METHODOLOGY FOR THE SYNTHESIS OF LOGISTICS SYSTEMS

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Abstract

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 in logistic area too. One of the base steps in logistic system/LS/ creation is synthesis. Generally, synthesis is understood as a process of the logistic system creation.

Keywords: Project, synthesis, logistic systems, benchmarking, simulation, heuristics, model

1. INTRODUCTION

What is the project? A project is planned and organized allocation of resources focused on fulfilment of particular aims. From logistic point of view, project consists of aims, tasks and activities which create the chains and nets. Tasks and activities are work units between particular dates , which has define the recources for its realization. Project has a creative and technical-managerial side [1] [2].

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, division of the project into phases, technique of work verification (control days), project documentation, time schedule, realization technique, delivery of the project, etc. [1] [2].

Steps in logistic systems design are described by **algorithm** on **Figure 1** [1], [2], [6], [8].

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

- by an order.
- by an cooperation approach.
- by own work team

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 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.

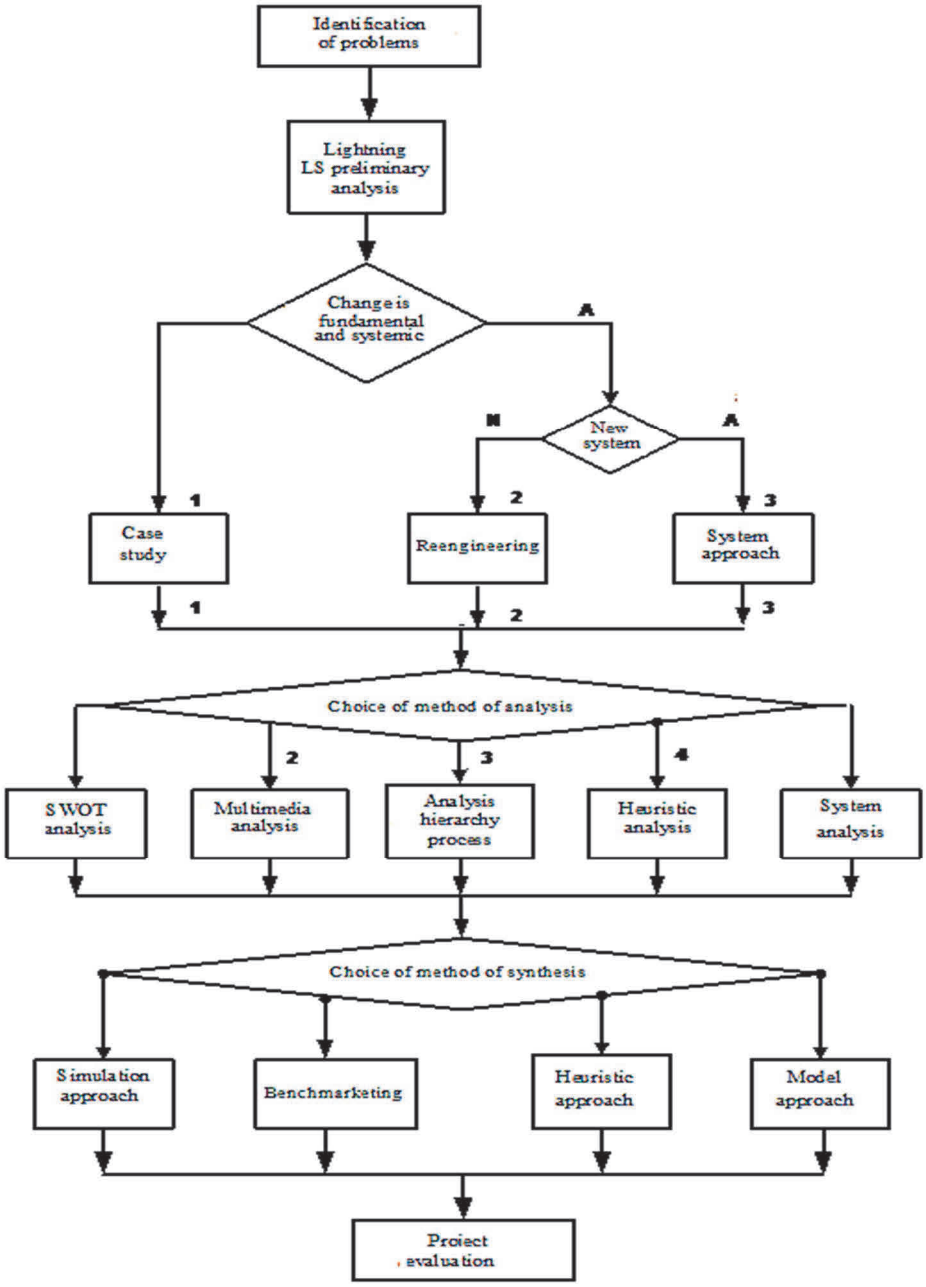

Figure 1 Steps in the logistic system design

T*he 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.

LS design which is made up of workers of his own business has benefited from the knowledge of the system, easier application of solutions and operation and updates. Workers do not have the theoretical knowledge and experience from design.

2. 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 (**Figure 1**). It is possible to select the design paradigm based on the current analysis and project aims:

1) Case study.
2) Re-engineering.
3) Systems (model) approach.

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

1) 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.
2) *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.
3) *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, if we choose "case study", then we apply SWOT analysis 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.

