or certification of the process is used for stabilising it and maintaining at the statistically controlled level. Certification of processes is based on statistical methods and includes measurable and non-measurable characteristics. The result of using this tool is repeatable production of high quality items.

The tenth tool is process management which consists in permanent and consistent implementation of preventive methods in process improvement. It enables determining the optimum process and identifying its weak points. It eliminates activities that do not bring added value to the process.

Beside the described tools, Kaizen system is in use. It consists in making slight improvements in a continuous series with use of the existing tools or systems, through the employees of proper company departments for the benefit of which improving actions are taken. Such activities mostly do not require involving significant financial assets or external experts. In Kaizen, standardising and a system that supports maintaining the level of changes are essential. It is also related with the principle which says that no further actions may be taken if the level of previous change is not maintained.

We may use either all the above mentioned tools, the chosen ones or even only certain parts of these tools. However, positive effects will not last if they are not supported by the organisational structure facilitating changes in the company operations and by professionally trained personnel.

Achieving Competitive Excellence system is based on three basic components:

- quality management principles developed by Yuzuru Ito – ITO University carries out weekly training sessions within this scope for all employees, in particular directors and managers.
- a system which helps the organisation identify and solve problems, improve processes and supports strategic thinking.
- professionalism, dutifulness and involvement of all employees and the entire organisation.

Training company employees is essential. All employed persons have the possibility to participate in a free training and improve their qualifications, mainly within the framework of the scholar programme in which course fees as well as the costs of materials and textbooks are covered.

ACE system is not a one-off action - within its framework teams of employees systematically reach four successive levels:

- qualifications.
- bronze.
- silver.
- gold.

It is the primary motive for constant improvement and consistent use of ACE tools. It is hard to define and measure the results of implementation of the system. However, if we take a look at individual companies of the UTC concern, we may notice that they beat their competition, gaining contracts, for instance to supply aircraft engines. In the times of the today's crisis, companies not only collapse, but also develop while UTC buys other ones in the aviation industry.

All companies within the concern carry out an annual survey among all their employees. Answers are helpful in improving the company activity and reflect results of the implemented system. The survey carried out at WSK "PZL – Rzeszów" presented good economic condition of the company and over 80% of the respondents said that the good points of that company are care of quality and following occupational safety and health rules, whereas around 80% of them referred to the company as a good workplace.

4.6.3 Conclusion

Achieving Competitive Excellence system may be implemented and used not only at the UTC but also in other companies. However, it always requires adjusting the system principles to the specific character of individual companies as well as monitoring and analysing results obtained in implementation of the modified system.

Implementation of the ACE system is not easy. Costs of preparation of individual system components, training of employees and making necessary organisational changes must be incurred.

Good preparation and consistency are vital in implementation, and in particular in employing the developed solutions in everyday business. Therefore change in mentality of all employees including the management is very important, so that the introduced and implemented actions would be the work culture on each post.

The most significant threat related with implementation and functioning of the system is lack of consistent actions of the management and employees of the company. Low qualifications of the personnel may also be a threat, therefore particular attention must be paid to training and professional education as well as all company staff. Problems may also occur if other, competitive companies employ the same or similar solutions. But ACE system is flexible enough to enable introduction of other, new components, which makes it possible to beat the competition.

Still most important chances lie in improvement of the company structure and organisation, reduction of costs. But above all, implementation of the ACE system and its everyday functioning may contribute to improvement in management and functioning of the company, also in the area of logistics, which is followed by improvement of its condition and market position.

4.7 Application of Logistic Principles in Metallurgical Production

Logistics is the branch of management, where the objects of management are flows and chains with the target of their overall optimisation [24]. Logistics has a cross sectional character [88, 93]. The specific characteristics of the logistics of metallurgical production follow mainly from the object of management i.e. metallurgical production processes. The production processes of metallurgical production have several specific characteristics, which have to be accepted while managing them.

MPP is a chain of continuous and discrete technological, transport, manipulation and storing operations, which have to be transformed into a discrete form first when modelling these processes.

Then, there is a long production cycle and also great inertia especially for thermal processes, long delivery cycles of supplied material (even several months) and typical tree structure of the production process [24]. From these the strategy of Feed Forward management resulted. [24]

Metallurgical companies are huge companies making very high investments (even billions of Euro) resulting in long recoupment period of investments and high lifetime [18]. Metallurgical products are at the beginning of the production chain. These products are materials like metals, semi-products (plates, pipes, wires) which is the reason why products with different than planned quality do not need to be scrapped (as it is e.g. in machine or electrical industry) and it can be still used for a lower quality purpose. The output of these production processes is only one product or a narrow assortment of products.

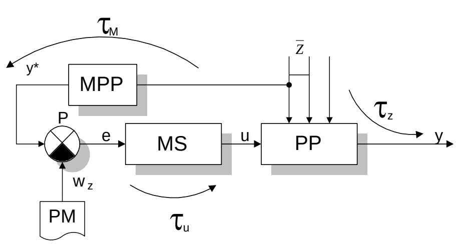
Above mentioned and other characteristics of MPP – classify these production processes into so called homogeneous production processes. [24] The costs for its automation, informatization, and logistics applications are relatively low compared with the costs for building the technology and equipments. All of these approaches bring at least 5% of cost savings. In absolute value these savings are high. That is the reason, why metallurgical companies are leaders in these applications which means also leadership in logistics as well as production logistics. [24, 88, 91]

4.7.1 The Specific Characteristics of MPP Logistics

The specifics characteristics from the point of logistic are:

(a) *Great inertia* - This is influenced by a long production cycle, thermal processes (blast furnace, push furnace) and big amount of moving material flows.

