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Systematic mitigation of model sensitivity in the initiation phase of energy projects

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ABSTRACT

Early project risk identification and assessment is a complex issue based on decision-making methods that are methodically suitable for successful project delivery. Nevertheless, although there are several risk management assessment tools, in practice, this issue is still not taken seriously enough in the project initiation phase. Literature research reveals a need for an applicable systematic risk model approach, systematic sensitivity of mitigation action plans, considering the need for early systematic project risk awareness. This paper not only explains the evidence that a risk systematic model tool is essential in the project initiation phase but also narrows the gaps through the systematic sensitivity approach with the accent on the integrated risk systematic model. The sensitivity approach is taken in the project early preparation phase, where evaluation, the establishment of limits to which risks are controllable, is based on the stage-gate model. The stage-gate model evaluates which risks are specific to a certain analysis in the early project definition phase, leads to the conclusion that excluding any mitigation elements or probability of risk occurrence reflects on the outcomes, and presents an unrealistic picture of the given project targets. This research represents a reliable risk tool with improvements in resolving systematic risk system faults, 'stakeholders' subjective decision gaps, constricting project contingency, and shortening project schedule deviation. The research is based on two complex industry (case studies) projects within the energy industry.

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1. Introduction

Various authors emphasize that a crucial part of risk management is a reaction plan, which ensures proactive problem solving [1, 2, 3]. Numerous studies, including authors such as Ward or Chapman, have shown a need for project risk management (PRM), including its benefits [4]. Various authors have found that the quality of stake estimates, assessment method tools, and scheduling are essential for proactivity in project management [5, 6]. In the last decade, risk project solving has significantly improved within the risk management tools, where a more reliable risk allocation is being facilitated [7]. Thus, gaps still exist, and improvements in risk management are necessary. These should include a more detailed or quantified approach, early reduction of risk and risk avoidance, and prompt systematic action of suitable integrated techniques to improve risk management practices [8, 9, 10]. Over the last years, risk management (RM) has attracted the attention of both scientists and practitioners. The Project Management Institute (PMI) included risk management as one of the ten knowledge areas in project management (PM) [11]. Considering the previously stated, this study aims to identify the major needs for a systematic risk model response within the energy industry, taking into account the preparation projects phase and its impact on (time constraints) schedule with an emphasis on model sensitivity [12]. The results of different authors suggest that in the engineering industry, project risk management still having some ineffectiveness. Mainly it is related to the 'stakeholders' lack of involvement in the risk management appraisal, as well as the failure of projects with some specific elements of the outcome presented through the study of various risk tools and their technological doubts [4, 13, 14]. One of the uncertainties was the inadequate participation of all stakeholders from the initiation until project closure [4]. Dale, Stephen, Geoffrey, and Phil highlight that risk should be considered at the earliest stages of project planning to avoid correction later on in the execution phase. The authors mention that risk management activities should be continued throughout a project lifetime [13, 15]. It is also suggested that risk management focuses on identifying and assessing risks to a project and managing those risks to minimize the impact on project objectives. Therefore, the presented model takes into account all the mentioned gaps and collectively and systematically resolves the issue from the definition or initiation project phase.

Authors Zwikael and Ahn, considering the lack of provided solutions on the market, emphasize the need for tools that are easy to use and lead to better outcomes [16]. As proactivity is needed in the engineering industry, risk management tools have to overcome and actively solve potential problems in the early initiation, definition, and implementation phase of a project [10, 12, 17]. Systematic process model steps and criteria will allow risk-handling stage-gate strategy by selective elimination based on relevant available mitigation criteria (considering the contingency), including the objective probability of the desired successful project results. The desired successful project results are given through a detailed stage-gate systematic approach of establishing all risks according to the predefined and locked model criteria. The approaches and the final objective show that the new systematic process model will generate less deviation and improve the implementation of projects [18].

