
Sustainable Resilience of Company Management System

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Resilience management performance comprise the resilience management processes: building awareness of resilience issue, selection of essential organizational components, selection of organizational operation, identification and prioritization of keystone vulnerability. Management knowledge comprise following elements: Commercial knowledge management, Quality knowledge management, Health and safety knowledge management and Environment knowledge management. The assessment of the overall resilience profile for each organization represents the set of rules to be followed in the assessment procedure. Resilience profiles have been developed to give organizations a visual description of their resilience and indicate areas of strength and weakness.

The Resilience Index is the stability parameter of any system and can be used as the measuring parameter for the assessment of the potential hazard events. In particular, it is of interest to mention that the Resilience Index is the parameter of the system which can be used as the diagnostic tool in the assessment of the potential hazard event of the system. As regards management hazard events can lead to mal function of the company and its destruction.

The catastrophic event prediction is imminent to every complex system and requires the permanent measurement of the indicators fluctuation and evaluation of the resilience index in the time scale. If there are simultaneous changes of the indicators there is a need to have validation of their agglomeration in order to verify those situations which are the potential catastrophic events.

Keywords: *sustainability, resilience, management system, complex system, resilience index, vulnerability*

Introduction

The company management system is the structure of the elements which functionality is defined with the respective task to be performed in the system [1]. The company management system comprises management process which includes elements devoted to the specific issues to be used as the main in the definition of the resilience of the management system. In this respect the resilience of management system has to meet specific roles to be achieved by the design of the resilience monitoring system. In essence the resilience monitoring system comprise ability to recognize potential vulnerability of the of the company management system.

The Resilience Management process involves [2]:

- **Element 1:** Building an Awareness of Resilience Issues. The tools used to achieve an increased awareness of resilience issues include the use of semi-formal, open ended interviews, surveys, reporting of observations back to the organizations and brainstorming hazard events using Consequence Scenarios.
- **Element 2:** Selection of Essential Organizational Components. Essential organizational components are those parts of an organization critical to ongoing operations and functions. These components are mapped from an internal and external perspective, including the identification of key stakeholder groups.

- **Element 3:** Selection of Essential Organizational Operation. The organization then assesses each of the selected essential components for criticality to operations (both during the immediate response and recovery periods of a crisis) and preparedness for disaster. Additionally, organizations that want to investigate a specific event, or embark on planning for a specific purpose, can assess the susceptibility of components to that event. Assessments are all completed on a qualitative scale.
- **Element 4:** Identification and Prioritization of Keystone Vulnerabilities. Information from the vulnerability assessments is then plotted onto Vulnerability Matrices that allow the organization to visualize those components that present the greatest threat in a crisis. Matrices are produced from an all-hazards perspective (using only criticality and preparedness information) and from a hazard specific perspective (using criticality, preparedness and susceptibility data).
- **Element 5:** Identification and Prioritization of Keystone Vulnerabilities. The tool used in this part of the process is the Readiness Exercises and Disaster Simulations (REDS). REDS offer a way for organizations to practice and test their crisis preparedness, leadership skills, decision making and communication skills in a time and resource efficient way. Desktop REDS can be completed in a matter of two hours and can be scaled to include only a small group of key decision makers through to the entire organization. They can also extend to include key external partners via a multi-organizational approach.

Organization of management knowledge

Management knowledge comprise following elements [3]: Commercial knowledge management, Quality knowledge management, Health and safety knowledge management and Environment knowledge management. Each of these elements are defined with respective criteria and corresponding indicators.

The commercial knowledge is a specific action to be performed in order to reach appropriate commercialization of the product. It includes market assessment, market promotion and product pricing policy. The verification of this knowledge is obtained by the assessment of specific procedure including: unit cost, increase in the sale, and profit. The adaption procedure is the commercial knowledge which is the element of the management knowledge.

The quality knowledge is the methodology for the assessment and validation of the object production. It comprise: reject in, reject out, late delivery and complains. In every production process these knowledge is the verification of the product quality. The quality knowledge is explicit knowledge expressed in numerical form as the measuring parameter the process quality.

The health and safety knowledge management is a collection of the data which are aimed to verify potential injury and long term accidents leading to the degradation of process. This knowledge management is aimed to quantify safety aspect of production process. It is an explicit knowledge expressed in numerical, descriptive, and logical form.

The environmental knowledge management comprises environmental concern of the respective production process. This knowledge is the explicit knowledge presented in the form of logical verification specific procedure. It includes legal concern and citation of the similar events. The environmental knowledge management represents collection of data for the environment assessment.

