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RESEARCH ARTICLE

Using Process Analysis and Modelling in an Integrated Problem Solving Approach to Business Performance Improvement

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Abstract

Thearticle develops a conceptualization ofproblem solving and decision making which synthesizes a number of models and approachesin the context of multi-methodological practice to process analysis and performance management.It also emphasizes the combining of hard and soft systems methodologies and the mutual complementarity of methods and tools incorporated into and associated with these methodologies.An important part in a search for feasible and desirable changes in business systems under complexity and uncertainty is given to the problem structuring at different levels of performance management.The developed overall framework of problem solving for performance improvement is based on Soft System Dynamics Methodology and the combined applications of logico-linguistic modelling, causal analysis, petri nets, process-centric modelling, network modelling, simulation and others.A loading-unloading process at warehouse (cargo terminal) has been taken to examine the application of the framework.

Keywords: *Decision making, Modelling and simulation, Problem solving, Problem structuring, Process, Systems approaches.*

Introduction

Human activity system is a cultural mechanism, which finds and realizes ways of supporting desired relationships and eliminating unwanted ones [1]. Due to instability of system and its environment and diversity of changes early defined ways lost their actuality and adequacy eventually, therefore the mechanism's cyclehas to be restarted to reach the new"good mode" of performance. Rules, regulations, standards and experience are reviewed periodically to reflect new knowledge and experiences. However these problems are often considered asvery complex and difficult to track.Some theories of management and system control postulate that the complexity of social and economic facilities is just perception and inference, that is the complexity of thinking, but other theories (for example, system dynamics, chaos theory and the theory of adaptive systems) assign it to explored systems [2].

Numerous descriptive theories have been developed to describe how decisions are mad [3]. But the gap between descriptive and normative decision making is extensive [4]. Practitioners and academics are calling for better decision problem structuring in order to improve the quality of the decision outcome [5].There are such problematic areas in business performance management as follows [6]:

- The uncertainty of external environment and the low adequacy of information about it and its interactions with the system.
- The gap between goals and actual results.
- The discrepancy between strategic and operational levels of control and lack of coordination of decision making at them.
- Situational analysis tools are isolated and narrow focused because reflection on system's element(s) depends on one or several points of view.
- Delayed responses to changes.
- The presence of red tape hampering staff's initiatives and responsibility.
- The local nature of measures for the improvement and optimization of the system as well as opportunistic behaviour of agents notably resistance to innovation and changes, low responsibility, consciously and unconsciously improper involvement of other agents to implement decisions.
- The hidden knowledge.

Problem structuring involves [5]: a search for underlying structure of the system (processes); a fixing of facts; the identification of a problem situation, making it specific and the conversion to tasks of best choice; dealing with issues; the support of managerial goals and objectives setting; the specification of nature, options, and attributes for evaluating options.

Complexity of economic objects and situation nullifies efforts to get the best model of system and the method of problem solving. Untenability of hard methods of operational research (OR) for business management is explained by such reasons as follows [7]: fundamental differences between physical and human activity systems; variety of desired performance criteria that interferes with the definition of objective system features, metrics and indicators; complexity of business systems; static and linear nature of methods; academism of methods, i.e. weak focus on practical problems and needs.

Failures in the system, e.g. refusal to fulfil a customer order or a monthly backlog, are adverse (negative) events and have its latent period, during which there is a sequence of controversial events that is perceived as weak signals of a possible threat. Weak signals remain undetected frequently or are not taken into account or improperly interpreted. System Failure Dynamic Modelclassifies failures into internal, predictable external and unpredictable external types [8]. Failures of the first type could be generally fixed in a short time while events of the last two types require much more time. In this case, system failures of the second and the third types could be mistakenly interpreted as ones of the first type so that decision-making gets less effective.

Moreover it should be noted that individual goals are often not related to organizational values, tasks and strategies in business performance management systems. Agents' needs, aims and intents are hardly recognizable. There is a lack of efficacious models, which are able to handle with qualitative features analysing business processes, system state and perspectives. Modelling and control are mostly based on the top-down approach though the up-bottom approach allows of clarifying what tools and computer-aided decision support system are useful for troubleshooting [9].

Phenomena complexity and uncertainty encourage multi-methodological researches for performance improvement to progress further [10]. There are five well-known systems approaches to managing complex issues [11]: System Dynamics (established by Jay Forrester); Viable System Model (Stafford Beer); Strategic Options Development and Analysis (Colin Eden); Soft Systems Methodology (Peter Checkland); Critical Systems Heuristics (Werner Ulrich).Critical systemic thinking and total system interventionfounded on systems methodologies use a range of decision making approaches and different views of managing.They alsojustify choice of those that are helpful in situation whenproblem are identified considering the principle of complementary applying [12].Soft System Methodology (SSM) focuses on the structuring of problems in social and business management by experts. But in order to reduce subjectivity there are system dynamics, discrete-event modelling, graphs, operational research and other tools that need to be applied to SSM.

Soft Systems Methodology has been combined with System Dynamics by R. Rodriguez-Ulloa and A. Paucar-Caceres [13]. This so-called Soft System Dynamics Methodology (SSDM) has 10 steps across three worlds: Real World; the Problem-Situation Oriented System Thinking World; and the Solving-Situation Oriented System Thinking World.

Any problem could be represented by the hierarchically ordered sequence of questions and issues, complemented by methodological principles and settings on the basis of knowledge, experience and value orientations, which contain prohibitions, standards and guidelines. Generally, problem field structuring is aimed at the identification of key problems that give impetus to a set of other problems and challenges. Moreover the main causes must be found among them. It’s similar to the task of identification of root causes for the sequence of events, including deviations.

Thus, root causes, factors and events-causes, changes in the internal and external environments, conflicting events (weak signals) and outcomes, state and effects and side effects are to be determined to describe the overall pattern of the problem. It is also assumed that a complex problem situation may be described by the terms of elements and flows at bottom and top levels of management.

Article’s purpose is to elaborate integrated approach to problem solving and decision making in business performance management through the combination of systems approaches according to SSDM, hard and soft OR methods that focus on problem structuring, process analysis and modelling.

An Integrated Approach to Problem Solving and Decision Making

Multi-methodological practices combine methods from across hard and soft systems methodologies [13]. Soft OR methods, unlike hard OR methods, which are useful for the originally well-structured problem and clearly defined goals[14], would be significant in the identification of situation in which problems are perceived, managing of a goal and perception conflicts and reaching a consensus on the way forward. The choice of methodologies for problem solving and decision making depends on the level of management,to which problem and tasks belong.There are logical and physical; abstract and real; top, middle and bottom; strategic, tactical and operational levels;the standard MODAF allocates tasks to strategic, service, operational (logical) and systemic (physical) levels[15].

Moreover emergent properties of entities denote the levels of hierarchy.As mentioned by C. Khisty [16] hard and soft systems methodologies complement and supplement each other in the real-world situation. Malhotra and Birks[17]have explored marketing issuesand emphasized complementarity of quantitative and qualitative researches.