3. LS SYNTHESIS

Synthesis is the process of logistic systems creation and it has 2 phases:

Synthesis = Know-How + Design

1st - How to do it - proposal for methods, rules, algorithms and techniques (know- how),
2nd - To do it - projection - creation of particular system on the base proposal methods and inputs, parameters and conditions gathers during the analysis.

Synthesis LS differs according to a project type:

1) *Routine project* - always looked for *analogy* of a problem with a problem solved in the past; this solution is applied synthesis bases on correctly defined conditions of similarity.
2) *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.
3) *Creative project* - when a new system 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.

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 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.

Synthesis Method Selection: For synthesis can by apply: - benchmarking,
- analytical models,
- simulation models,
- heuristic models.

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 [2] ,[4].

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 [5], [6], [7], [8]. Benchmarking is used when we are able to find the problem solution in analogical case.

a) Benchmarking

Synthesis principle for case study is benchmarking. This principle is used either directly - analogical solution is looked for when solving particular problem, 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 [1] [2].

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.

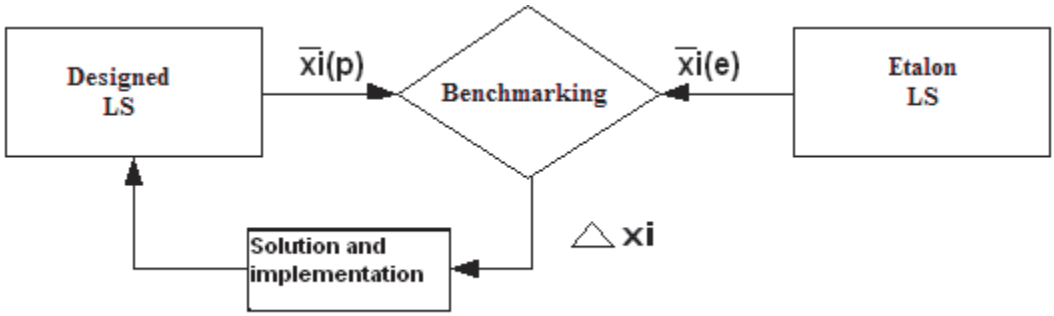

Figure 2 The principle of benchmarking

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.

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).

b) Analytical model application

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 **specific** problem, e.g.:

- If we need to solve allocation of the distribution centre or stores, we apply Cooper iterative model .
- If we need to design a project of the maintenance big furnace, network analysis CPM and PERT can be 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.

c) Application of Simulation Models in LS Synthesis

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 very complicated cross-roads (**Figure 3**):