Resilience of management system

The assessment of the overall resilience profile for each organization represents the set of rules to be followed in the assessment procedure [3,4]. Resilience profiles have been developed to give organizations a visual description of their resilience and indicate areas of strength and weakness. In the organization resilience assessment the procedure it is of the primary interest to verify the vulnerability of the company management system and its structure.

Situation awareness is a measure of an organization's understanding and perception of its entire operating environment.

Management of keystone vulnerabilities defines those aspects of an organization, operational and managerial, that have the potential to have significant negative impacts in a crisis situation. The impacts of keystone vulnerabilities may be either instantaneous (occur suddenly and take the failure of only one component to have a significant negative impact) or insidious (small failures of key components lead to a large scale cascading-type failure over time).

Adaptive capacity is a measure of the culture and dynamics of an organization that allow it to make decisions in a timely and appropriate manner both in day-to-day business and also in crises. An organization with heightened resilience is able to quickly identify and respond to those situations that present potentially negative consequences and find solutions to minimize these impacts. Furthermore, resilience enables an organization to see opportunities in even the most.

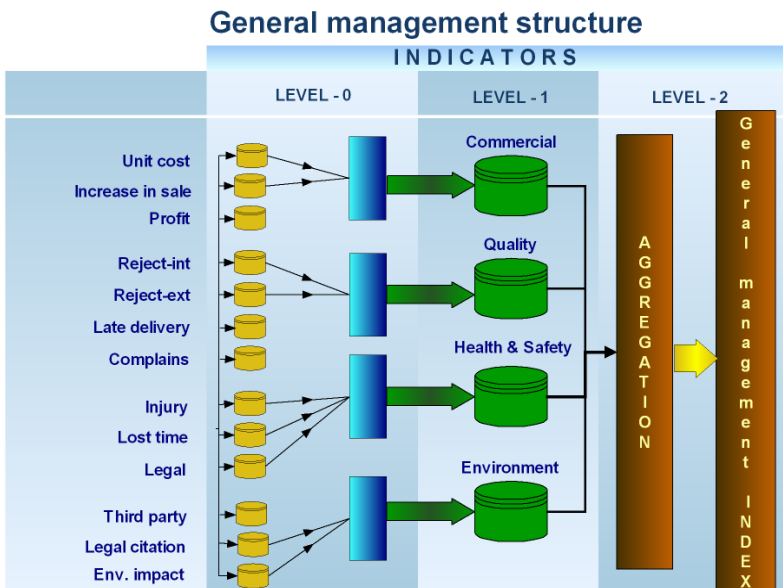


Figure 1: General Management Structure

Definition of resilience index

Data processing is organized with the appropriate definition of the Sustainability Index. The first step in data processing is the data normalization with the aim to obtain specific indicators to be agglomerated in the Sustainability Index. It is assumed that the Sustainability index [5, 6, 7] is a linear agglomeration function of products between specific indicators and corresponding weighting coefficients, in the form of additive convolution. If it will be adapted that each of the specific indicator is weighted by the respective weighting coefficient. The sum of specific indicator multiplied with the corresponding weight coefficient will lead to the Sustainability Index, $Q(t)$, with the following mathematical formulation

$$R = \sum_0^n w_n \int_{t_0}^t (1 - q_n) \quad (1)$$

Where: w_n - weighting coefficient for the n -th specific indicator
 q_n - n -th criterion for sustainability assessment
 n - number of indicators.

The evaluation of company management system as the complex system is the prestigious goal of modern approach to the validation of the complex system. In this context it is introduced notion of the Resilience Index as the agglomerated indicator for the measurement management system quality [8, 9, 10]. Resilience Index presented on Figure 2 is graphical presentation of the sudden Sustainability index change in time and its recovery to the initial state of the system. The integral value of the Sustainability Index recovery after a sudden change leads to the definition of Resilience Index.

The second step in the data processing is the determination of the resilience index component corresponding to the sudden change of the specific indicators. It is anticipated the total Resiliency Index is the sum of the resiliency index components.