Systems and empirical approaches are widely applied to an analysis of various systems. There are structural, experimentalist and descriptive approaches to empirical researches in economics and technics [18]. So the analysis of economic and socio-technical (human activity) system based on these approaches gives out conceptual, structural and descriptive models [4, 19, 20]. Here it's expedient to use graphic notation techniques to create visual models of processes, entities or situations.

While description focuses on how decision makers actually make decisions and what reasons are for this, prescription focuses on how they should make decisions to improve performance and outcomes [5]. So problem structuring and problem solving includes models "as is" and "to be" (or "may be"), respectively.

The overall framework of problem solving (Fig. 1) is based on Soft System Dynamics Methodology and propose the range of hard and soft OR methods, tools and techniques for performance improvement. The methodssupport situation analysis, problem structuring, process analysis and simulation, decision making, oriented towards adjusted goals, and knowledge formalization in business performance management and process control.The presented framework's scheme (Fig. 1) includes the basic blocks (stages) such as:

- The initial perception of a real-world situation, the identification of changes on the regulated performance indicators, the assumption about conditions, changes and problems. But at this stage, analysts have no clear views and necessary knowledge about stakeholders, their interests, aspirations and requirements, conflicts, objects and their properties, system's state, both formal and informal relationships among entities, etc. In addition, those aspects remain unclear, which should be paid attention to.
- Analysis of the situation, which allows to transit from non-formalized situation to formalized one. There are the awareness of problems and the common understanding of object domain, trends and stakeholders' behaviour at the stage. As a result, analysts formulate common questions that show an essence of the alleged problems. Over time, changes in the 'real world' cause the reverse transition that is characterized by a negative managerial situation (link FB_1) because, as further analysis may show, changes and challenges have long been ignored. In such case the resulting description of the situation is irrelevant or based on "distorted" perception and contains wrong interpretation, errors and gaps. It should be noted that the problem structuring, as the part of continuous learning process, exercises also at later stages, especially at the stages 3-6.
- Formulation of the problem-oriented key definitions for the current situation (its image "as is"). The purpose is to identify: the main control objects and agents that are affected by this situation; decision makers, and executives responsible for responding to the situation; changes in the system and their expected effects. It allows specifying a list of questions that reveal the essence of the problem situation, reasons and ways of its occurrence. If analysts cannot assess the current situation and explain its transformation process, perhaps they have incomplete, inadequate and inaccurate description. Such case requires for re-analysis of the situation (FB_2).

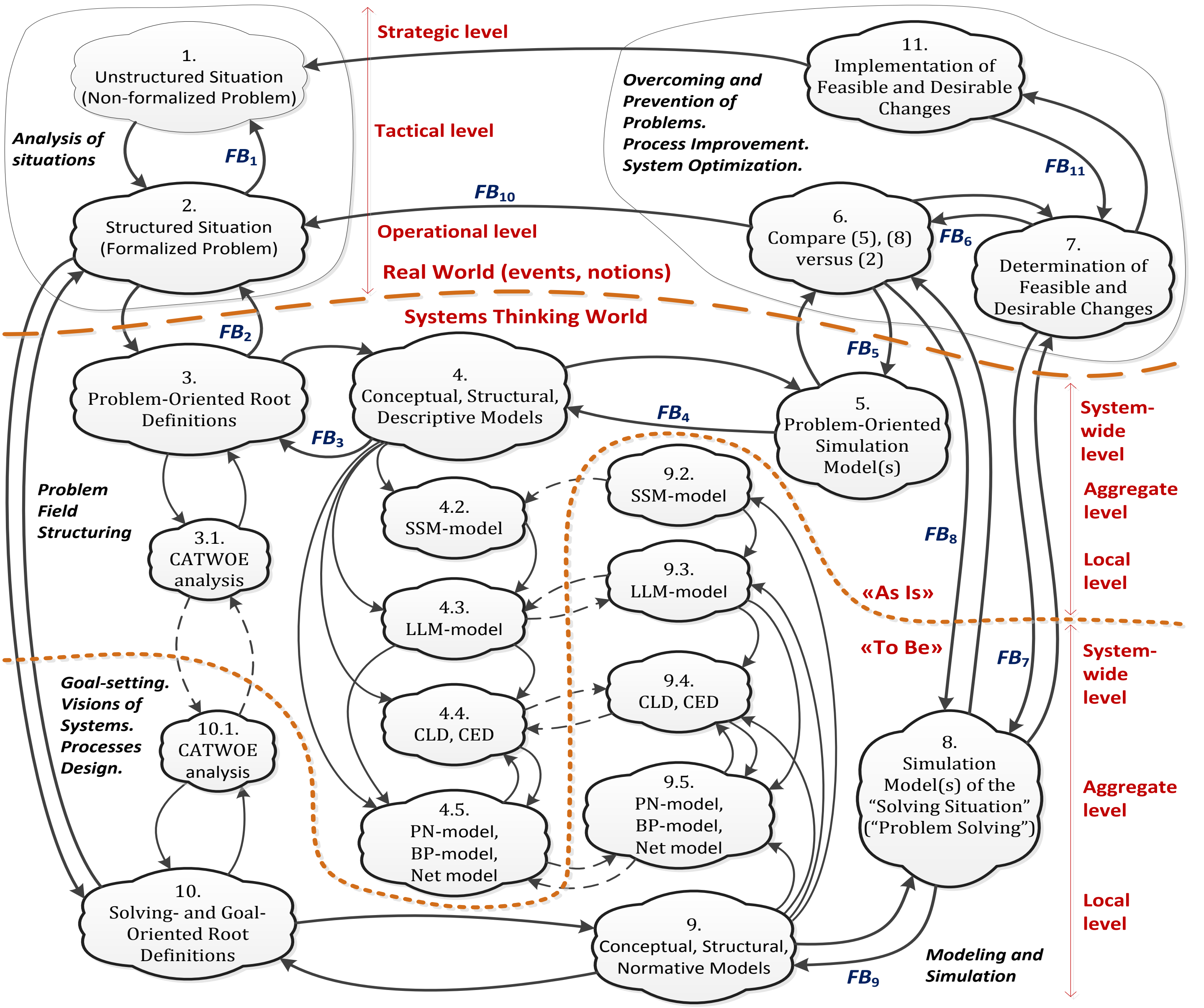


Fig. 1: The framework of problem solving in business performance management based on SSDMand the range of hard and soft OR

Sources: Checkland and Scholes [1]; Rodriguez-Ulloa and Paucar-Caceres [13]; Rodrıguez-Ulloa et al. [21]

- Development of conceptual, structural and descriptive models. Their main purpose is the most complete and accurate description of the system, processes, the external environment, managerialmechanism and cases, as well as the validation of problems, their root causes and the consequences. Here, abstract, logical and graphical notations are useful. In particular, models based on SSM and Logico-Linguistic Modellingmethod have significant importance for the mentioned purpose. But keeping in mind their shortcomings [9, 21] another models must complement them. All models must disclose the contents of the problem-oriented key definitions.Structural and descriptive modellingmethods, tools and techniques include causal analysis, network modelling, graphical notations of processes, Petri nets, etc. Decision-makers need answers to the questions: "*Whathappens if the event E occurs*?"or"*What caused the eventE?*".

