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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.

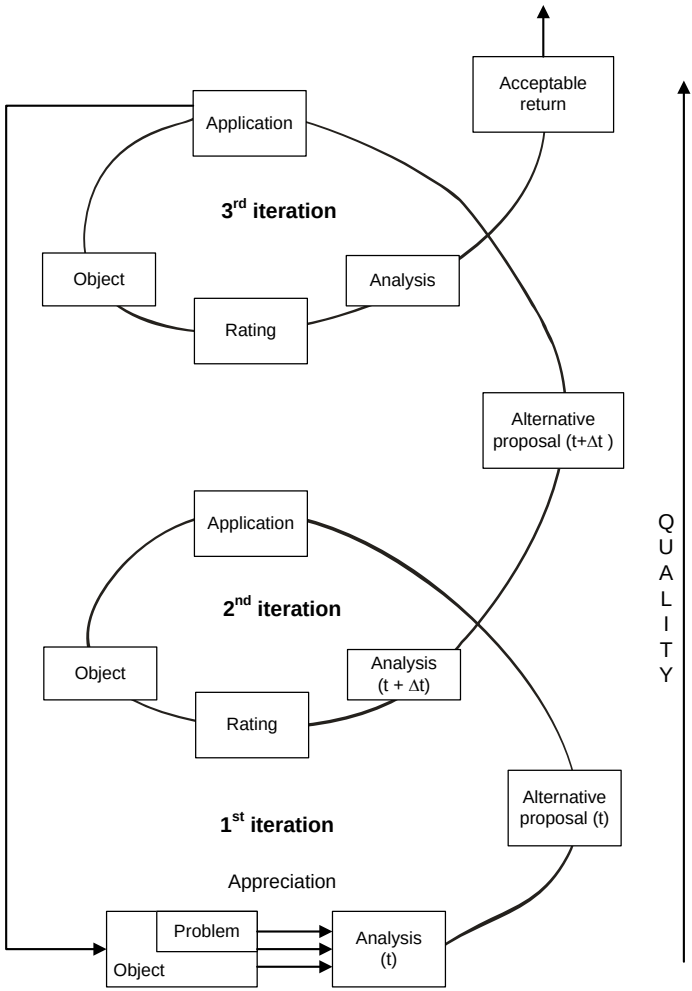


Fig. 26. *Design process.*

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:

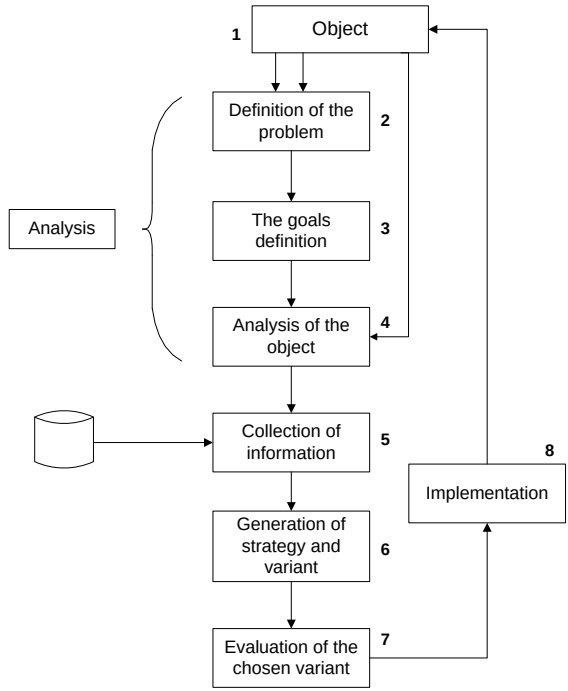


Fig. 27. *Generic design algorithm.*

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.

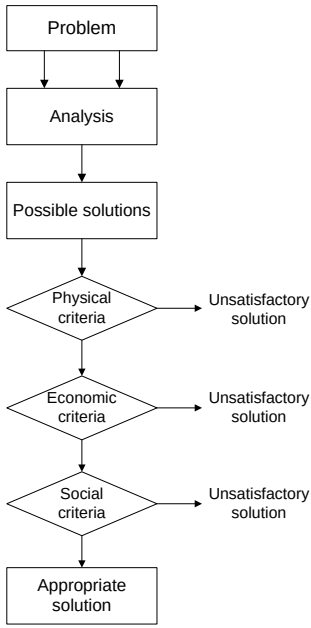


Fig. 28. *Generic algorithm of decision making.*

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).