For this types of processes as the basic logistics model is the feed-forward principle of management is applied, which is based on the program – operative plan of production (PM) and monitoring of inputs $\bar{z}$ to the production processes. On the basis of the vector $\bar{z}$ and the model of production process (MPP), the forecast of outputs y* are simulated (Figure 1). PM is usually created on heuristic principles. [18]



P – comparison process – element
PM – planning model – program
MS – management system
MPP – model of production process
PP – production process
z – inputs, break down
y – outputs
y* – simulated outputs
e – deviations
u – decision making
w_z – the goals of production
τ_M – simulation time of the outputs y*
τ_Z – transmission the break down to outputs of PP
τ_U – decision making time

Fig. 82. *The structure of feed-forward management – philosophy FFM (Feed forward model).*

(b) *Big investment* and long life cycles mean long economic return. It is necessary to continuously adjust and keep the parameters of the products from the point of facility and aggregates utilization. This fact has to be taken to MPP.

(c) *Narrow product assortment* - Narrow product assortment (metal sheets, cement, wires etc.) enables application in the production process of special purpose aggregates, facilities, and machines with high level of automation. A disadvantage here is low level of flexibility in changing the production. These characteristics have to be taken into account in the planning models (PM).

(d) *Combined continuous-discrete process* - Metallurgical processes consist of continuous and discrete technology processes. If we want to create MPP, it the first step is transforming these processes into discrete types and then to apply a system for modelling the discrete system, because the continuous discrete production processes are very hard to model. [89] For modelling and simulation of discrete production processes, it is easy to apply the systems such as GPSS, SimFactory, Extend, Witness etc. The second alternative is a balance model.

Other specifics of metallurgical processes are:

1. Tree structure from roots to leaves.
2. Faulty product does not need to be considered as a faulty product, it can be sold as a product with lower quality. [90]

4.7.2 Example of the Logistic Principle Application to Metal Steel Production

Each company has its own specific structures of production processes, rules and objectives of management, is unique and also is unique from the viewpoint of logistics. [91] Logistics is a management concept, which the following principles applied:

- system approach.
- co-ordination.
- planning.
- algorithmic realization; and
- overall optimization of the chain. [24, 93].

In this case slabs of required sizes and quality are cast by two equipments for continuous steel casting (CC I. and CC II.). The diagram of material flows is in Fig. 83. The cast slabs are transported to the slabs reparation plant where they are repaired before rolling and from there to the cold slabs storehouse or they are directly transported to four push furnaces (PF1 to PF4). After heating up to the rolling temperature they are pushed out from the push furnaces and transported by a roller table for rolling at wide hot mill (WHM – 1700, named also as TŠP - 1700). The field store yard serves to balance the differences in production at times of regular repairs at WHM - 1700 or during operation shutdowns at CC I. or CC II.

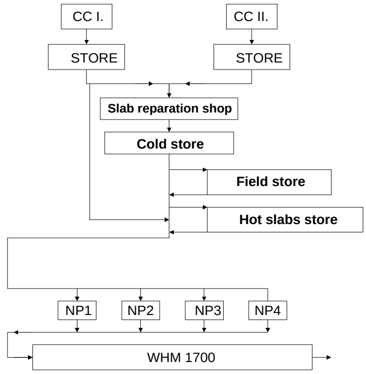


Fig. 83. *Scheme of material flow in the CC – PF – WHM.*

The three main parts of the steel division, WHM - 1700, PF1 - PF4 and CC I. and CC II., have their own system of operation planning.

Each single part is understood as unit of one system, its mutual relations create material flows, but also information relations in the way of operative plans.

One of the logistic goals of the Steel division is to coordinate production operating plans of WHM - 1700, PF1-PF4 and CC I. and CC II. in order to accomplish the maximum portion of slabs are in direct sequence (CC - FP – WHM-1700) thus solving the problem between the difference production capacity of Slabs reparation plant (approx. 1.5 million tons yearly) and production of CC I. and CC II. and WHM - 1700 (approx. 4 million tons yearly) but at the same time the more slabs there are in the direct sequence the less is the energy consumption for their heating up in the push furnaces (cold slabs are of outdoor temperature i.e. approximately 10 degrees Celsius, the temperature of hot slabs is from 150 to 400 degrees Celsius).

The fact is that every hour material with the value of about 200 000 € flows through these aggregates requires very precise systems of scheduling. At WHM - 1700 it is so called schedule of WHM - 1700, 24 hour and 7 days plan, at FP has a schedule of charging and at CC I. and CC II. has a schedule of casting.

Planning, system approach and processes coordination must be controlled by the overall optimization [36, 92]. Individual elements of the production process have different criteria of optimization. For example, for WHM - 1700 slabs groups of the same type in the amount of 20 to 40 are best for rolling from the standpoint of rolling technology because with such amounts the best exploitation of operation and support rolls of roll stands is achieved when changing the slabs groups according to certain rules.

It is therefore an effort of operating planning of WHM - 1700 to form groups with these amounts of slabs. From the standpoint of characteristics of production processes at CC I[st] and CC II[nd] it is necessary to readjust the crystallizer through which slabs are cast with every change of their size. However, the readjustment of the crystallizer means idle time of CC I[st] and CC II[nd] and also creation of a reducing slab which must be adjusted before rolling (if we know how to sell it in the final product) or it becomes scrap. The goal of CC I[st] and CC II[nd] is therefore to cast the greatest series of the same slabs possible. For PF the optimal batch is equal to the length of the dominant II. Zone, see Figure 3 The optimal production batch is the compromise among the technological batches for these three aggregates.