Distinctive features and new information about objects and situations gathered in the development of these models lead to a refining, exclusion and inclusion of new key definitions (FB_3).

- Design of problem-oriented simulation models based on a set of conceptual, structural and descriptive models and the results of their analysis. Simulation model helps determining the effects of the problem situation with and without control actions, as well as adaptation of the mode of operationsto new conditions. In this case, the overall structure of the system mostly remains the same at the image"as is".Changes may relate to functional, process and technological structures. They usually are not large-scale or long-term radical transformations and justified by explicit short-term causes of the problem. Consequently, conceptual, structural and descriptive models can also be adjusted or replaced with new models (FB_4). It is possible that a need for substantial structural changes can be seen at this stage too. These and other changes have to be taken into account in the development of goal-oriented simulation model.

- Comparison of problem-oriented simulation models with formalized situation from block 2. The correctness, relevance and adequacy of the modelare under study. If the model does not have these properties, the corresponding information is sent through $FB_5$to block 5 for adjustment.This block is subjected to comparison of goal-oriented simulation model with the situation. It may indicate that the model assumes invalid changes or ignores some limitations, capabilities, and other factors (FB_8). Due to the simulation and validation of changes experts can understand that the problem has been improperlyidentified (FB_{10}).

- Search for possible and desirable scenarios to overcome or prevent problems, improve processes and optimize system. The difficulty of the block 7 is usually a lack of the necessary information, whichis signalizedby FB_6, meaningthe re-implementation of the previous blocks.

- Design of goal-oriented simulation models in terms of problem-solving scenarios and transition to a qualitatively better mode of operations. Efficiency, boundaries and consequences of decisions are under exploration with these models. Some of proposed changes may be rejected due to the fact that they are not clearly defined, cannot be practically implemented or do not improve performance (FB_7).
- Modifying or designing new conceptual, descriptive and normative models of the system and processes with regard to the planned, ongoing and completed changes. It also helps in the detection of inaccuracies and errors in goal-oriented model (FB_9).It is important that a clear sequence of actions, based on the prevailing conditions, is available for agents who implement decisions (stage 11). Therefore, a set of normative models include flow charts and tables of actions (decisions) regarding elective set of conditions.
- Adjustment of goal-oriented key definitions and their matchingsituation.

- Practical implementation of approved solutions. Negative manifestation of this stageis ineffective actions and inefficient performance (FB_{11}).

The framework doesn't imply the strict sequence of the stages. Therefore it may be rational to relate the framework's stages to steps, listed in some other conceptualized model of performance management (systemcontrol, management cycle, problem solving method), which might beappropriate for staff. Table 1 depicts possible associations of the stages to the steps of Creative Problem Solving (CPS) method [22, 23, 24].

Table 1: Possible associations of the framework's stages with the steps of CPS

CPS steps	Content of CPS steps	Possible links to the framework's stages										
		1	2	3	4	5	6	7	8	9	10	11
Objective (Mess) Finding	Identify areas of concern, most critical general problems, and goal, wish or challenge	X										
Fact Finding	Gather and assess all the data (who's and what's involved, when, where, and why it's important). Make a list of the facts, as well as subjective experiences.		X	X	X							
Problem Finding	Explore the facts and data to find all the problems and challenges inherent in the situation, and all the opportunities.Consider different ways of regarding and focus on the right problem.		X	X	X	X	X					
Idea Finding	Search for a variety of ideas, options, alternatives, paths, etc. Take risks.					X	X	X				
Solution finding	Decide which ideas are most likely to solve the redefined problem and meet criteria. Assess the consequences, implications, and reactions to the selected ideas to develop an action plan.						X	X	X	X		
Acceptance Finding	Plan for action (who's responsible, what has to be done by when, and what resources are available). Develop a working plan for implementation of ideas (solutions).							X	X	X	X	X

Thus, the problem solving and decision making in business performance management and control of economic facilities are based on a multi-methodological research and the combined application of hard and soft ORand simulation. The focus is on the situation analysis, problem structuring, flow and process analysis, modelling and simulation.

Problem Structuring, Process Analysis and Modelling

SSM-Model

The main purpose of conceptual models based on the SSM [19] is identification of what can or should be done and what there may be. On this basis, experts eliminate conflicts in the understanding of business processes, their objectives and applications. Ontological models at the stage of structuring domains, as a special kind of knowledge base (explicit specification of a conceptualization [25]), harmonize the specification of systems, processes and resources that were made by different experts and may have contradictions and ambiguities of interpretation. Ontologies can be formed by the procedures of system-cognitive analysis.Typically, conceptual models meet, first of all, to the questions

"*what could it be*?" and/or "*what must/should be achieved*?", and after *what does it need*?" and/or "*how it must/should be achieved*?".

Additionally the model reflects "*what has been done*" and "*what is now*".
Conceptual SSM-models are developed in the language of instructions (actions, tasks and functions) that do not have a truth value. Therefore, imperative (declarative) sentences are formulated in the model, and logical dependencies are established among them such as:

the identification of needs–the confirmation of needsthrough a consumer survey;

theacceptance of entities (agents or objects, AO, ordered into processing)–*entities* (AO)*feed to the workplace* (unit of processing, service or handling).

This follows that a conceptual model formulatesstatements such as:

First do Task L AND/OR Task K,THENdo Task M;

Task M depends on Task L AND/ORTask K;

Task L AND/OR Task K cause Task M;

To performTask M, at first Task L AND/OR Task K mustbe done.

There's the conceptual SSM-model of strategic planning of entities (AO) processingin Fig. 2.