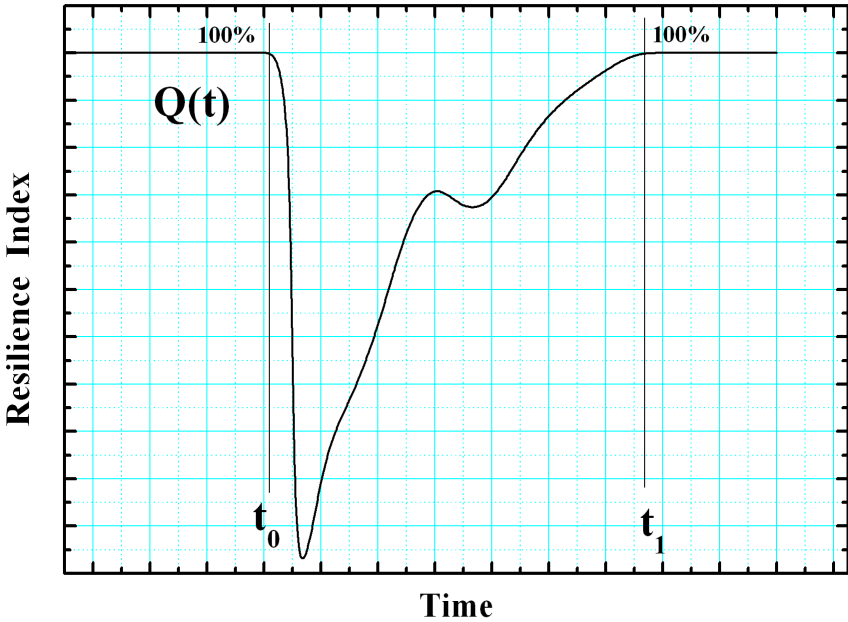


Figure 2: Graphic presentation of Resilience Index

Resilience Index is the variable immanent to the specific potential hazard. This means that Resilience index as the parameter which quantifying the potential probability for the malfunction of the system. Definition of the Resilience Index can be simplified with the assumption that the integral format can be determined as the surface of the triangle formed by the amplitude of sudden change of indicator Δq_i and time period Δt_i , Eq. (2), so that Resilience index is expressed with following mathematical formulation

$$R_j = w_i \sum_0^n \int_{t=t_0}^{t=t_1} [1 - q_i(t)] = w_i \sum_{i=0}^n \frac{\Delta q_i \Delta t}{2} \quad (2)$$

Where: Δq_i - indicator change
 Δt_i - time change

In this definition it is anticipated that there is time independent constant for every indicator.

In the processing of resilience index components a following simplification is introduced. The sudden change of the specific indicator from the initial value will be recovered within the time period Δt . Under the assumption that the sudden indicator change resumes is a linear function of time, then we can write

$$R_j = \frac{1}{2} w_i (\Delta q_i \Delta t) \quad (3)$$

If it is assumed that the time interval for resuming starting state is equal for all indicators than and then the Resilience Index for the individual case is

$$R_j = \frac{\Delta t_0}{2} w_i \Delta q_i \quad (4)$$

The total Resilience Index is an additive function of all resilience Indexes as follows

$$\sum w_n . R_n = R_{TOT} = w_1 R_{CP} + w_2 R_{IC} + w_3 R_{PC} + w_4 R_{MP} \quad (5)$$

Where:

- RTOT – Total resilience index
- RCP – Company Profit
- RCI – Company Income
- RPC – Product Cost
- RMP – Company Manpower
- wn – weighting factor

The procedure for the determination of the weighting coefficient is based on the ASPID method designed to quantify weighting coefficients under specific constrain defined in the verified for every option.

In the procedure for the determination of weighting coefficients there are several steps, namely:

- Normalization of indicators
- Determination of the average values for the weighting coefficients for the option which meet specific constrain
- Determination of the total resiliency index for every specific constrain

- Formation of the Rating list among options under consideration

The graphic presentation for the online processing of the resilience index is given on the Figure 3.