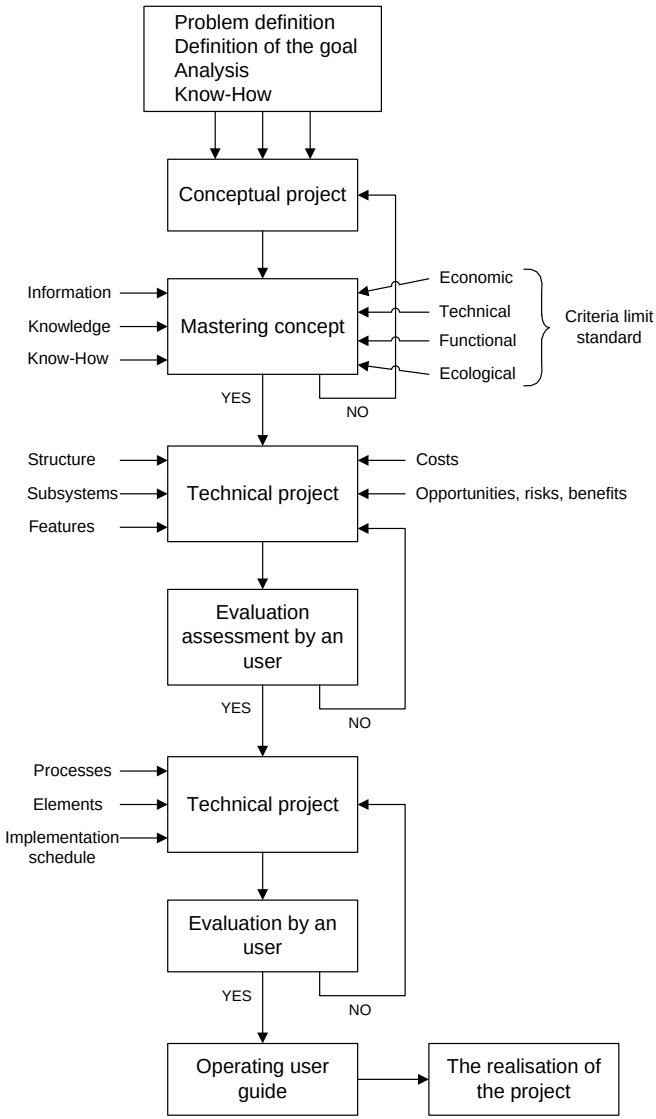


Fig. 29. *Technical side of the design realization – projection.*

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).

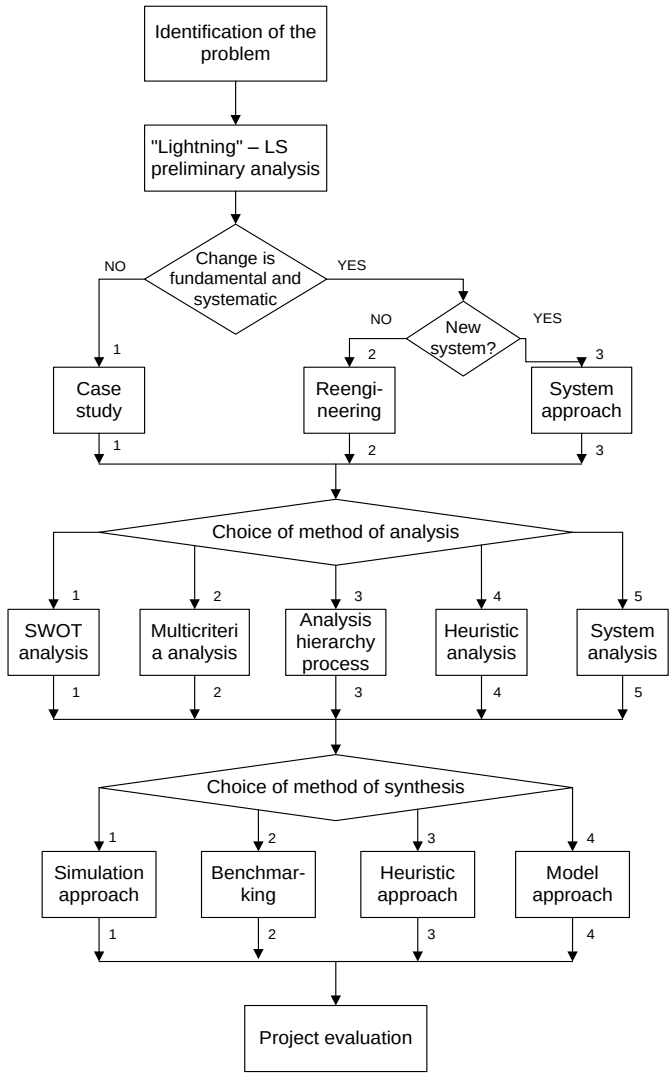


Fig. 30. *Selection of paradigm, analysis and synthesis of the design.*

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 20^{th} 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.