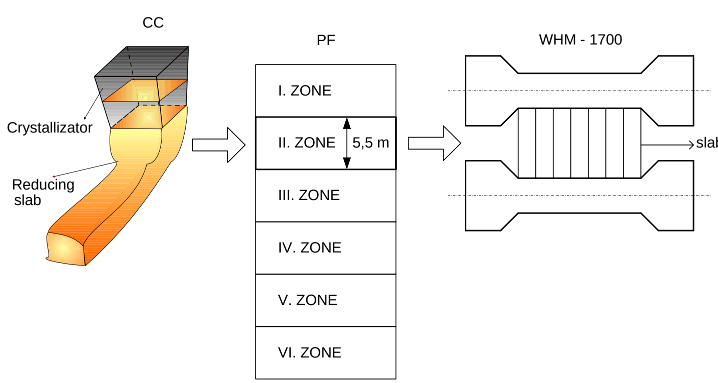


Fig. 84. *Creation of the optimal production batch.*

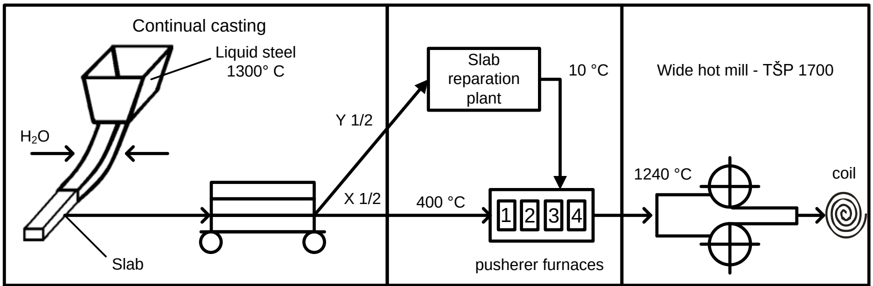
It results from the previously mentioned that local criteria of optimization must adapt to the superior overall criteria, for example maximum profit, minimum energy consumption, keeping the confirmed terms of order etc. [24, 89].

One of other characteristics of logistics is logical organization of individual operations of the production process and the algorithmic consistency of their effectuation. Algorithmic realization ensures logical order of steps, activities continuation, activities repeating, compatibility in communication and realization. Likewise with the algorithm, it can be a definite activity sequence, cycle, alternative selection- decision-making, etc.

4.7.3 The Relation of Management, Logistic and Technological Operation Control in the Conditions of Metallurgical Process

Inner enterprise processes of the company can be divided into three levels:

- economic processes.
- logistic processes (chain of the technological, transportation and cumulating operations).
- technological operations.



CONTROL: - speed of casting - quantity of cooling - ...	- furnace temperature control - ratio of air and gas control	- roller pressure power control - distance roller control
LOGISTICS: - min. number of reducing slabs - optimal sequence of casting - optimal number of slabs in sequence - coordination with TŠP	- increase of the ratio of hot slabs - synchronization of heating and roling - optimal system of storing slabs in the warehouse - choice of proper furnace for heating of certain slab	- size amount off rolling - sequence off rolling of each amount and coordination with heating of slabs in pusherer furnaces - coordination of rolling with continual casting
MANAGEMENT: - minimizing of costs of coils production - fulfillment of terms of delivery products - energy, maintenance, performance costs - division production, etc.		

Fig. 85. *An example of activities and variables for three management levels [18].*

These three groups of processes are characterized by other variables, other managing variables and managing criteria. While technological operation control manages physical, mechanical, thermal and chemical variables like pressure, temperature, liquid level, speed of rotation, ratio among the variables etc., the management criteria are used for example to find out the optimal curve of heating with the aim define economically e.g. minimal heating costs.

When there are the subjects of management of technological and transportation, cumulative processes, which are considered as the chain or network, then we speak about logistics. There are managing time, place, and capacity variables.

Management – management of economical processes of an enterprise is based on the principle of hierarchical managing i.e. the logistics have to respect the aims of the management, as the supervising level (for the whole enterprise to work optimally) and aims of the logistics are moved beyond the base level on the technological process control.

4.7.4 Conclusion

In the 60s and 70s of previous century, automation was the basic dynamic factor of production industry. Toward the end of the 20th century, information systems like Steel man, SAP R/3 etc., which partly include logistics, were the dynamic factor.

The dynamic factor of early 21st century is the logistics. From the logistic point of view, each production process is different, each has its specifications and this is the reason why logistic systems are needed to be developed and implemented as unique, “made-to-order” systems, based on the present conditions of modelling, simulation and information technology and to be applied their knowledge to heuristic models and expert systems.

Metallurgical companies, especially by reason of fast return of investments, are always the leaders of implemented automation, information technologies and they are also the leading companies implementing logistics in their production.

4.8 Heuristic and Logistic Model for Production Scheduling of WHM 1700 in OCEĽ VSŽ a.s. Košice

Production technology modification in OCEĽ s.r.o. company (main division VSŽ)- conversion into a continuous slabs casting (CC) in CC I and II and progressive rejection of slabing, as well as costs reduction for heating in push furnaces (PF) through the use of increased amount of hot batch, but especially by conversion of production philosophy in hot wide line (WHM 1700) in conditions of market economy, i.e. maximal satisfaction of customers requirements, represented by orders, of delivery terms, quality and ordered amounts- were a main reasons for model processing for operative plans in CC, PF, WHM 17000 automatization and co-ordination. This model is not a project, so some concrete information is not mentioned designedly.

4.8.1 Description of Material Flow in Division CC-PF-WHM 1700

Slabs of required dimensions are casted in two devices for continuous steel casting (CC I, CC II) (fig.1). Casted slabs are transported either to the slabs cleaning shop and cold store or by direct sequence into a four pusher furnaces (PF 1 to PF 4) for heating. After heating, slabs are pushed out from pusher furnaces for the rolling in hot wideband line (WHM 1700). Field store is used for differences compensation in production during regular repairs of WHM 1700 or during longer downtime of CC I or CC II. [24]

4.8.2 Purposes, Principles and Rules for Operative Plans WHM 1700, PF and CC Co-ordinatiom and Automatization

Operative Planning Objectives.

Production technology modification in OCEĽ company- conversion to the continuous slab casting in CC I and CC II with perspective of slabs rejection and maximal effort for customers' requirements adaptation- results in following solution objectives:

(a) Maximal satisfaction of customers in term of demands is represented by orders and observance of delivery term and ordered amount per week.