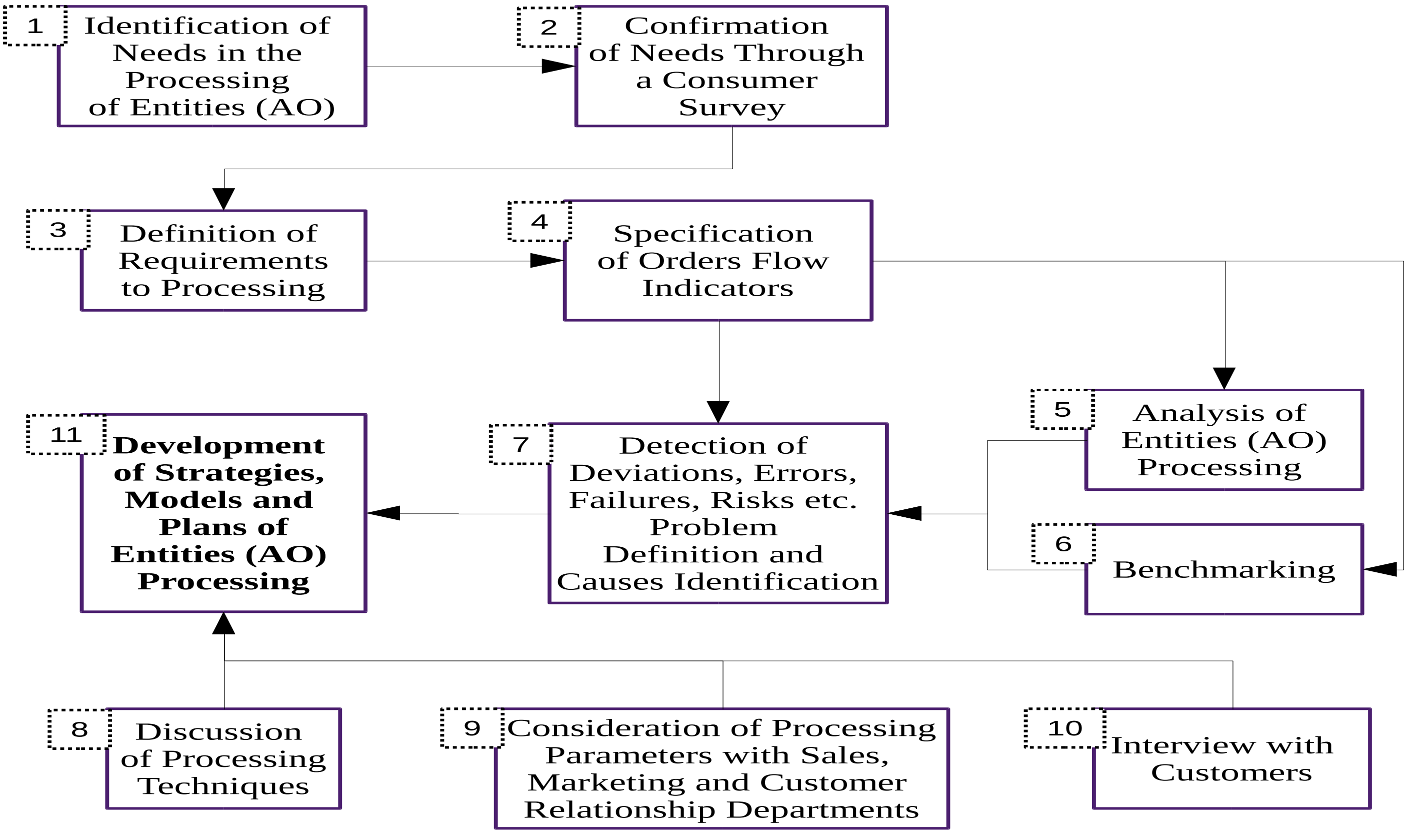


Fig. 2: The strategic planning of entities processing: SSM-model

Multi-methodological approaches and techniques are focused upon complex process and uncertain situations to enhance system's performancefor as long as possible. Gong Y. has identified uncertainty sources of a warehouse system which implements warehouse arrival, service, and departure processes at strategic, tactical and operational levels, and has classified uncertainty sources according to the location and the variance structure of uncertainties [26].

Logico-Linguistic Modelling

The SSM-model underlies a logico-linguistic model (LLM-model). Logico-linguisticmodelling is used for the analysis of information sources, knowledge-based system and decision support system design. LLM-model provides an answer to:

Whatevents lead to the desired state / outputs / outcomes?

This requires the following steps:
Step1.Convertcommands in the event-related conditions that have truth value: "yes"-"no", "true"-"false", "right"-"wrong", etc.) for example:

theidentification of needs – the needs are identified;

the acceptance of AO– AO are received.

It should be noted that compliance ofelements defined in the LLM-model with elements in the SSM-model is not anobligatory rule, becausedue to discussion and analysis of problems many of them can be reviewed and refined.

Step 2. Define relationships among elements of LLM-models using:arrows with dotted and solid lines;connectors AND, ANDOR" and OR (exclusive or).So, entities processing (AO) requires next ***sufficient conditions*** (events),displayed in the diagram with dottedlines:

IF *AOarrived*AND*Resource 1 is ready* AND*Resource 2 is ready*AND ... AND *Resource N is ready*,
THEN*AO will (can) be processed.*

This means a statement of the form "*In order to process the arrived Entity, Resources 1, ...,N must be ready*". By the way, terms"available","prepared", "formed" and others along with the term "ready"describe the state of a resource due to the sequence of operations like event that have occurred. Similarly "handled", "done", "performed", "worked out", "met", "achieved" and other terms along with "processed" and "served"describe the occurred event, meaning transition to the state of entity, which assumes the sequence of operations.
Let's get look at loading and unloading operations in a warehouse system (or a cargo terminal), which is, as pointed above, has uncertainties. Denote loading and unloading zone by LUZ, working team – WT, storing place – SP. Fig. 3 demonstrates LLM-modelfor the processof loading and unloadingof vehicle at the warehouse.