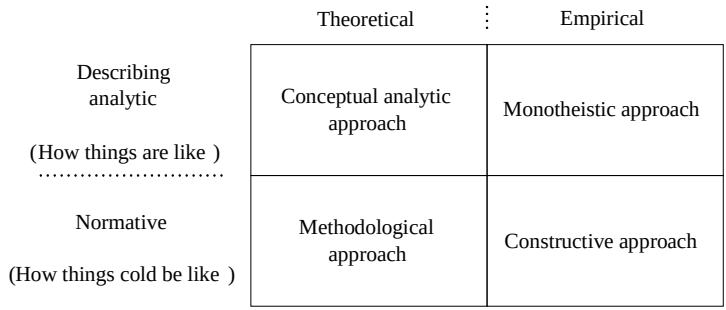
E.g. in case we will select a system approach design, we have to take into consideration the system analysis, respectively method of multi-criteria evaluation (but almost never a SWOT analysis, or heuristic analysis). For the synthesis is typical model approach.

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.



Projection methods can be analytically divided :

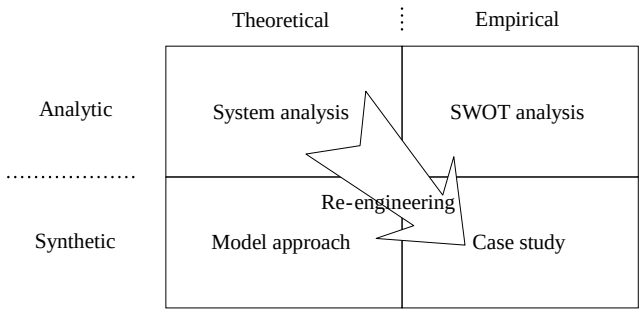


Fig. 31. *Methods classification of analysis and synthesis.*

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.

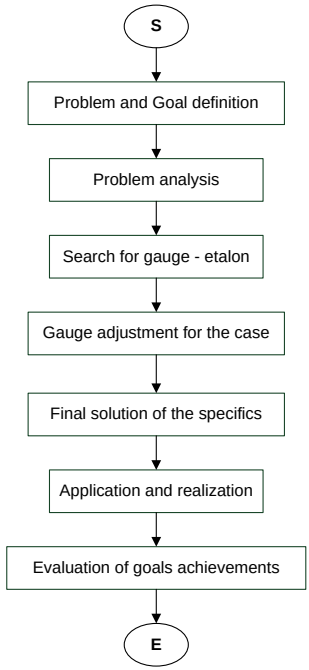


Fig. 32. *Algorithm of solution steps for case studies.*

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.

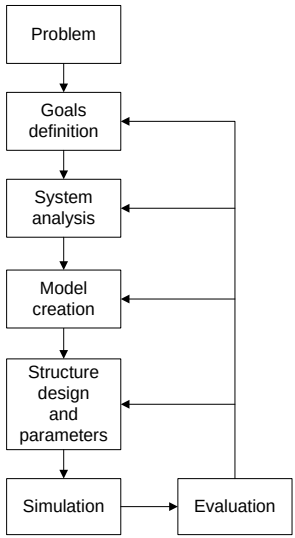


Fig. 33. *Model approach steps.*

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.

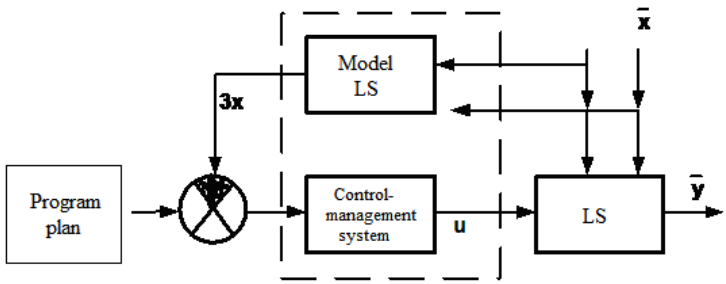


Fig. 34. *Forward control system.*

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.

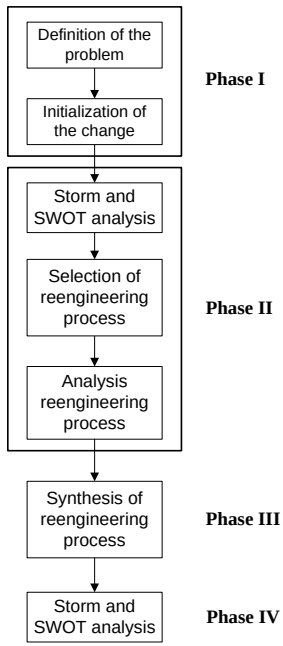


Fig. 35. *Sequences of step for re-engineering application.*

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).

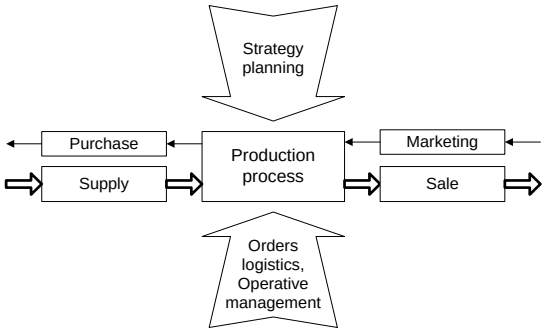


Fig. 36. *Cross micro-logistic mode.*

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.