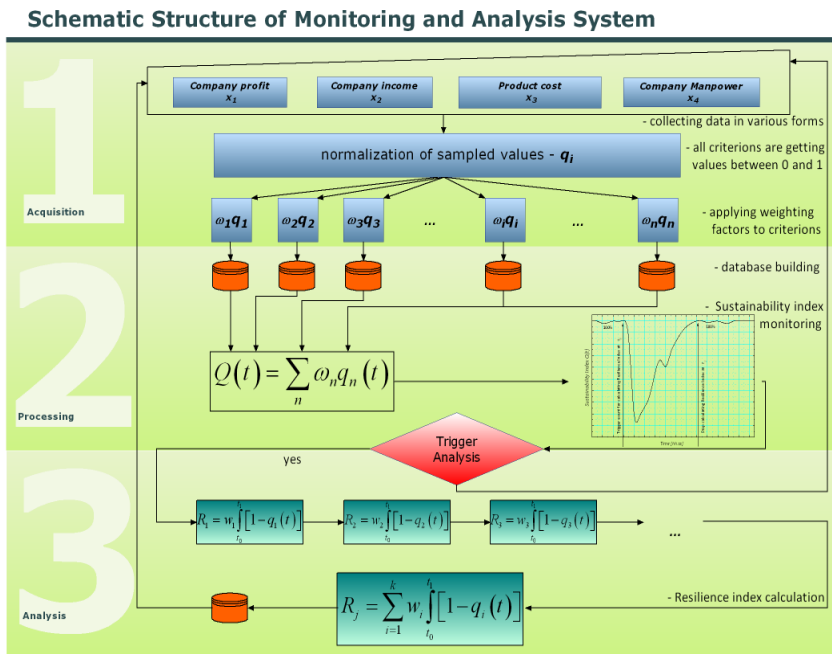


Figure 3: Schematic presentation of online processing

Demonstration of resilience index monitoring

The monitoring of individual indicators is performed by the respective instrument. It is anticipated that instruments are calibrated to appropriate scale for individual unites. Signal processing includes a following operation: instrument calibration, signal digitalization and signal acquisition within the respective time increment and calculation of the resilience indicator.

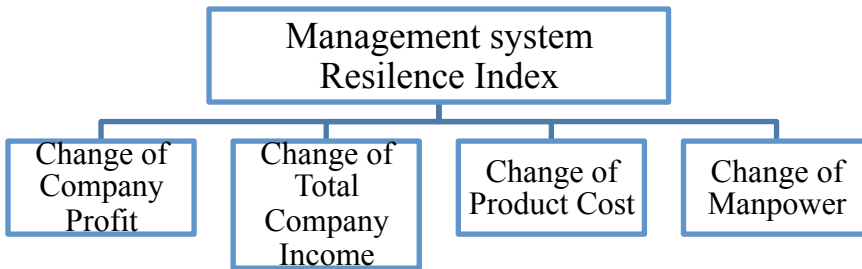


Figure 4: Schematic presentation of Management System

Following the determination of the resilience index in the appropriate time period reflecting sudden change of the individual period the agglomerated value of the total resilience will be monitored.

Resilience Options of Management System

In this demonstration exercise we have taken into a consideration the situations defined as the demonstration with the sudden changes of individual indicators.

Following situations are taken into a consideration:

a. Change of the company profit

Among the indicators used for the assessment of the company management is the company profit as the commercial parameter used to measure economic effect of the sudden change of the management system [10,11,12]. The effects of this change can be a warning signal for the company crises. It should be mentioned that if this effect will be added to the potential other sudden changes it may lead the catastrophic event. In this respect it is of interest to emphasize that the potential crisis can be envisaged as the multiple effects of the individual indicators. The indicator for this change of will be expressed in $\Delta\text{Euro}/\text{year}$ per Euro/year in steady production

b. Change of total income of the company

The potential change of the total income of the company is a measure of the management achievement [13]. For this reason a sudden change in the total income may be envisaged as the important resilience indicator. It is of particular importance to monitor the sudden change of total income in order to verify eventual critical value of the resilience element resulting

from the change of this indicator. The indicator change for this parameter will be expressed in $\Delta\text{Euro}/\text{year}$ per steady total income of the company.

c. Change of the product cost

One of the important parameters which define the company success is market price of the product. Since, it is immanent to any product the fluctuation of the market price [14]. The change of the price beside fluctuation in small scale is sometime result of the sudden change which leads to the resilience index change. The indicator for the change of the product cost is expressed in $\Delta\text{Euro}/\text{product price}$ per steady product cost in normal operation.

d. Change of the company manpower

One of the social parameter effecting state of the system is manpower availability [15]. For the different reason there is potential manpower strike leading to the production shortage. It depend on the management assessment to what extend the change of the manpower may effect company system. If there is a sudden change manpower indicator the crisis of the system may achieve catastrophic event. Indicator for the change of product cost is expressed in $\Delta\text{Manpower}$ per manpower in steady operation.