The objective of the early risk initiation phase is to prepare a plan of risk mitigation by identifying potential gaps, narrowing down all known and unknown risks before proceeding to the next stage [8, 10]. If we are looking from the qualitative standpoint of resolving these issues by using the existing software, the project definition does not differ from project planning with minimum information [19]. The degree of risk information varies with project complexity, the scope of work, timeframe, approved funds, and project location [15]. A few studies present risk management frameworks from the 'developers' perspective, integrating the software development cycle, and involving the concerned stakeholders [15, 19]. The main message from the findings is that successful projects resolving possible problems before they arise. That should be the most crucial task of project risk management, and the aim of the current presented study, with the focus on the given sensitivity systematic matrix tree [12, 20]. Even the overview of risk standards calls for further process improvements. Based on the David H. comparison of the risk standards limitation, it is apparent that risk standards have a great deal in common, and that with a universal consensus of risk management, gaps should be covered [21]. On the other hand, there are some, substantial gaps and material differences between them:

- The first is the general observation that none of the included risk standards covers all the fields regarding the ''stakeholders' involvement, communication, and collaboration into organization structured adoption of risk implementation.
- The second is that specific standards cover only the risk management process but not the establishment of organizational infrastructure to apply such processes.
- The third is the differentiation of the risk definition, an approach to risk both as a threat and an opportunity, as opposed to the approach that risk is only a threat.

What follows from all the above is that there is a broad consensus regarding the main steps and activities of the generic risk management process, but there is still room for a comprehensive approach that will cover the gaps. The contribution of the research is the effective and continuous involvement of stakeholders. The effectiveness is visible throughout the entire risk process. Predefined, concrete steps resolve possible systematic risk system faults with precision and functionality. The results show a leaner project contingency approach and shorten the project schedule deviations.

Risk model methodology approach

The objective of the research is proposed with a systematic risk management model that uses a quantitative technique with the active involvement of stakeholders throughout the entire risk management process (identification, analyses, and response to risks) [14, 22]. The systematic risk management model is an integration of the existing tools such as Risk Work Breakdown Structure (RWBS), Risk Registers (RR), Probability and Impact (PI), Analytic Hierarchy Process (AHP), Fault Tree Analysis (FTA) [23]. Two significant areas must be introduced through the model tree: early systematic risk assessment and the project stakeholders understanding what and how those steps may impact the project beyond its objectives [9, 10]. The entire method is based on the approach with one step ahead of any project definition and implementation. The risk model provides details, breakdown into actions that will support the research from the moment of decision-making, emphasizing the quantitative approach to risk evaluation with the effectiveness in bridging the gaps mentioned above.

The presented model involves advanced strategic steps for risk management. The advanced strategic steps practice corrections or mitigations of risks utilizing knowledge of the managerial resources, as well as the given model benchmarks [24]. With this quantitative methodology, considering quantitative risk elements and risk management integration, the risk model process will be developed through stage-gate. Such an approach contains steps that will enable better implementation of project risk management. A systematic approach to risk management is the most common problem in the pre-definition phase of the project management industry [12].

There is a concern with the policy prescription to remedy the problem to provide a deeper understanding of what constitutes systematic risk management and how it impacts on incentives and welfare measures. The purpose of the paper and the presented model in risk analysis is a data-level specification of a ''more systematic risk 'treatment' including objectives of stakeholders. It is clarified through the matrix tree how the definition criteria differ from the existing definitions of systematic risk. The definition is applied to all steps in the model and the stage gates where criteria are well-coded to ensure the given option over random choice sets. The definition is also innovative, as opposed to the consideration of the existing random choice sets. In circumstances where a stakeholder has the option to discard risk identification for a well-defined reason, it is clear that risk treatment should be much more systematic [4, 14].

The systematic decision model tree represents the level of involvement and the level of predictability of risks, including the external and internal factors with the focus on all risk elements known, unknowns, known unknowns, and unknown unknowns. The weighted probability of risk categorization and mitigation is included in all stage gates following risk assessment according to all established criteria. The main aim of the research is to evaluate and establish limits to which level risks are manageable and the extent to which risks are specific to a certain analysis in the early project initiation stages [10, 13]. The study is focused on improving schedule deviation through the systematic process model approach for future preparation and implementation of projects. The most important motivation for the paper comes from the research gaps where risk management and risk assessment in the early stage is not thoroughly considered [8, 10, 17].

The paper addresses the problem of risk management in the field of energy industry projects using a knowledge-based approach. It proposes a systematic methodology based on five main segment criteria: systematic process matrix tree, risk registration, control flow plan, risk support documents, and data with applicable criteria. The expected mitigation and the presented risk response stage-gate strategy are there to eliminate uncertainty factors of the, anticipated new unwanted risks and their post evaluation. The first challenge is the modelling of the risk management function area managers (FAMs), criteria of its evaluation, and the possibility of integrating best practices into the model.