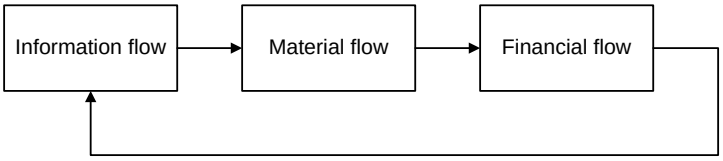


Fig. 37. *Logistic chain of continuing flows.*

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).

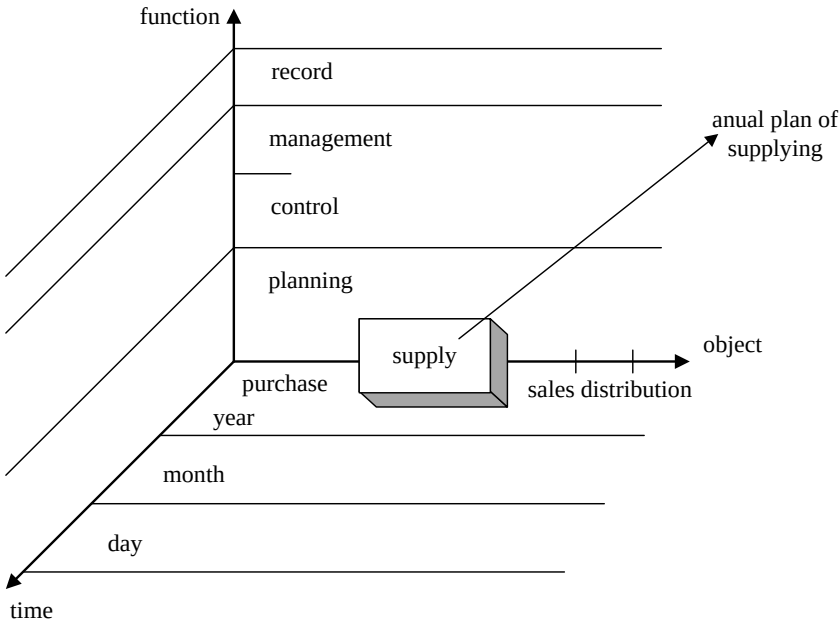


Fig. 38. *Decomposition of company's space.*

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:

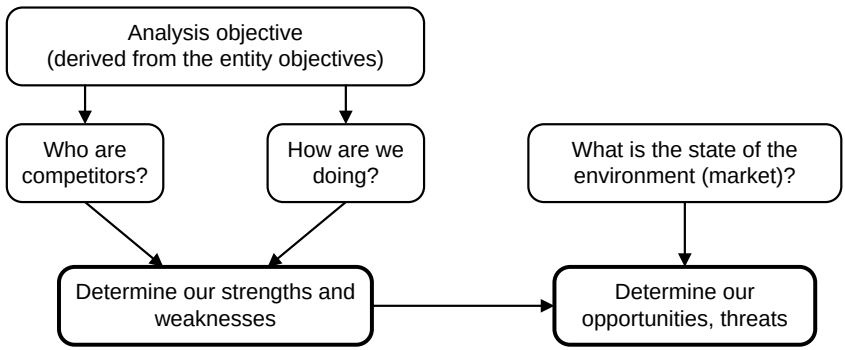


Fig. 39. *SWOT analysis sequences of steps.*

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:

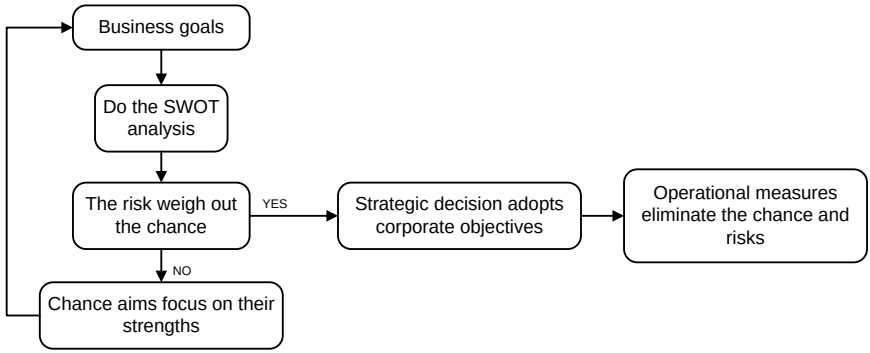


Fig. 40. *A change of subject objectives based on SWOT analysis.*

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.