• Management resilience cases

In the design of the options under consideration it is introduced assumption that the sudden change of indicators is triggered at the same moment for all indicators. In the design of the Option under consideration it is introduced assumption that the sudden change of indicators is triggered at the same moment for all indicators. Also, the change of indicators are normalised and the maximum change for each of the indicator expressed in normalised value. It is of particular interest for this demonstration to have each object defined as the composition simulations sudden changes of all indicators as shown on Table 1. The Total Resilience Index is determined in following cases:

Case 1: $CP > IC = PC = MP$

Case 2: $IC > CP = PC = MP$

Case 3: $PC > IC = CP = MP$

Case 4: $MP > CP = IC = PC$

The results obtained for these cases are shown in Table 2.

Table 1: Option Indicators

Option	Company profit CP	Income of company IC	Product cost PC	Company manpower MP
	Δ Euro/y/Euro/y %	Δ Euro/y/Euro/y %	Δ Euro/y/Euro/y %	Δ Manpower/Manpower %
Option 1	15	10	5	0
Option 2	10	15	10	5
Option 3	5	5	15	10
Option 4	0	0	0	15

Graphical presentation of the cases is presented in the following figures. It is of interest to emphasize individual cases.

- **Case 1**

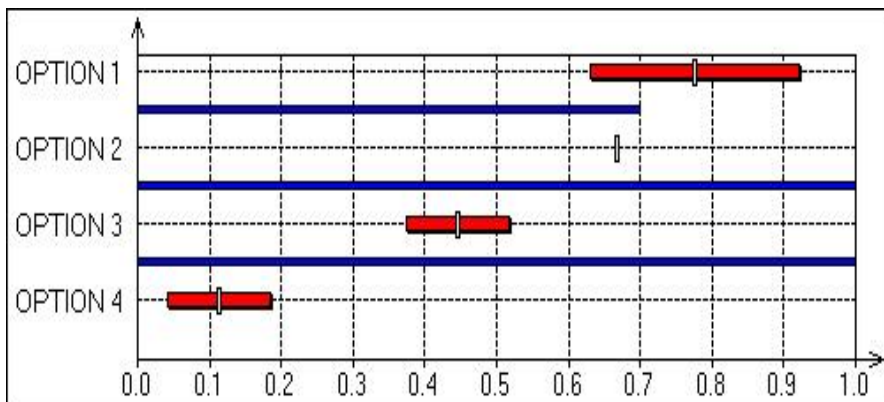


Figure 5: Graphical Presentation of the Priority List for the Case 1

Case 1 is devoted with the constrain expressed with the relation:

$$\text{Case 1: } CP > IC = PC = MP$$

Result obtained is giving priority to the Option 1 followed by the Option 2, Option 3 and Option 4. It is of interest to notice that even priority is given to the Maximum Company Profit Change the effect of the other indicator changes has proved substantial influence to the finale result. In the case the change of company profit parameter will override the maximum change of company profit the catastrophic event will occur. Even this option represents the changes of other indicators the catastrophic event will not necessary occur.

- **Case 2**

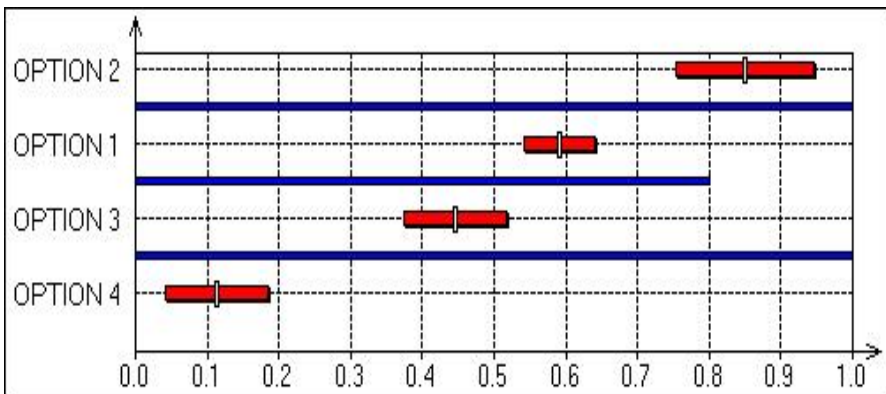


Figure 6: Graphical Presentation of the Priority List for the Case 2

Case 2 is devoted with the constrain expressed with the relation:

$$\text{Case 2: } IC > CP = PC = MP$$

The sudden change of the Income Company indicator has affected the priority list rating so that Option 2 is followed by Options 1,3 and 4. The maximum change of the Income Company indicator leads to the catastrophic event caused by the overriding of the respective value of the indicator with other indicators having the same value. Resilience Index as

the measure of the stability of the management system and results in the occurrence of the unexpected inverts.