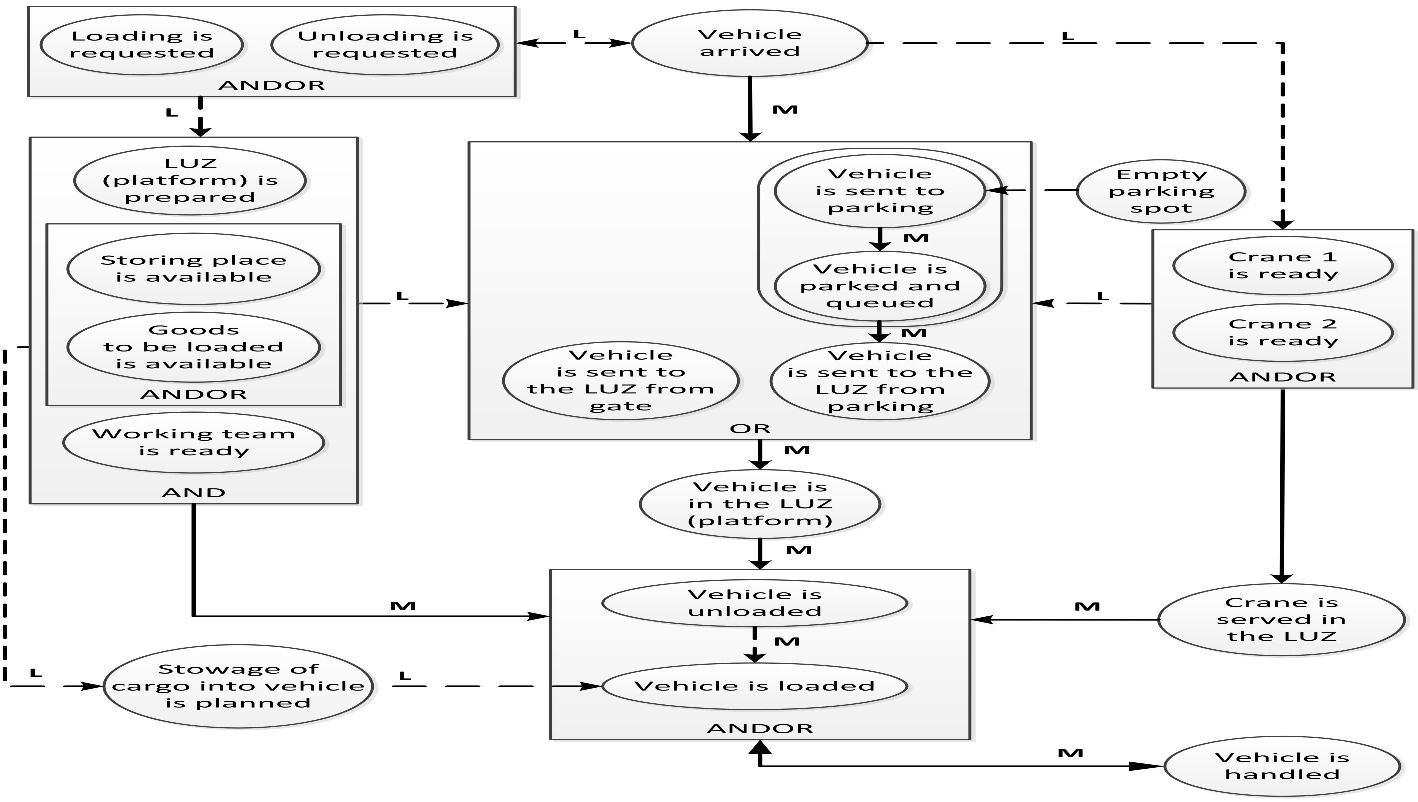


Fig. 3: The process of loading and unloading: LLM-Model

LLM-model indicates:

IF *Vehicle is in LUZ* AND (*Loading is requested* AND/OR *Unloading is requested*)AND *Crane is served*

AND *WT is ready* AND *LUZ is prepared* AND (*Goods to be loaded are available* AND/OR *SP is available*)
THEN *Vehicle will be unloaded* AND/OR *Vehicle will be loaded*.

IF *Vehicle is unloaded* AND/OR *Vehicle is loaded*THEN *Vehicle is handled*.

From the first logical expression we can see the necessary condition that

Vehicle loaded cannot happens unless (*LUZ is prepared* AND *Vehicle is in LUZ* AND *Loading is requested* AND *Goods to be loaded are available* AND *Crane is served* AND *WT is ready*) happen.

Generally speaking, necessary conditions, displayed by arrows with solid line, reflect the following:

Action/Event E happens until Action/Event D happens,

Action/Event E implies the truth of Action/Event D.

So, the arrow from *D* to *E* means that the truth of *E* implies the truth *D*:

IF*E isTrue*THEN*D must be True*.

Step3. It must be ensured that the LLM-model includes all possible sufficient conditions (SUN-conditions).
Step 4.It requires from an analyst to make sure that the set of necessary conditions is complete and sufficient.
Step 5.Information that is necessary for implementationof items included in the LLM-model is put into table (Table 2).

Table 2: Description of events within the LLM-model

№	Events	Adverse, undesired events (AE)	Causes of AE	Failure effects
1	Vehicle is ready for handling	No vehicle	Low rate of vehicle arrivals (recession of demand)	System downtime costs
2	Vehicle is queued	Queue arises. Excessive queue	Vehicle arrival rate increase (growth of demand). Low capacity. Resource shortages or failures.	Costs due to vehicle waiting in queue
3	Vehicle is sent to the LUZ (platform) from gate	Vehicle is not sent – it's idle	Resource shortages or failures, in particular: **AE (4)-(9)**	Costs due to vehicle downtime in system (demurrage charge).
4	Crane is ready	Crane is not ready	It is being used for a previous vehicle. It is failed. It is under repair. Technological mismatch.	Costs due to vehicle downtime in system (demurrage charge). Losses in case of refusal to fulfil clients' orders. Expenses for emergency troubleshooting.
5	Crane is served in the LUZ	Crane is not served	**AE (4)** or **(3)**. No passage to the LUZ. Feed path is faulty.	
6	Working team is ready	Working team is not ready	Improper schedule. Errors in stuffing. A worker is absent.	
7	LUZ (platform) is prepared	LUZ (platform) is not prepared	Maintenance is delayed.	
8	Storing place is available	Storing place is not available	No free space. Technological mismatch to cargo storing specification.	
9	Goods to be loaded is available	Goods to be loaded is not available	No tare or packaging. Access to storage area is difficult. Transporter is faulty.	
10	Vehicle is in the LUZ	Vehicle did not come to the LUZ	Atypical event.	
11	Vehicle is unloaded	Vehicle is not unloaded	**AE (5)-(8), (10)**	Overall costs and losses due to failures in the cargo handling and vehicle processing. Lost profits.
12	Vehicle is loaded	Vehicle is not loaded	No optimal stowage plan. **AE (5)-(7), (9)-(11)**	
13	Vehicle is handled	Vehicle is not handled	**AE (11)-(12)**	

Graphs and Petri nets

If we look at network model in Fig.4 based on LLM-model (Fig. 3 and Table 2), we can see, for example, that adverse event "Vehicle is not unloaded" (AE 11) may be caused by adverse events "The crane is not served" or "Vehicle did not come to LUZ" (AE 5 or 10). Similarly, if AE (12) is fixed, then AE (5), (10) and (11) are subject to review, which of them have happened.The network model of the handling of vehicles, shown in Fig. 4, is directed graph that represents nodes by one of two ways:

1) Nodes express normal and adverse events as results of certain operations, e.g. "Vehicle is unloaded" or "Vehicle is not unloaded". So, we analyse event-graph $G1$, and nodes represent events that determine a state of the process. If we take a look at them we can see whether the job has been accomplished or not. Arcs of the event-graph depict these jobs (operations).

2) Nodes express tasks or works (operations) like "Unload vehicle" or "Vehicle unloading", and arcs show how they are linked. This is network graph $G2$.