(b) Coordination of WHM, PF and CC production plans to achieve the highest possible number of slabs in direct sequence, so difference between slab cleaning shop capacity and CC I and CC II production was resolved, but great acquisitions should be also from energy savings for slab heating in PF. [24]

To achieve energy savings for slabs heating in PF through material flow organization and PF operative planning.

Principles of co-ordination:

(a) Operative planning is timely and by content realized contra directionally to material flow.

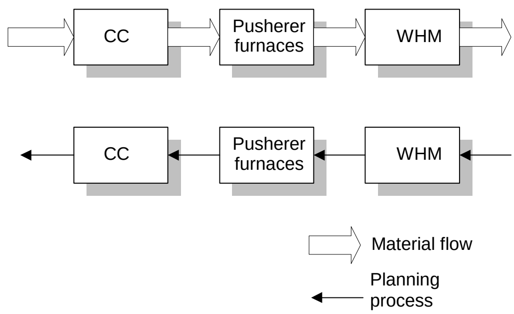


Fig. 86. *Operative plans and material flows directions.*

(b) It was selected interval for 7+7 days for optimal plan WHM 1700 development, because of orders confirmation per "week". Another 7 days of the plan is preliminary, allowing coordination, feedback of unrealised slabs from first 7 days, longer interval 7+7 days allows more convenient commutation and longer series in CC. Second 7 days allow production of slabs for orders from these 7 days, in the case of capacity CC over WHM dominion, so they will stay in store limited period only.

(c) Plan is developed for 7+7 days. First 7 days, the optimal plan is definite, another 7 days- preliminary. We suppose max. 10% of changes during preliminary plan re-planning into a definite one (moving planning).

Content coordination (figure 87).

(a) Direct sequence slabs are manufactured in CC approx. 6 hours before rolling and they are transported to the PF approximately 2,5 hours before rolling.

(b) Slabs through the cleaning shop, in relation to the technological time, necessary for cleaning, will be casted minimum 3,5 days before rolling.

(c) In the case of CC over WHM output dominion, slabs of non-direct sequence are planned in steel-mill's operative plan for first 7 days, from WHM 1700 operative plan for another 7 days.

(d) Operative planning system has three levels of hierarchy. Operative plan WHM 1700, (OP WHM) for 7+7 days, consists of WHM 1700 schedules for 24+12 hours, containing campaigns.

OP WHM (7+7) => {24+12} => {campaigns}

Operative plan PF is created for 24+12 hours and consists of images two genarations operative plans OPN1, OPN2. Operative plan CC is created for 7+7 days and more detailed one consists of 24+12 hours operative plans, and these plans consists of WHM schedules-campaigns (for 2,5-4hours).

(a) Coordination, mostly of the direct sequence, is based on JIT principle.

(b) Scheduling models are based on heuristic principles. Technological rules are rules, derived from rules of technology and logistics principles. Heuristics are rules, derived from experiences of schemers - logistic-men and employees of operation, based on principle of analogy and induction.

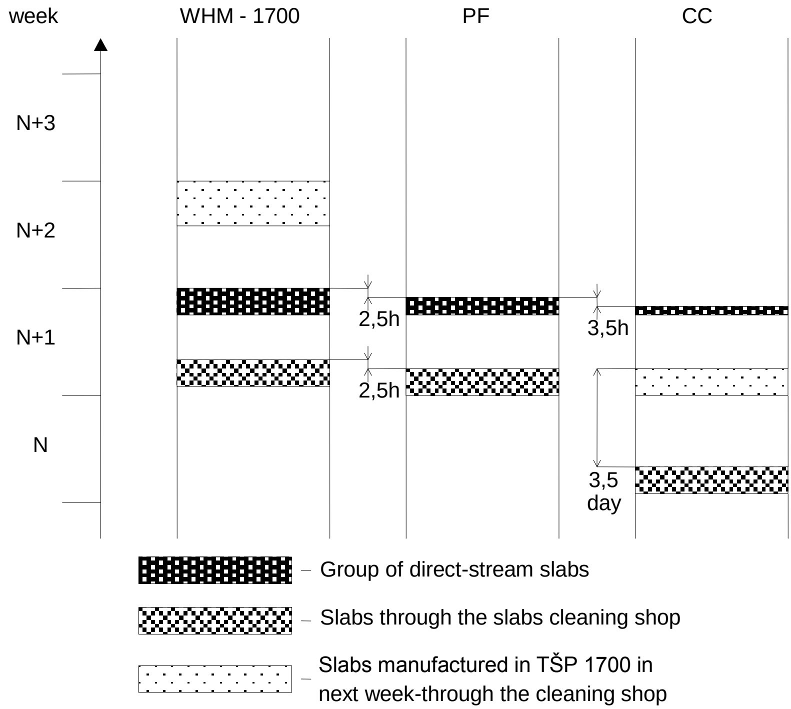


Fig. 87. *Material flow co-ordination between WHM, PF, CC.*

Example:

Technological rules:

Rules of campaigns creation C1, C2, C3 are derived from WHM 1700 cylinders abrasion rules.

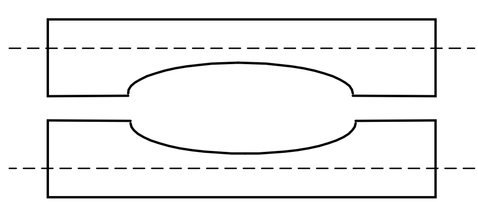


Fig. 88. *Cylinders abrasion.*

Example:

Heuristics:

During large cylinders replacement in WHM 1700, hot batch of slab loading to PF is necessary.

Note:

In term of technological rule we understand such rule, which was created on the base of logic consequence, technological soundness. Heuristic rule (heuristic) is such rule, which is raised on the base of experience, practice, intuition, i.e. by repeating of analogical situation solution and consecutive induction.

4.8.3 Model for WHM 1700 Production Scheduling

Schedule WHM 1700 development is based on orders file for 7+7 days.