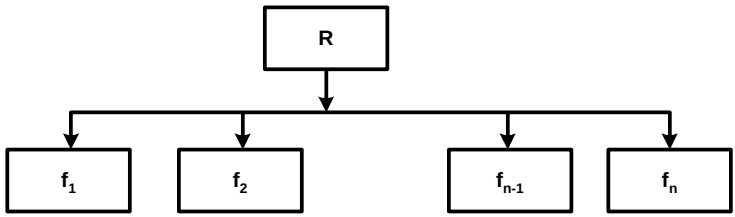
Multi-Criterion Analysis

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).

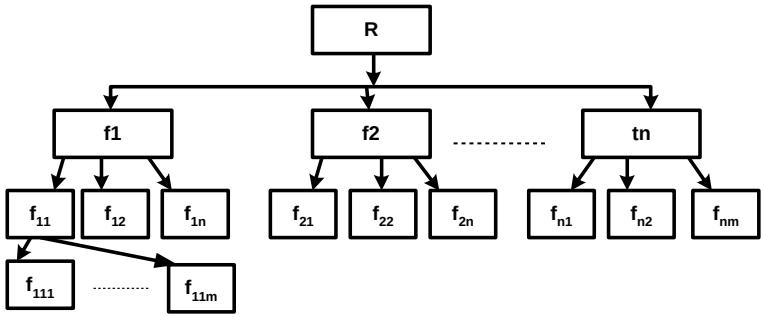


Fig. 41. *a). one-level factor structure (Ratio-index method); b) multilevel factor structure (AHP – method).*

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.

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

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:

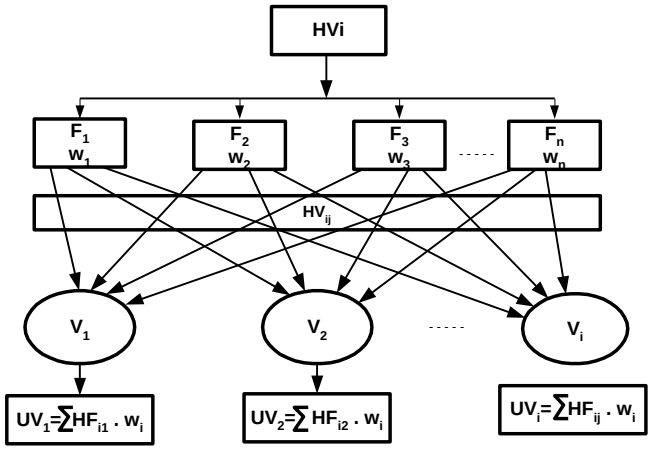


Fig. 42. *Evaluation according Ratio-index method.*

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_{12}	$HF_{12}.w_2$	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.

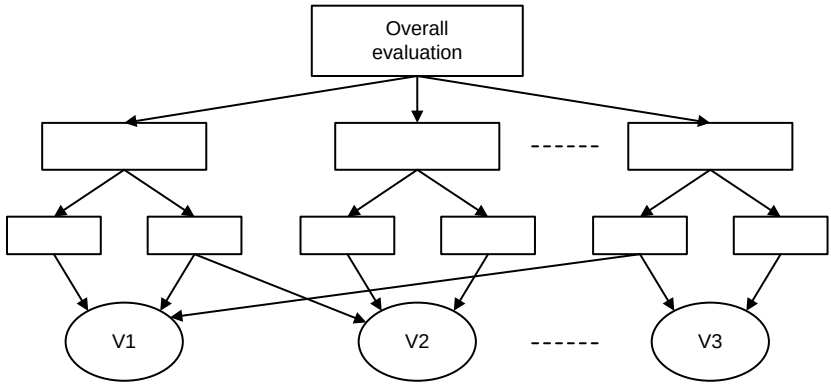


Fig. 43. *Hierarchical structure of the analysis process.*

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.*

	F_{11}	F_{12}	F_{13}	…	F_{nm}
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

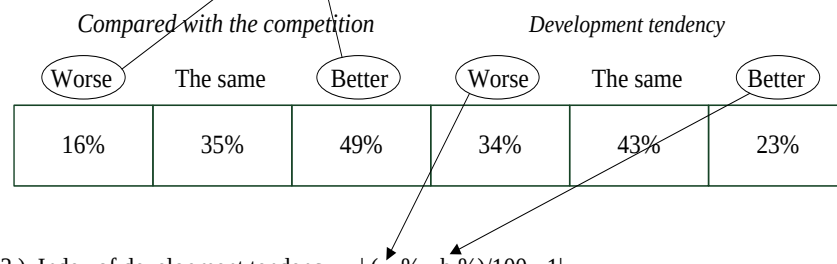
Implementation indexes (IMPL) are used for usability rating of results from AHP estimation. Implementation index determines importance and pressure evolving in improvement. It is created to increase the aberration sensitivity in competing environment. This index is raised by division of standard aberration 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|



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

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

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} F_{12} : F_{1n1}	w_{11} $w1_2$ w_{1n1}	HF_{11} HF_{12} HF_{1n1}	w_{11}. HF_{11} : :
F2	w_2	F_{21} F_{22} : F_{2n2}	w_{21} w_{22} w_{2n2}	HF_{21} HF_{22} HF_{2n2}	: : :
Fn	w_n	$F_{n,1}$ $F_{n,2}$ $F_{2n,nn}$	$w_{n,1}$ $w_{n,2}$ $w_{n,mn}$		
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.