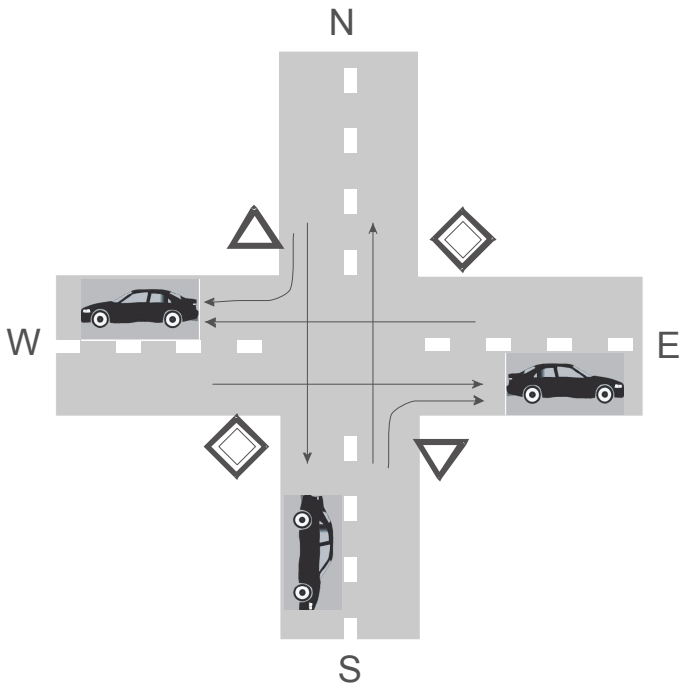

Figure 3 Cross-roads as the LS

For example, 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.