During schedule WHM 1700 development, following is necessary:

(a) Distribution of individual orders (represented by slabs groups) in to the campaigns in such way, that:

- all rules (heuristics) of scheduling in WHM 1700 are observed,
- every campaign will be used as much as possible, i.e. the largest possible amount of material, concerning the cylinders life-cycle, will be rolled in campaign.
- term order will be manufactured within required term.

(b) distribution of individual campaigns between support cylinders replacement in such way, that scheduling rules in WHM 1700 will be observed.

(c) To provide WHM schedule to operative plans and schedule-makers on CC I and CC I in sufficient advance- so they have a time for their development and co-ordination.

Heuristics and technological rules for production scheduling in WHM 1700:

Note:

Because of copyright, there is not introduced complete list of rules. In the case of interest, you can find them in the reference [94]. From technology and production management, 16 rules were derived, e.g.:

Introduction of width and size assortments of operating cylinders individual campaigns shall be executed in dependence from support cylinders abrasion condition of final order.

1. Line testing after operating cylinders replacement shall be performed with assortment from 3,0 – 4,0 x 1015 – 1240.

2. Minimum 6 and maximum 12 pieces of slabs shall be used for the beginning of campaign.

3. In campaign, assortment shall be arranged from wider to narrower, because of cylinders abrasion.

4. Allowed size-jumps in individual items planning upwards and downwards are as follows:

   - up to 4,0 mm .... 2,0 mm jump.
   - maximum allowed width pass is +/- 250 mm, etc.

These rules led to the characteristic campaigns development. In term of campaign it can be understood production time period in WHM 1700 between two "large cylinders replacement" and in the same it is time typical assortment structure, in terms of quality, amount and dimension and their typical sequence:

(a) wrapping campaign without small replacement of cylinders - C1.

(b) dynamo-campaign with cylinders small replacement - C2.

(c) wrapping campaign with cylinders small replacement- C3.

Every campaign has its own limitations and rules.

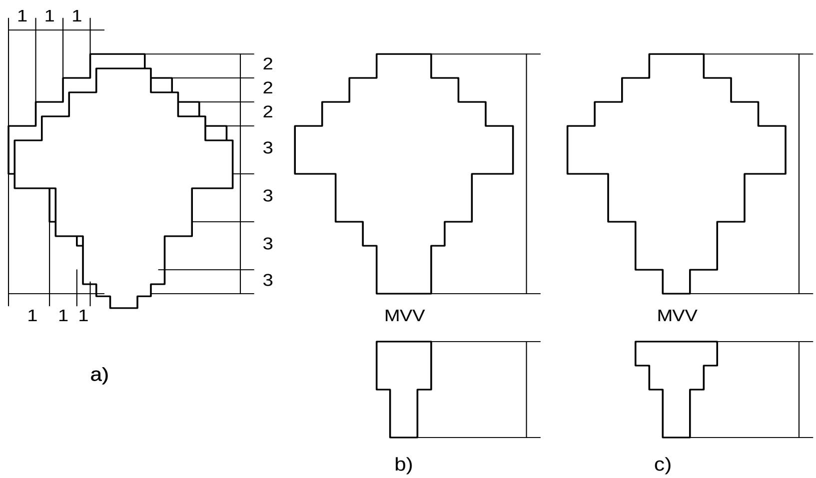


Fig. 89. *a. b. c. Campaign types in WHM 1700 (C1, C2, C3) [24].*

Explanations of figure:

1. Min. difference in band width 80 mm.
2. Max. amount in item 9 pcs.
3. Max. amount in item:

2,0 – 2,5 mm ..... 20 pcs.

2,6 – 3,0 mm ..... 25 pcs.

3,1 – 4,0 mm ..... 30 pcs.

Orders set processing:

Weekly stock of work (7 days) is possible to divide into the groups in accordance with width and direction, to simplify determination of order type, convenient for given place of campaign filling, during individual campaigns filling (Fig. 90).

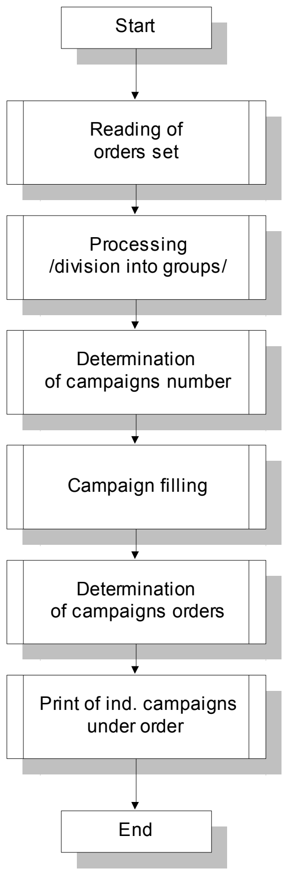


Fig. 90. *Algorithm of production planning in WHM 1700 [24].*

Disposal in accordance with width:

S1 up to 899 mm.

S2 900 – 1039 mm.

S3….

…

…

over 1380mm.

Disposal in accordance with width has a given structure, to allow a steady secure transfer from one group to the other in individual parts of campaign, without exceeding the max. width jump 250mm.

Disposal in accordance with size:

H1.... up to 2,99 mm.

H2.... 3 – 3,99 mm.

H3.... 4 – 5,49 mm.

Disposal accordance to with size has a given structure, to allow a steady secure transfer from one group to the other in individual parts of campaign, without exceeding the max. size jump for certain band size.

Disposal in accordance with direction:

SM1: 676x, 6844- dynamo sheets.

SM2: 677x, 676x, 684x – it is not possible to roll in first campaign after supporting cylinders replacement.