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

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.

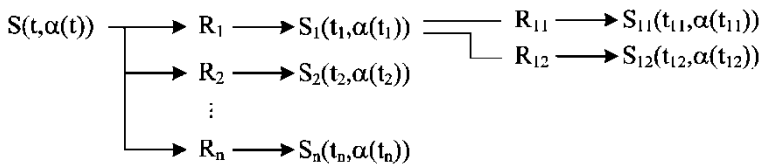
This means, that it's mostly used there, where the essence of such activity or a process is decision.

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.

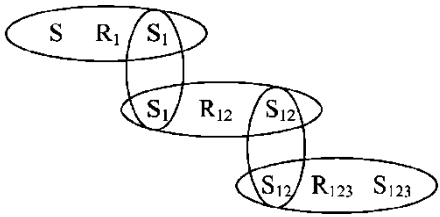
An analysis for heuristic model creation and LS synthesis according such model is executed on an existing systems respectively on analogical – gauge system. This method is suited for innovation projects, where productivity and process efficiency by automation and informatization of control activities 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:



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

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.

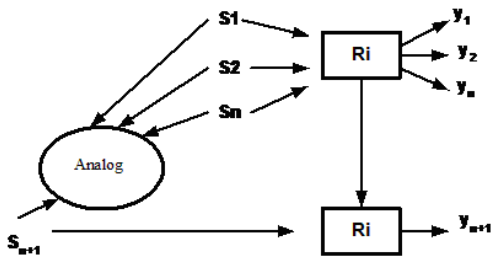


Fig. 44. *The induction principle.*

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.
- *Ō - constraints*, rolling temperature of slabs at the entry to the rolling path cannot be less than 1200 ℃.
- *Ē - 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.

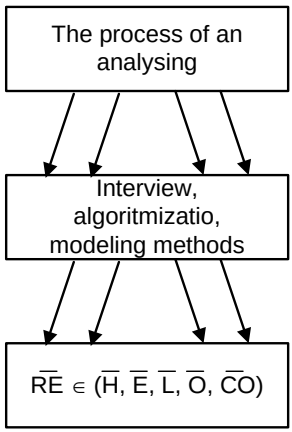


Fig. 45. *Principle of rule definition.*

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

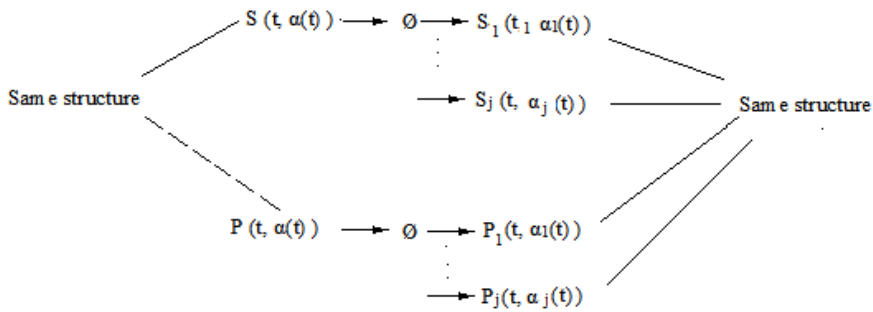


Fig. 46. *Principle of analogy.*

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:

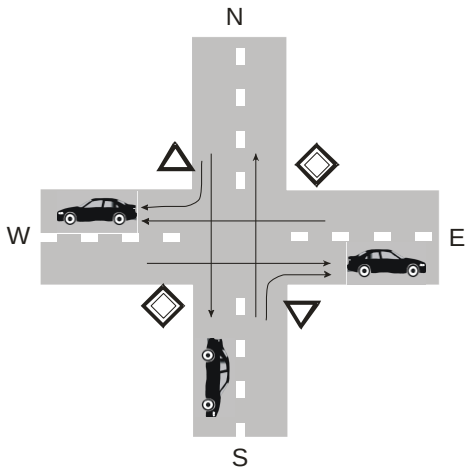


Fig. 47. *A crossing as LS.*

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.