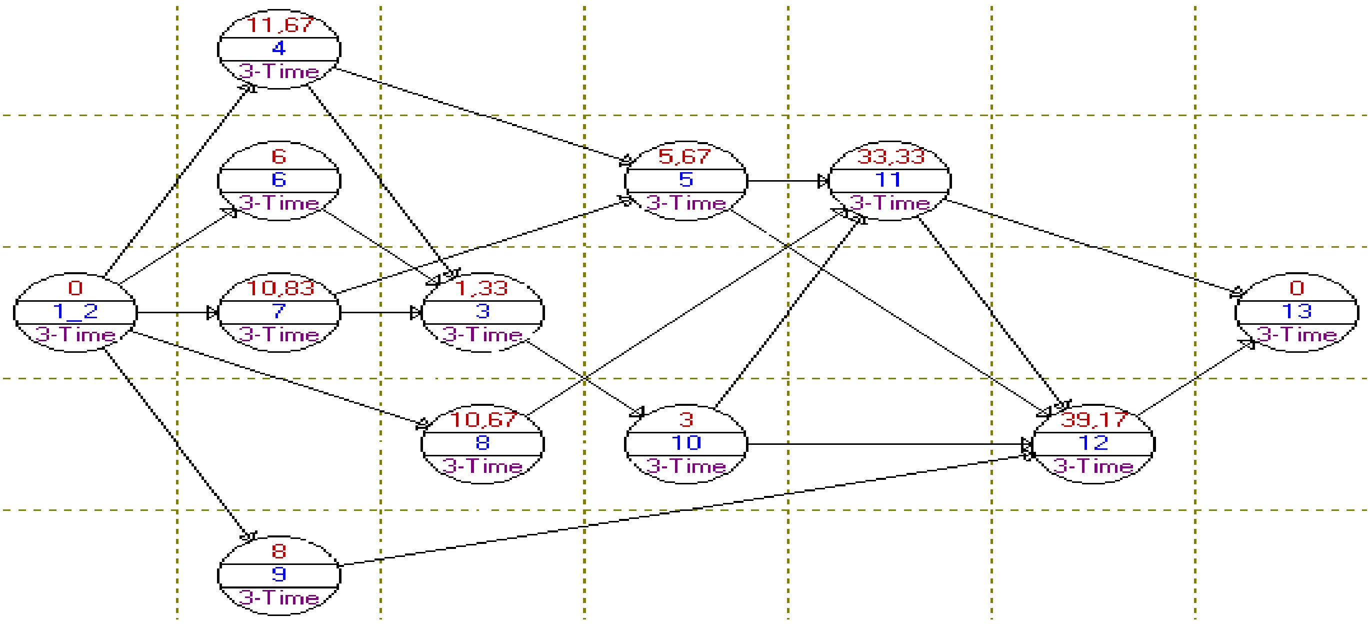
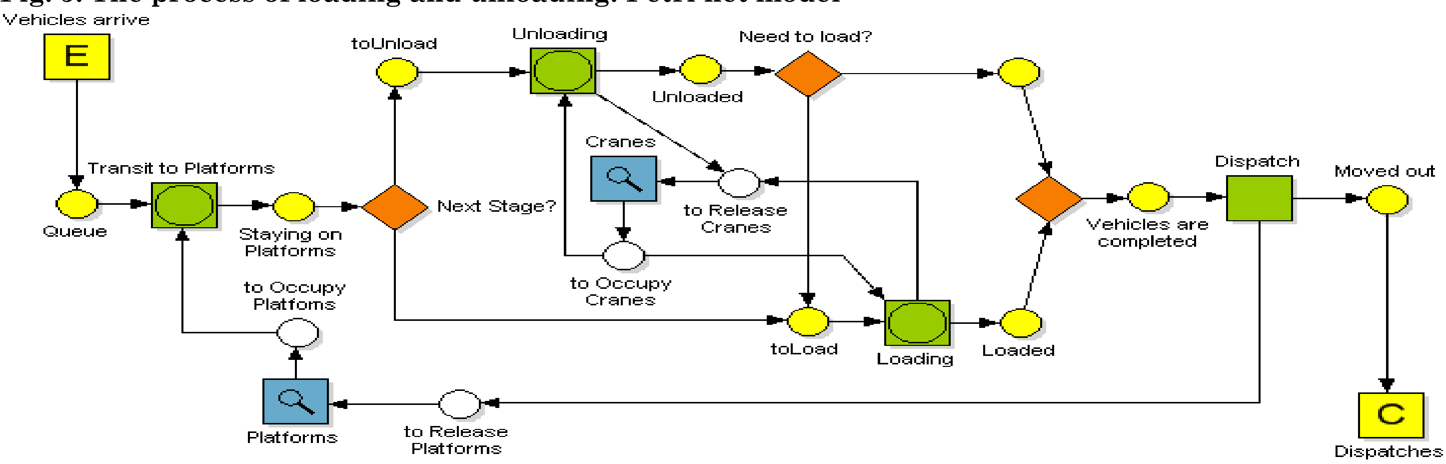


Fig. 4: The process of loading and unloading: Network model

Graphs $G1$ and$G2$ enableto calculate critical path for the process. In addition, thetaskand event are characterized by costs and adverse events lead to losses and additional expenditure. Therefore, the critical path can be adjusted in view of losses due toprocess failures. Moreover net graphs with random time parameters allowassessing probability of that vehicle can be handledearlier or later the schedule date.

LLM-models, flowcharts, statecharts, workflow diagrams, business process models (BP-models)and graphs $G1$ and $G2$ are intended to be aidsfor the creation of simulation models.Petri nets are useful tool at the operational analysis [27, 28, 29]. Fig.5illustrates the Petri net model of the vehicle handling (loading and unloading) process; and the model has been designed in the applicationsoftware "Yasper".

Fig. 5: The process of loading and unloading: Petri net model



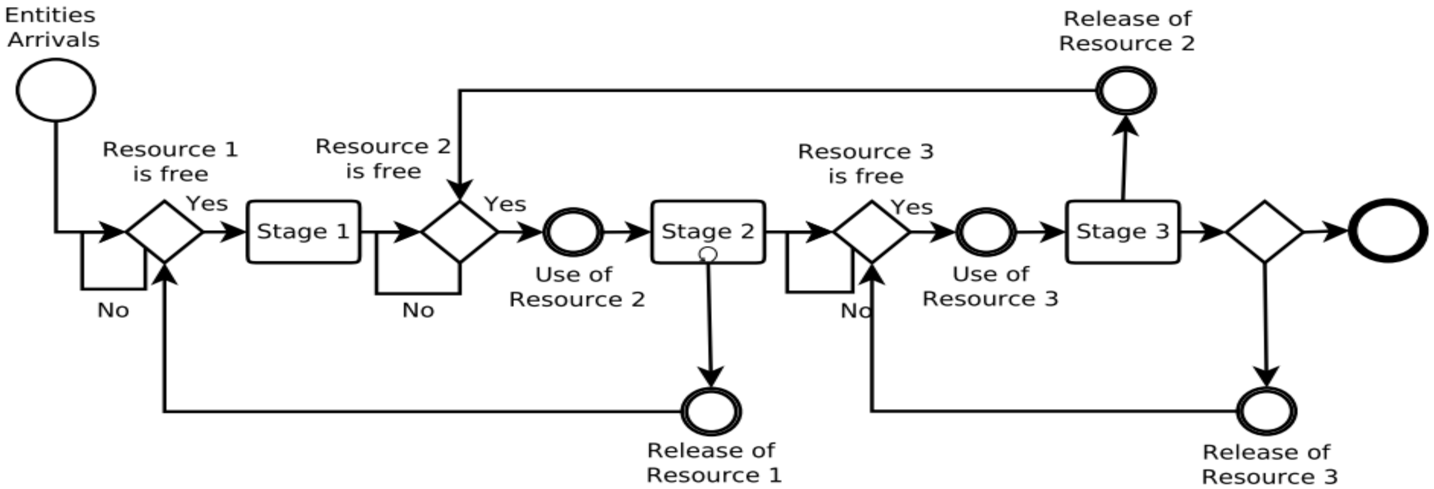
The Petri net model (Fig. 5) is based on the assumptions. Firstly, working of cranes and LUZ means that they change their states over time. Possible states and transitions of these resources and mechanisms are defined by the relevant subnets "Cranes" and "Platforms". Secondly,dynamics of resources is given by the reachable markings graph that includes typical states "ready for use", "use" and "not ready for use".Transitionfrom one state to another is the outcome of preparation for operationsto be applied to a vehicle orexecution of these operations or release. Thirdly, a single mark corresponds to a single resource.Initial number of marks show maximum amounts of resource. Finally, workforceconsists of "working team" and "crane operator" and "driver" of a vehicle. Terms "busy" and "not busy" ("work" and "does not work") describe their states. Furthermore, avehicle needs only one unit of workforce from one kind. To put maximum amounts of workforce units in the model use option "Roles" in the "Yasper".
Petri nets simulation helps evaluate:

- The possible number of handled and unhandled entities.
- The expected full processing cycle for a single or a batch of entities.
- The average processing time of entities.
- The mean residence time of entities in queue to the handling.
- Possible time periods when entities wait for entries to stages and theaverage idle timeof entities in the system.
- The handling value of entity based resources expenditures and time waste.
- The expected idle time of resources and stage work load and system utilization at whole.
- The percentage of equipment utilization, workers employment and so on.
- Sufficient amount of resources to support high process reliability.