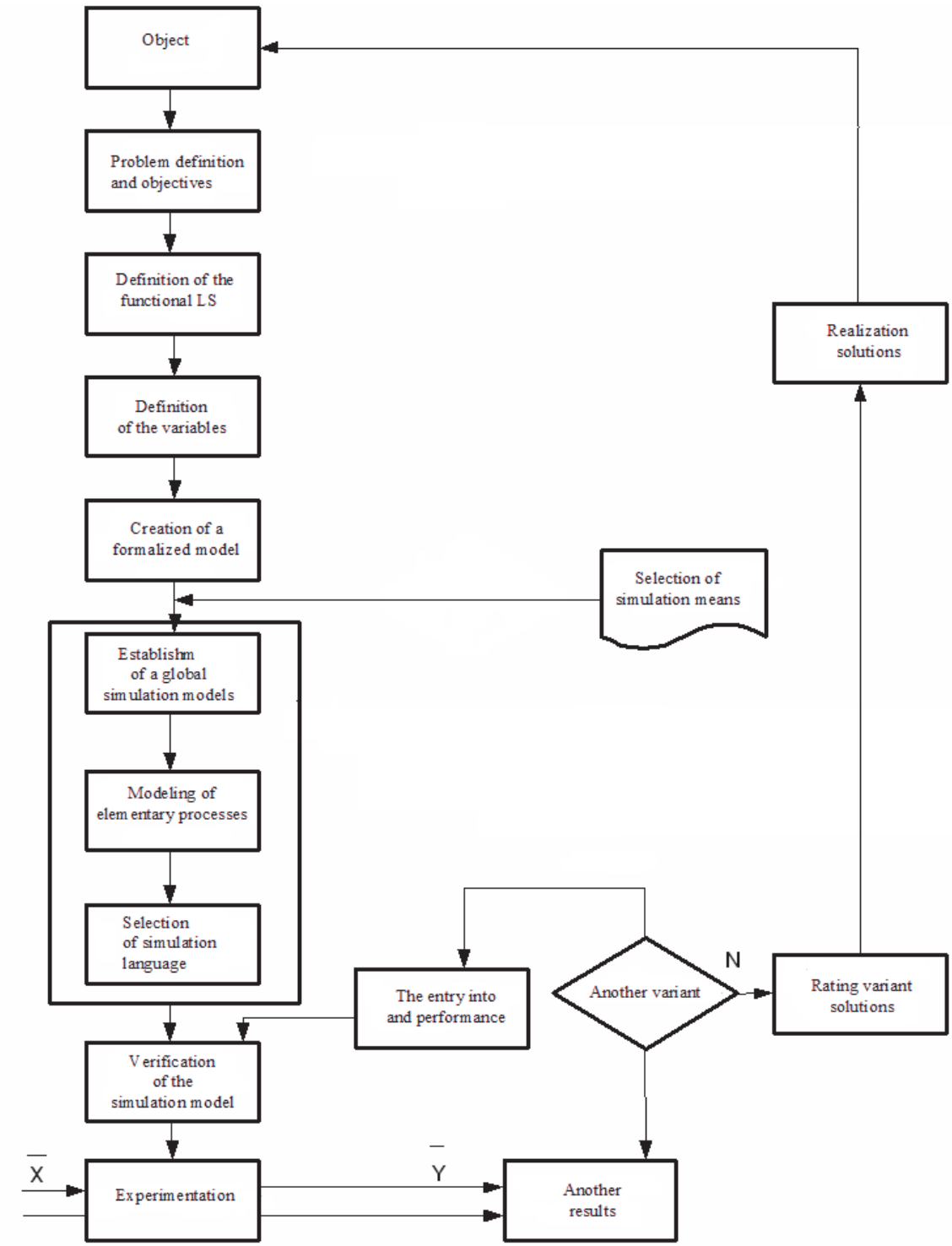

Figure 4 Sequences of steps during the LS synthesis according SM

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.

The methodology is based on Dahls definition of simulation (**Figure 4).**

d) LS synthesis based on 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 **Figure 5**. 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.

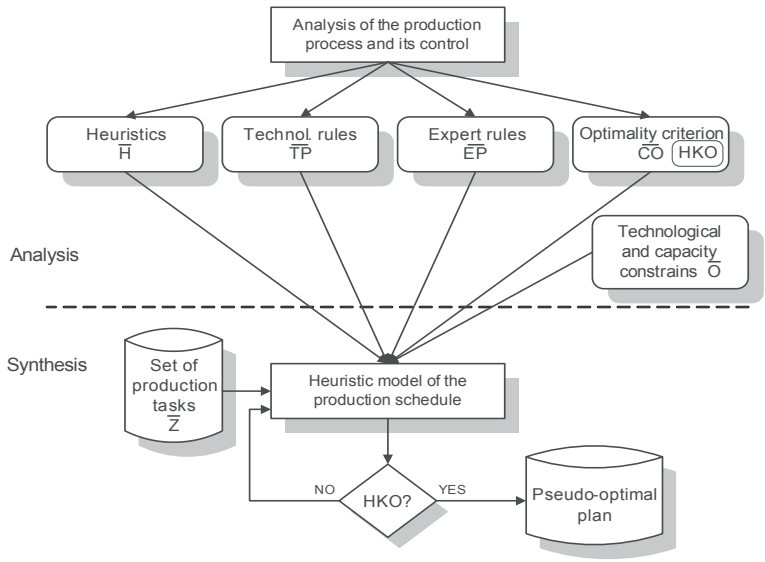

Figure 5 Creation of heuristic model

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.

$$\{\overline{R}\} \in \{\overline{H}, \overline{TP}, \overline{EP}, \overline{O}, \overline{CO}\}$$

Group of rules comprise of following groups:

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

4. CONCLUSION

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- benchmarking- multi analogy
- Analytical model- deduction
- Heuristic models - induction.
- Simulation models - imitation.

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.

REFERENCES

[1] MALINDŽÁK D., TAKALA, J.: Projektovanie logistických systémov (Teória a prax), Expresspublicit, Košice, 2005.

[2] MALINDŽÁK D. et. al. Design of Logistic Systems / Theory and Application, Open Science, New York 2015.

[3] MALINDŽÁK D. Production logistic, Stroffek Publishing, Košice, 1998.

[4] BUKOWSKI L. A. Problemy przetwarzania informacji logistycznych w zintegrowanych systemoch produkcyjowych, VII. konferencja Logistyki Stosowanej (Total Logistic Management), Zakopane, 2003.

[5] RAYWARD-SMITH V. J., OSMAN I. H., REEVES C. R., SMITH G. D.: Modern heuristic search methods. John Wiley &Sons Ltd., England,1996.

[6] LENORT R., KLEPEK R., SAMOLEJOVÁ A. Heuristic Algorithm for Planning and Scheduling Forged Pieces of Heat Treatment, Metalurgija, VOL. 51, NO. 2, 2012.

[7] MALINDŽÁK D., ZIMON D. The basic principles of the analysis for heuristic model creation in metallurgy: 23rd International Conference on Metallurgy and Materials Location: Brno, Czech Republic, 2014.

[8] CHRISTOPHER M., LOWSON R., PECK H. Creating Agile Supply Chains in the Fashion Industry. *International Journal of Retail & Distribution Management*, VOL. 32, NO. 8, 2004, pp. 367-76.