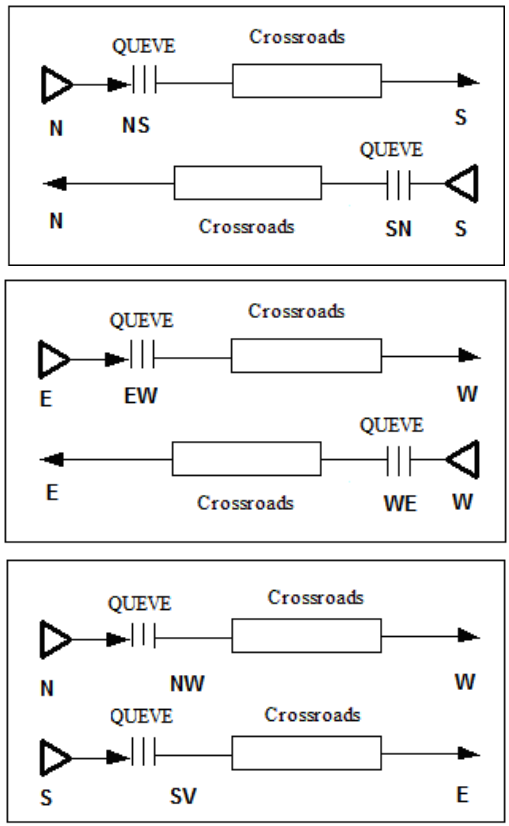


Fig. 48. *Formal model of a crossing as guening (QS) Crossroads Series.*

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.

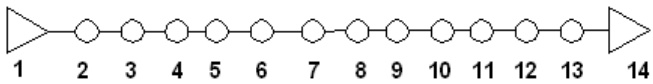
6. Experiments for another variant.

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.

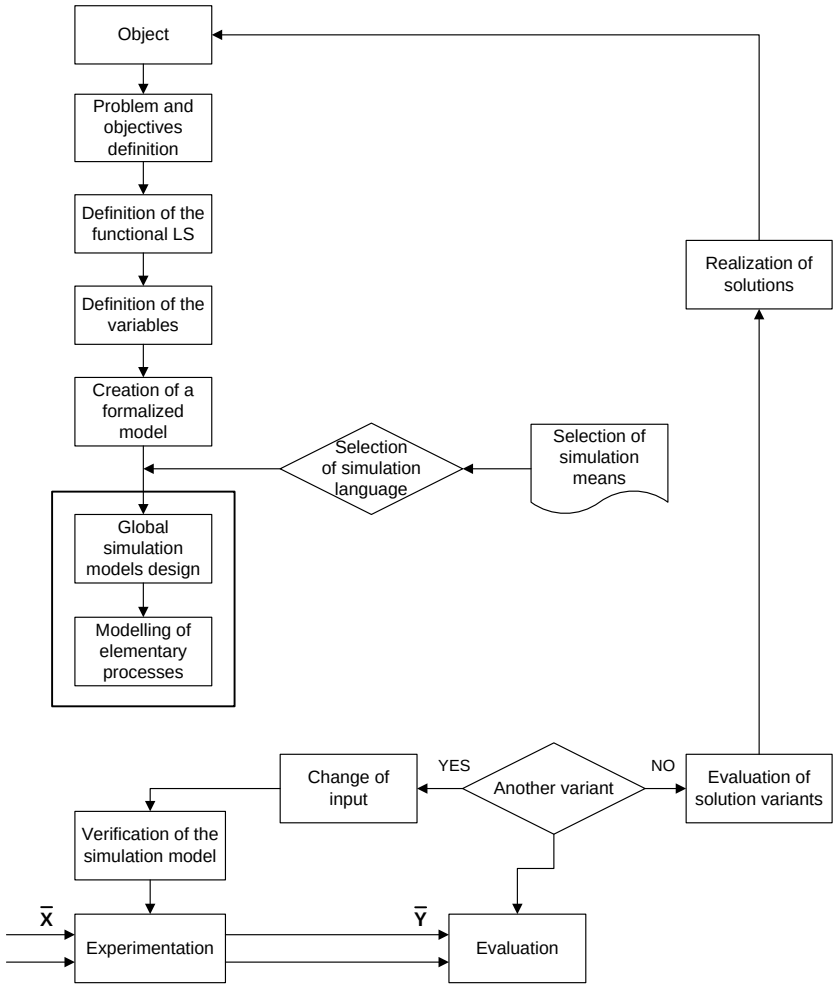


Fig. 49. *Sequence of steps during LS synthesis according SM.*

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.

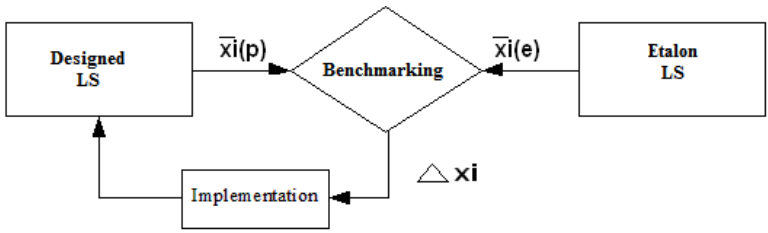


Fig. 50. *Principle of benchmarking.*

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.