Method of campaign types and number determination:

At first, we will determine number of dynamo campaigns – NC2 and number of slabs for dynamo sheet production – DC. We will determine approximately, how many slabs is possible to roll in one dynamo campaign- NSC2. Number of dynamo campaigns:

$$NC2 > DC/NSC2,$$

where NC2 is an integer. Then, we will determine, how many slabs, belonging to the group with the widest slabs, will remain. We will determine, in how many wrapping campaigns these slabs can be rolled – we will obtain min. number of wrapping campaigns –NC1. Then we will determine if it is possible to roll other width groups in given number of campaigns. If not, NC1 is reduced by 1 and number of wrapping campaigns C3 –NC3is determined.

We will determine again, if in given number of campaigns, rolling of other width groups is possible. If not, repeat the procedure, till all the width groups are covered by campaigns. In the case, that NC1=0 and number NC3 not cover all the width groups, NC3 is increased to cover them. In such way we will obtain number of campaigns: NC1, NC2, NC3 and we will continue with their filling.

Campaign filling:

Campaign filling depends on campaign type in accordance with planning rules in WHM 1700, e.g. campaign C1 filling.

TRIAL RUN:

(a) begins with number of 6-12 pcs. from group S3, best 1040 or 1050mm, because it is the largest amount, size H1, direction SM4, SM2, SM3 or SM6.

(b) continues with number of 6-12 pcs. from groups width S4, best 1290mm, because it is the largest amount, width H1 or H2, direction SM4, SM2, SM3 or SM6.

CAMPAIGN:

(a) begins with width S6 (if possible), otherwise S5, width H1, H2 or H3 (if trial run was terminated by width H2), direction SM4, SM2, SM3, SM6 or SM8. Number of pcs.- over 6.

(b) continues with the same groups, only size can be change upwards by 1 group and downwards by two groups. Number of pieces over 6, total number of pieces in points 1a and 1b must not exceed number 20-30 in dependence from size, as far as scheme from fig. 111 is not applied.

Campaigns order determination:

Campaigns order is determined in accordance with planning conditions in WHM 1700:

- 1st campaign: it cannot contain SM9 and S6 intersection with H1, H2 or H3 (H1, H2, H3- size groups, S1 – Sn are width groups).
- 2nd campaign: it cannot contain SM3 and S6 intersection with H1, H2 or H3.
- 3rd campaign: it cannot contain S6 intersection with H1, H2 or H3.
- 4th campaign: it cannot contain S6 intersection with H1, H2 or H3.
- …
- campaign: it cannot contains S6 intersection with H1, H2 or H3.
- campaign: it cannot contains S6 intersection with H1, H2 or H3.
- campaign: it cannot contains S6 intersection with H1, H2 or H3.

- …
- N[th] campaign: cannot contains S6 intersection with H1, H2 or H3.

4.8.4 Conclusion

The case study describes the methodology of model development for production schedule WHM 1700 atomization in OCEĽ comp. VSŽ a.s. Košice. It defines rules, criterion, restrictions and objectives, and on the base of heuristics and logistics, it creates model's algorithm. It is an application of theory for production scheduling heuristic models development.

4.9 The Heuristic Approach for Maintenance of Operative Planning Model Design of a Gas Distribution Company

4.9.1 Introduction

According to new estimates, all economic subjects in economically developed countries spend approximately 10% of national income on maintenance. In search of cost saving in maintenance process it puts great accent on effective operational planning. Appropriate organization of these activities has a direct impact not only on the technically safe and reliable operation of devices, but also indirectly on the amount of their operating costs. [95] In the distribution company for oil and gas the maintenance cost are dominate. [99].

Developed methodology is addressed in the enterprise for the first-stage maintenance management, which is directly responsible for the design of planes from the volume of work which are defined by annual plan and from the operative evidence of reported and detected faults [97, 98, 101, 18].

Targets of maintenances management – we define by the norm STN EN 13306as the objectives established and adopted for maintenance activities, whereby they may present for example usability, cost reduction, product quality, environmental protection, safety etc. [96].

Operative planning issues from three main sources, namely from:

1. Annual plan of maintenance, which contains defined planned preventive and corrective actions in certain cycles, which are specified by law, standards or they are defined illative by technical risks management.

2. Continuous assessment of the state of gas devices by ATS and RS indexes, which assess the technical state (ATS), safeness and reliability (RS) by multiple criteria. On the basis of exacerbated values of quantification indexes, gas devices can be integrated to the operative plan of maintenance.

3. Operative evidence of determined failure and escapes which were filed by preventive maintenance and also failure and escape reporting by consumers, for example through breakdown line.

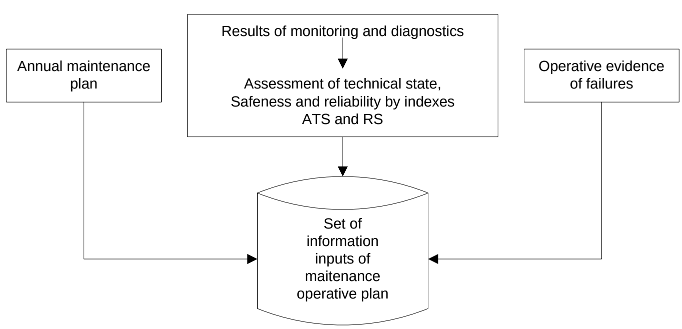


Fig. 91. *Basic information sources of operative planning [99].*

The volume of unplanned maintenance, which is performed after failure of devices, forms the value by 20% from total volume of maintenance in the enterprises for distribution of continuous media. The part of planned (preventive) and unplanned (reported or ascertained) maintenance is different on the part of time, it is 80/20 at average. [99].

Operative maintenance plan is a weekly plan on days, it is the last level of decision about the future maintenance activity within the hierarchy of enterprise objectives.

On the part of maintenance management system analysis in the current enterprises we see as a major shortage of operative planning the absence of one level of planning – capacity planning, that would prove at greater lapse to respond to changes in maintenance requirements.

4.9.2 Methodology for Model Design MOP

The Information Sources for Model of MOP

Information from annual plan

From the aspect of activities this plan includes:

- Regular cycle activities of technical inspection (different types of control and measurements, for example tightness control…).
- Preventive maintenance activities (special inspections and tests, routine and minor repairs of equipment).
- Medium and major repairs in the field of renovation and modernization (repair of technological objects etc.).