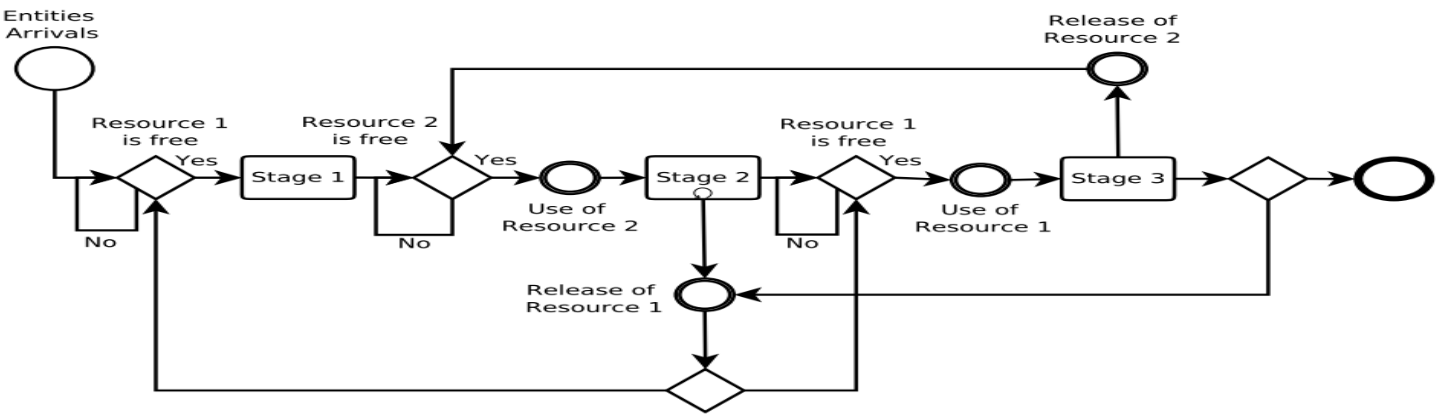
Process-Centric Modelling

Processes are divided into stages, which have inputs and outputs, tasks and workflows. Simulation of system processes is grounded on the formalization of resources utilization. Multistage process utilizes resources, which refer to fix assets, for the handling of entities, given that:

- One resource is used for all stages;
- One resource for a single stage (Fig. 6.*a*);
- More than one resourcefor one or several stages (Fig. 6.*b*).



a) **One resource is used for a single stage**



*b)***Several resources Go To One Or More Stages**

Fig. 6: Resources utilization for entities handling (BPMN diagrams)

Perhaps, there are buffers between stages of the process, which seize resources too.The assignment of any resource to a particular stage does not mean that the use of resource terminates at the end of a stage, when relevant operations have been carried out, and an entity goes to a next stage. Resource may be used during the execution of the next stage and it will be released upon the occurrence of certain events, such as the transition to the required state, or expiration of specified time interval. Therefore, decision makers face with the determination of resource optimal amounts, its allocation on process stages, and the operations synchronization to reduce waiting time, down-time and lead time.

Causality

Occurrences of events lead to changes in performance indicators used for monitoring and analysis of process inputs and outputs and states of entities, facilities and system. Indicators can be regarded as both causes and effects. The definition of events for different models, which are involved in problem solving, can be carried out on the issues that models are aimed to.If we analyse of situations and performance, then problems cause-and-effect links must be detected, approved and then visualized by cause-and-effect diagrams, casual loop diagrams or cognitive maps. Note that a cognitive map of problem field is the signed directed graph with feedbacks, its nodes show events and indicators of situations, and arcs correspond with cause-and-effect links. Parameters of events and degrees of their mutual influences can take both precise quantitative and fuzzy qualitative values. Cognitive map is modelling technique to assist problem structuring methods, in particular Strategic Options Development and Analysis [30].

Causal relations have interpretations:

- *IF X THEN Y.*
- *The more X the more/less Y.*
- *Y is directly/inversely proportional to X.*
- *X (strongly / … / weakly) affects on Y.*

Causal loop diagram comprises indicators and parameters from various management domains across several or all its levels. For instance causal loop diagram in Fig. 7 connects logistics, marketing, staffing, capacity and costs indicators and parameters of the warehouse control.