- **Case 3**

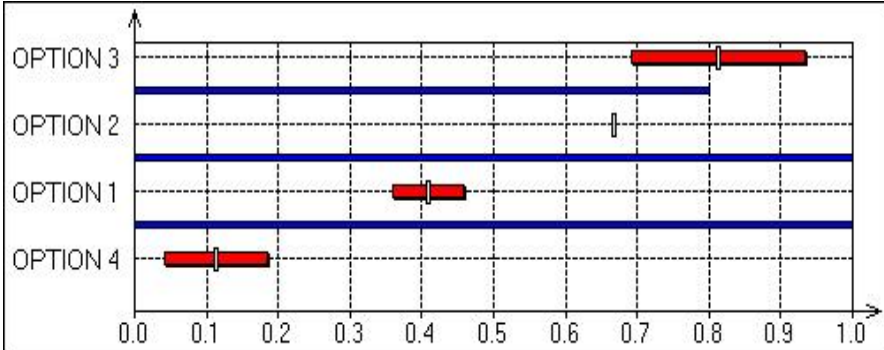


Figure 7: Graphical Presentation of the Priority List for the Case 3

Case 3 is devoted with the constrain expressed with the relation:

$$\text{Case 3: } PC > IC = CP = MP$$

The Case 3 is defined with the sudden change of the Product Cost. It results in the priority list having Option 3 at the first place and followed by Options 2, 1 and 4. It can be noticed that there is substantial difference in comparison with the Case 2.

- **Case 4**

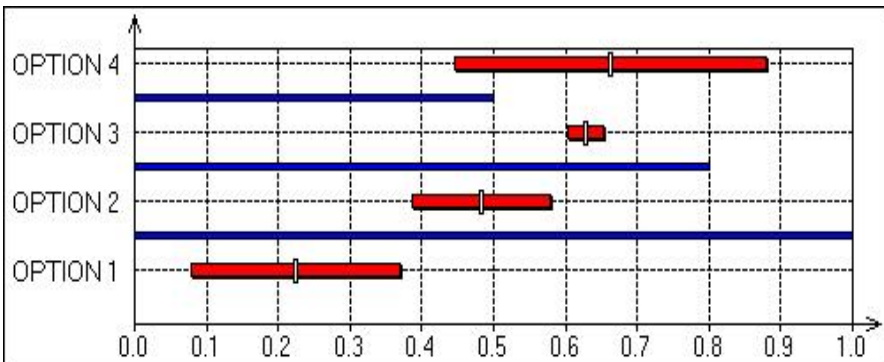


Figure 8: Graphical Presentation of the Priority List for the Case 4

Case 4 is devoted with the constrain expressed with the relation:

$$\text{Case 4: } MP > IC = CP = PC$$

If the sudden change of the Manpower indicator is used as the priority indicator in this Case then the priority list will be: Option 4, Option 3, Option 2 and Option 1. In this case the catastrophic event is with the sudden change of Manpower the priority list is: having negligible difference of the Resilience index. This implies that the Resilience index for Option 4 and Option 3 are the same. Under this condition the management system may have two potential causes for the overriding Maximum change leading to the catastrophic events.

Table 2: Option Rating List

Options	Resilience Index
Option 2	0.85
Option 3	0.82
Option 1	0.78
Option 4	0.66

The Resilience Index is the stability parameter of any system and can be used as the measuring parameter for the assessment of the potential hazard events. As regards the management system analysis it prove that the most stable case in sudden change of the indicators is the Case 2 when the priority of the indicators is given to the company income.

In particular, it is of interest to mention that the Resilience Index is the parameter of the system which can be used as the diagnostic tool in the assessment of the potential hazard event of the system. As regards management hazard events can lead to mal function of the company and its destruction.

Conclusions

Resilience assessment of management system under specific changes

Resilience engineering is applied in a number of systems in order to justify potential stability limits which may lead to the catastrophic events [16]. It is of interest to use the sudden changes of indicators for the assessment of the resilience index and use this data for the evaluation of the critical state of the management system. In particular there is the potential possibility to quantify eventual catastrophic events and the effect of the individual indicator changes on the behavior of the management system.

The catastrophic event prediction is imminent to every complex system and requires the permanent measurement of the indicators fluctuation and evaluation of the resilience index in the time scale. If there are simultaneous changes of the indicators there is a need to have validation of their agglomeration in order to verify those situations which are the potential catastrophic events. As regards management system it is of the particular interest to notify those events which are characteristic for the crisis of the management system.

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