The specific form of plan for the demand of operative management of maintenance must be available for each organizational unit (which relates to), for example by the help of software application. It is also important to say that the form of annual plan puts more precisely forever and it modifies by actual assessment of technical condition and safeness of equipment. [100].

Assessment of technical condition and safeness of the network by the indexes ATS a RS.

The methodology for assessment of technical condition and safeness presents the system of multi-criteria assessment of equipment. Each criteria and sub-criteria (technical or economic nature) are rated according to the weight of their impact on the overall technical state assessment (ATS), or safeness and reliability of the network (RS). Long-scheduled selected items evidenced in the operative records are the basis of actual assessment.

Concrete values of indexes ETS and RS are obtained after criteria and sub criteria items up in the concrete time. [103] By their values monitored devices are classed from time to time to three maintenance zones:

C - For devices without failures. It is exercised only basic maintenance and control in terms of laws, notices and standards.

B - For devices with compromised reliability. It increases the cyclicality of controls, it tightens up the regime of diagnosing and measuring, devices are classified into the development plan of reconstruction.

A - For devices with high age and relative reliability. It is given maximum frequency of controls, the most stringent system of measurement; devices are integrated to the planes of extraordinary reconstruction.

Operating managers are charged with responsibility for development of maintenance planes in accordance with evaluation of technical state (ETS), safety and reliability (RS).

Monitoring and operative evidence of the failures:

Maintenance operative management in enterprises for distribution of continuous media must ensure except for aforesaid activities the collection of information about fault rate of devices, too. By the character of measured data this collection can be provision manually, to before prepared blank forms, or automatically, by the help of various sensors and detectors. The administration of actual technical-operative documentation is provision from the results of reports from evaluation of diagnostic control, specialized checking and tests and so on. This is controlled and recorded electronically to software module, for example SAP. By found failures, or emission from the aspect of underground localization, to system GIS, too. Operative evidence subserves the role of feedback of the complete operative management. The use of its actual data has direct continuity to the process of operative planning.

Design of MOP

The first step by daily operative planes creation is assembly of demands on maintenance for the given week, including the delays from the previous period and determination of the priority of fulfilling on the part of its importance. [105] As we reflected, by operative planes of maintenance it is a combination of preventive and corrective maintenance. We used the process of multicriteria decision making for the selection and determination of priorities for several activities of maintenance. By the solution we used the method of weighted sum, in which we determined criteria, by which all basic activities of maintenance exploited in enterprises for continuous media distribution evaluated individually.

Criteria for evaluation of the maintenance activities. [99, 102].

1. Cyclicality – it is a factor which presents statutory or planned cycle for given activity realization. Generally it is a deal, that the cycle of the given activity is more frequent, by it has to get higher items up in this criterion. If the activity is not realized in cycles and it performs only by assignment (for example correction), it must be allocated to it at the highest value.

2. The importance of the segment - it is a factor, which takes into account the significance of a network segment, on which the action relates. By maintenance it is in force that the highest significance has the segment with the highest priority of importance.

3. Impact on safety and reliability – this factor predicates about it, how it affects a specific maintenance activity to ensure safety and continuity of service distribution network, as well as re-establishing in the event of failure.

4. Sequence of secondary activities – it is the factor which expresses the need of the next activities for given activity realization (for example measuring after correction and so on).

5. Personnel – qualification fastidiousness – factor which defines quantitative (personnel) and qualitative (qualification) demands for assess activity of maintenance.

6. Time limit – it is a factor, which defines limit usage of working standard hours for realization of this activity. If the work expenditure of maintenance activity is higher, the point value of this factor must by higher too.

7. Economic fastidiousness – it is a factor, which makes provision for expense fastidiousness and material-technical demands for maintenance activity support.

8. Conditionality to climatic influences – it is a factor, which expresses what the influence climatic conditions have to the possibility of activity realization. [104].

There are various activities in maintenance (for example control of the tightness of gas lines), which are directly weather dependent. After the choosing of aforesaid criteria, we used the method of sequence for establishing of their adequate weight. The most important criterion has the number n-1, the second has n-2 etc. The least important criterion has the number 0. By this method we obtained/get the matrix of preferences, which contains these opinions:

- opinions of employee of the management of particular networks operation,
- opinions of employee of the first-stage management of maintenance,
- opinions of employee of maintenance “master”,
- and also our preferences.

Because this valuation obtains our preferences, too, we can say that it was some pseudo-expert appreciation of ranking criteria. For each ranking criterion F_i for i = 1, 2, …8 we calculated the sum of sequential numbers pi, which was rationed to this criterion by participant of valuation. After calculation the weight of each ranking criterion by the relation:

$$W_i = \frac{p_i}{\sum_{i=1}^{s} p_i} = \frac{\sum_{j=1}^{4} p_{ij}}{\sum_{i=1}^{s}\sum_{j=1}^{4} p_{ij}} \qquad (1)$$

$$j = 1, 2, \ldots 4 \qquad whereby \quad \sum_{i=1}^{8} W_i = 1$$

Cardinal extends are determined - assessment within the range of 0 until 10 to items up of maintenance activities (by elected criteria with calculated weight). By the problems of points allocation to assess activities we used services of several experts from enterprises which are concerned with distribution of continuous media within the frame of “east” of SR. Items up was performed by maximization form, i.e. the bigger pointed value, by it the given factor has higher importance among values of the same factor by different activities.

The final overall assessment of this activity was obtained as a sum of items up of criteria k_i multiplied by their weight W_i.

As an example it was appreciated the gas enterprise, to which we specify the similar types of maintenance activities for the other enterprise and by this method it was appreciated 79 basic activities of maintenance. On the part of obtained evaluation these activities were classified into three groups.

Statistically it is visible in the next figure.