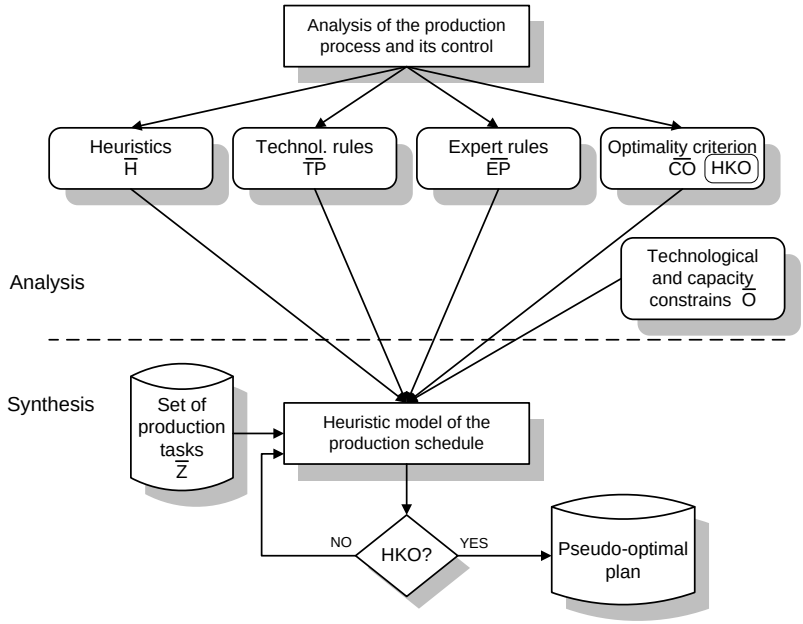


Fig. 51. *Creation of heuristic model.*

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

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).

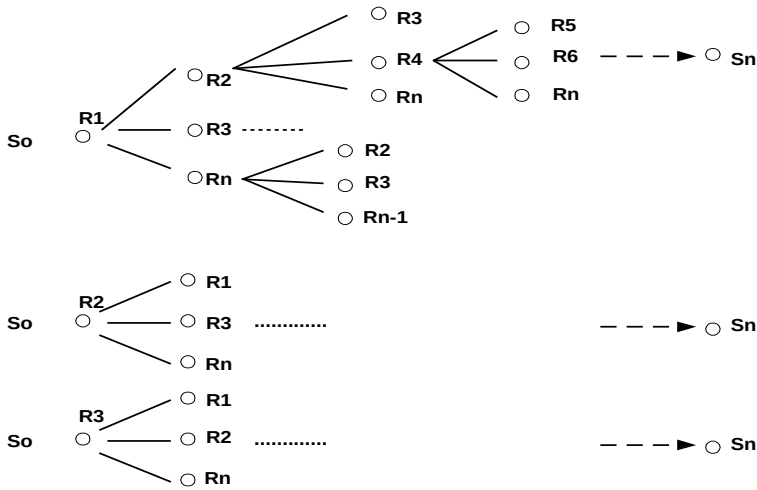


Fig. 52. *Labyrinth of tree structures presenting solutions of heuristic model.*

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:

$$S_o \quad R_1 \quad S_1$$

$$S_1 \quad R_2 \quad S_2$$

$$:$$

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

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.

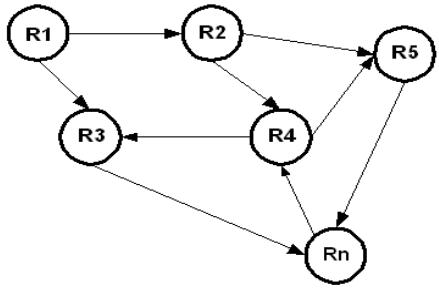


Fig. 53. *Criteria network.*

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.

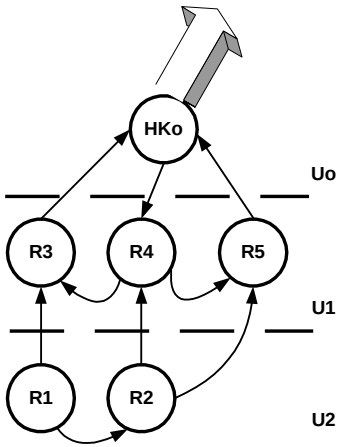


Fig. 54. *Criteria pseudo-tree.*

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:

$$\{U_o\} \rightarrow \{U_1\} \rightarrow \{U_2\}$$

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:

$$\text{HKO} \rightarrow R_5 \rightarrow R_3 \rightarrow R_4 \rightarrow R_2 \rightarrow R_1$$

This pseudo-optimal sequence will be applied to $\overline{Z}$ 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).

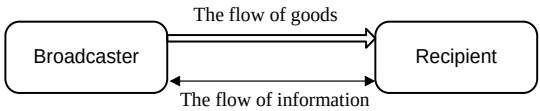


Fig. 55. *Flow of information and goods between the parties to the transaction in the logistics chain. Source: own.*

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.

[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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