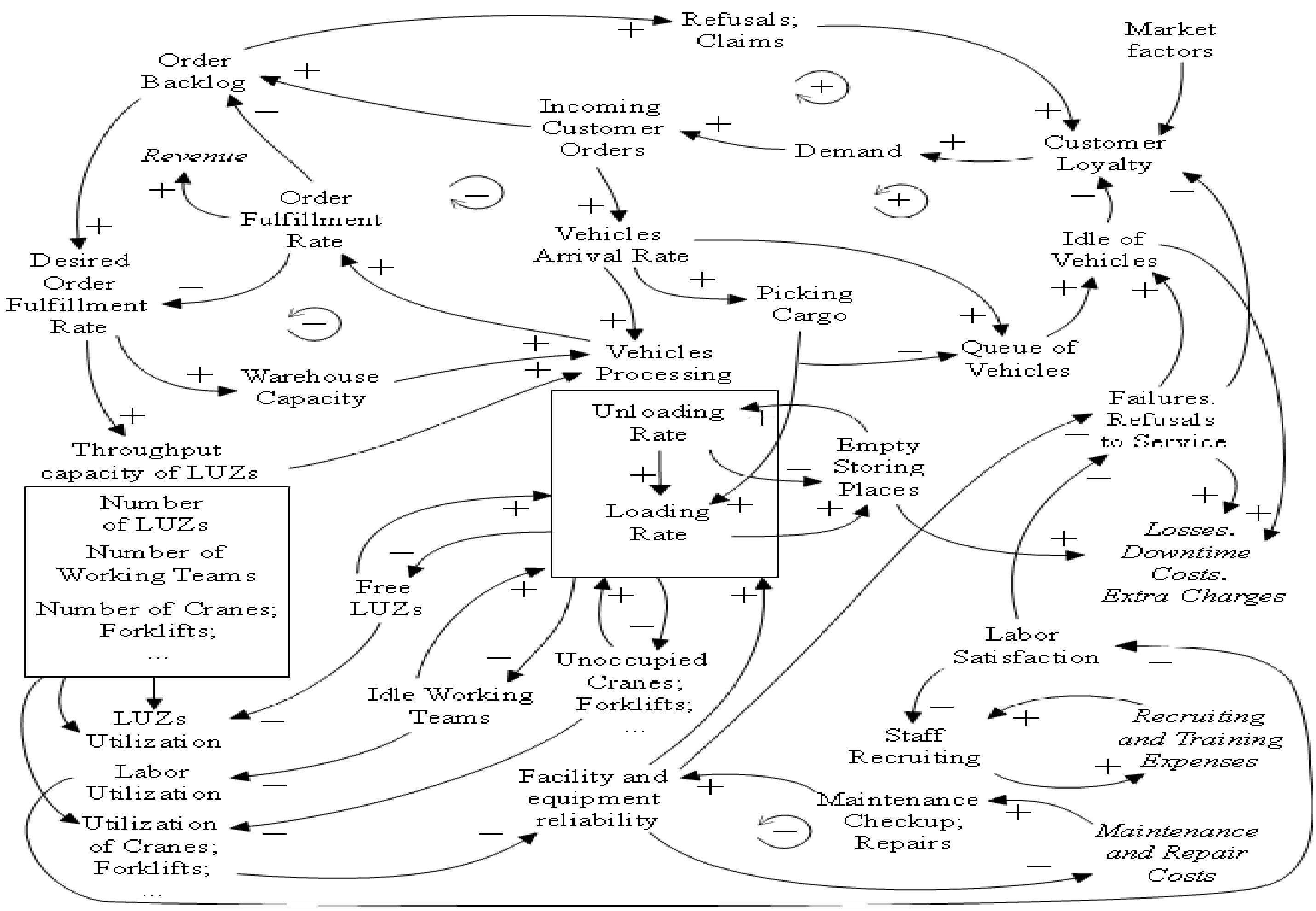


Fig. 7: The warehouse control: causal loop diagram

Competent combination of "hard", "soft" and "hybrid" decision making methods, tools and techniques should be applied jointly because of diversity of conditions, limiting the business activities, its unstable state, different capabilities and wide range of possible actions in the context of identified or expected problems. Uncertainty, complexity and instability inherent in the system bring different and ambiguous interpretations of situation and system control problems, vague insight or ignorance of events and their further consequences and, finally, lack of assurance in decisions.

It, in turn, leads to combining different approaches to research, control, management, modelling, problem solving, decision making and implementation. For instance there are may be performance-oriented, situational, process-oriented, adaptive, cognitive and other approaches. Often, decision makers ask themselves:

"*What happens if the event E occurs*?" or
"*What would have happened if the event E occurred*?" and
"*What caused the event E*?".

Events change patterns of agents, objects and resources, rights,property and use [31]. Some of them reduce the value of resources, while others increase it. Therefore resource's attributes "stock" and "flow" have associations with events formulated with terms of action "use", "consume", "produce", "give", "get" and so on.

Simulation

Discrete-event simulation software products, e.g. "SimProcess","Arena" or "FlexSim", often allow getting more details about the processthan computer implementation of Petri Net models. It's important when analysts might wish to set additional conditions for the handling process in order to ground its parameters within the alignment strategy.

Qualitative (soft) variables (metrics) can be incorporated into a system-dynamic model, if they reflect important aspects of the system, despite the difficulty of their measurement and quantification. But ignoring qualitative variables restricts models and prevents critical and creative reflection on the problems and prospects of the business. These variables are related to the social and economic categories, subjective and intangible in nature, for example: customer loyalty, consumer perceptions of product quality, employee liability, etc.

In addition to the difficulty of quantifying qualitative variables for system-dynamic models there are difficulties in defining their relationships with quantitative variables.

Nevertheless, fuzzy logic inference modules (programs) may be used to determine the values of qualitative variables in the simulation and decision-making models. So, for the simulation of warehouse control (Fig.7) customer loyalty indicator can be represented as a fuzzy variable and follow logical rules according to pattern:

IF *Refusals to Service* IS A_s AND *Idle of Vehicles* IS B_rTHEN *Customer Loyalty* IS L_q,

Where A_s, B_r, L_q are linguistic values of the variables which belong to linguistic term sets $\langle S \rangle, \langle R \rangle$ и $\langle Q \rangle$.

One, two or more input variables may be added at logical rules. And except indicator,its shift can be used for an output variable. For example, experts can choose *Customer Loyalty Change*, which gets "*Negative*", "*Small*" and "*Positive*" values, instead of *Customer Loyalty* ("*Low*", "*Medium*" and "*High*").Furthermore, we can usefuzzy inference for Labour Satisfaction, depending on Labour Utilization and Salaries & Wages;Number of Failures, depending on the Facility & Equipment Reliability and Employee Satisfaction.

Conclusion

The success of business activities is characterized by criteria and indicators of effectiveness, efficiency and economy. For many of them it is important timely, cost-effective and high-quality execution of business processes and workflows associated with customer orders fulfilment. Hard systems methodology searches for an adequate model of the system in the context of the goal or problem. However, managers have to cope with undesirable deviations, new problem situations and alternative scenarios due to complexity and uncertainty.

To accurately understand and solve the perceived problem, experts must apply problem structuring approaches and techniques in accordance to the principle of minimum subjectivity, whichcomes from the individual and group perceptions and awareness of the changes. Approaches should provide timely and accurate identification of the root causes, the measurement of changes in the system and its environment, monitoring and definite interpretation of conflicting events (weak signals), as well as evaluating effects. The result is a set of questions and issues that require multifaceted views on analysis and problem solving. Therefore SSDM has been chosen as the multi-methodological practice to problem solving for performance improvement. It was integrated with the methods of process and workflow management, analysis and modelling. The stages of the methodology may be arranged in accordance with steps of performance management cycle, which is stated within a concept, theory or methodology, for example, as shown in the paper, with the stages of Creative System Thinking.

The updated framework of problem solving based on SSDM involves the stages of problem- and goal-oriented development of conceptual, structural, descriptive and normative modelling to reflect situation "as is" and "to be". Proposed SSM-model depicts the sequence of issues concerned with the strategic planning of entities processing. Experts can define logico-linguistic model for the operational level of entities processing control. In such a way the process of vehicle loading-unloading has been represented by means of logico-linguistic modelling. The LLM-model helps set adverse events, the reasons for their occurrence and consequences, which are considered not only at the operational, but at higher levels of management. This enables experts to create "cause-effect" diagrams and network models to schedule and control the processes in time and costs. The above models together with causal loop diagrams and structural models in the process-centric notations form grounds of process simulation with Petri nets, discrete-event simulation and system dynamics. An inclusion of qualitative indicators, related to the categories of intangible and subjective assessments into simulation model, prompted by the system (processes) complexity and the situation uncertainty relies on an inference module, which allows quantifying and linking with quantitative indicators.

Perspectives of multi-methodological problem solving for the process management, workflow control and performance improvement forbusiness systems consist in the agent-based simulation and the design of meta-model that provides a choice of simulation sub-models and coordination in response to changes in the system and its environment.

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