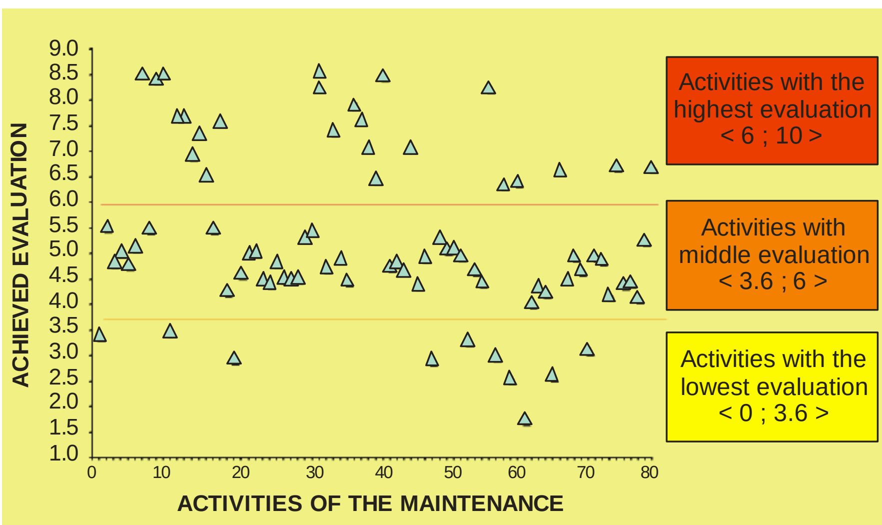


Fig. 92. *Statistic illustration of maintenance activities evaluation [own source].*

Activities with the Highest evaluation (A)	Maintenance activities, which have to be immediately classified do the weekly operative plan as a preferred *(23 activities)*
Activities with middle evaluation (B)	Maintenance activities, which can be classified, do the weekly plan. Their performance can be moved also to the next week. Their realization demands by the period of given month. *(46 activities)*
Activities with the lowest evaluation (C)	Maintenance activities, which from some reason we want to classified do weekly plan. Their realization can be moved also to the next. *(10 activities)*

Activities with the highest evaluation will be classified to the weekly operative plan as the first. Follow it will be the activities with the middle evaluation and finally, by free maintenance volume it is possible to class into the plan also the activities with the lowest evaluation. To restriction of intuitive progress and minimization of the possibility of subjective mistakes by deriving preferences of maintenance activities, we created for this process the algorithm, which is in the next figure. The sequence of the maintenance activities by the day (maintenance schedule) is in competence maintenance manager in this region.

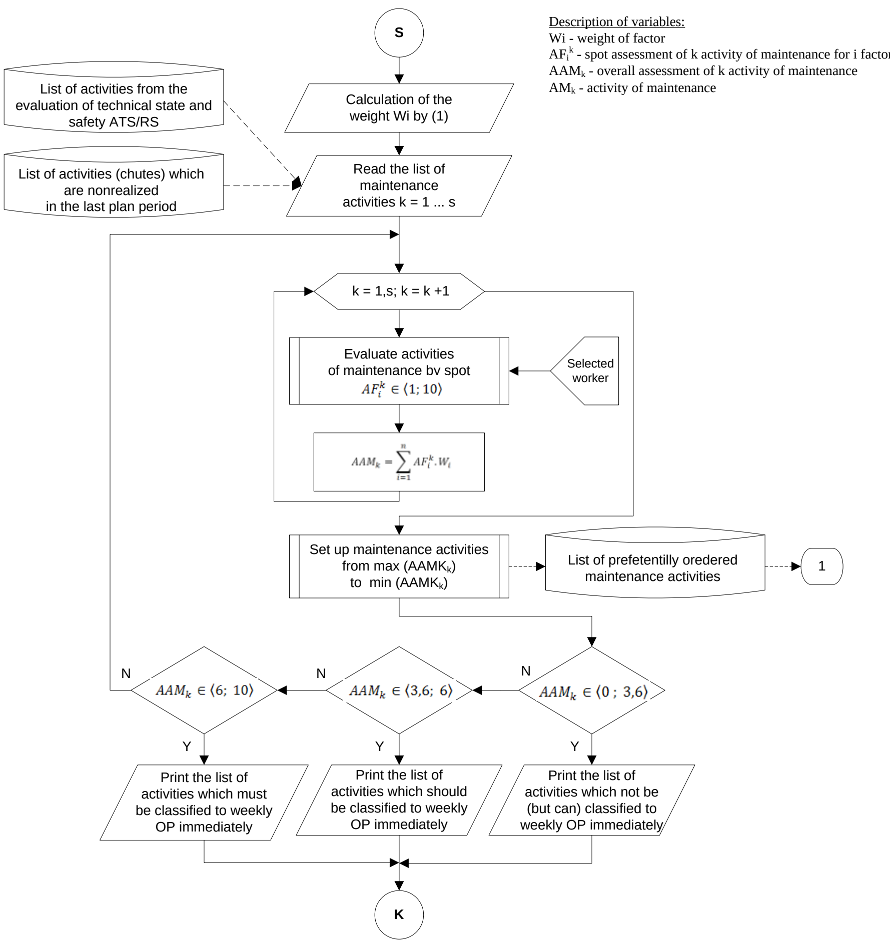


Fig. 93. *Process algorithm for design of the MO [own source].*

4.9.3 Conclusion

In this article we try to describe the methodology of maintenance operative planning design on in enterprises for continuous media distribution, for types of processes, when the frequency of failures is stochastic, but not explicit. Thereinafter it is described the process, which depends on technical state of devices by activities of planned preventive maintenance, which transfer to the corrective, or preventive way of maintenance planning by planning on the basis of immediate state of devices. The methodology in this article makes provision for the priority of reliability before productivity (applied for example in enterprises of main group of SPP a.s. – Slovak gas industry). We see contribution of this methodology mainly in standardization of decision making by concrete operative planes design.

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