Therefore, the systematic process model tree and stage-gate criteria include risk events, risk reduction or elimination actions and their effects, interactions between the stage gates concerning risks and risk decision, and mitigation efforts [18]. The systematic process model stage-gate criteria allow the risk-handling stage-gate strategy by selective elimination based on relevant available mitigation criteria, including the objective probability of the desired successful project results. The desired successful project, results are given through the detailed stage-gate systematic approach of establishing all risks in the model predefined criteria. The approaches and the final objective show that the new systematic process model generates less deviation show different levels of sensitivity results and improves the implementation of projects [20]. Further expectations are that the application of the proposed approach will allow functional area managers (FAMs) and end-users to develop project risk management functionality based on best practices and to improve the performance of the awareness.

The fundamental changes that are taking place today in the field of risk project management applications originate precisely in the area of the earlier risk identification work [25]. They are, on the one hand, positive and successful possibilities in project risk management, where such an approach can result in significant flexibility in operation (time savings) and cost reduction. The use of the earlier risk identification can be considered in terms of improving competencies based on which a company's primary strategy then develops and achieves a competitive edge and brings added value to the project management decision-makers. Risk management should be incorporated in the initial start-up phases of projects and continued throughout the project duration [26, 27].

Since risk can occur in three phases or levels, the initiation phase, the project risk definition phase and the day to day project operation phase, it is crucial, based on the conclusions of recognized authors, that risk should be considered at the earliest stages of project planning to avoid correction later in the execution phase [8-10, 12]. Project risk is always in the future, but if the risk is managed systematically and thoroughly in the early phase, project implementation should not have a vast deviation or corrections.

Scientific proofs illustrate that although there are well-developed, designed and implemented processes of project Risk Management (RM) such as risk management planning, risk identification, risk assessment, risk analysis, and risk response planning, in the construction project experience failure is always ascribed to a risk event [8, 28, 29]. Risk management is crucial in the planning stage of a project, and its scope and depth increase as the project moves towards the execution phase, while they decrease in the conclusion phase [30].

Section 1 presents an overview of the key research and objective glitches in a risk management society, based on the current technologies and the basic challenges of new tools as well. Summary of the methodology description, research, and data collection.

Section 2 presents the concept and assessment of the model. The particular emphasis has been put on the development, usage, and impact of applying the model to the existing risk management tools. The systematic and sensitivity approach, has been elaborated. Provides more insight into the model structure and implications. Also, discuss the model individual connections and model pattern demonstration.

Section 3 provides an overview of the two complex industry projects (case studies) as a key structure in any type of project management. Section 4 provides an overview of the given sensitivity results and comparison of the two complex industry projects (case studies), regarding the sensitivity capability RIO model itself. Section 5 presents the conclusions and discussion of the results obtained by research. The practical implications and limitations of the research are described and summarize the scientific contribution of the paper. Also, the directions for future researches are indicated. In the end, it shows the scientific literature that has been used during the research, also indicates the excellent structure of the due diligence path towards the findings.

2. Systematic risk model, risk identification oversight (RIO)

In the engineering industry, there is a wide range of risk management tools and techniques, all of which can add value to the performance in achieving project objectives [32]. The collected existing risk history data, together with the newly added risks, went through the checked Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis. SWOT analysis was used for identification, structuration, and comparison of the already existing data, their strong and weak sides so that it would be following the current project objectives. In this paper, the emphasis is not on computer model outcomes but rather on the interactions of the presented risk management tools, their participants, who in this case are the functional area managers, and the effects of systematic interactions according to the model given criteria with the main impact on the project timeline outcomes. The model, RIO matrix diagram, graphically shows various combinations and conditions that may fix failures, such as decision making, analysis, information data, and possible gaps [10]. Potential gaps are overcome in the model matrix tree according to the defined and constructed logical connections including the return possibility If Yes, "then proceed to the next step or stage-gate, and If Not, "return to the designated step of the gate. The risk identification oversight model RIO includes a detailed evaluation of the possibilities of various failure events at each stage-gate step before proceeding to the task. Such gaps are filled with the precision of a well-defined support document; and based on one of the equations used in excel, the model can format and recheck the status of documents each time before it proceeds to the next step:

$$\begin{gathered} IF(OR(OR(\sum_{n=1}^{\infty} C_n = "X");OR(\sum_{n=1}^{\infty} D_n = "X");OR(\sum_{n=1}^{\infty} E_n = "X"); \\ IF(OR(OR(\sum_{n=1}^{\infty} C_n = "X");OR(\sum_{n=1}^{\infty} D_n = "X");OR(\sum_{n=1}^{\infty} E_n = "X"); \\ OR(\sum_{n=1}^{\infty} F_n = "X");OR(\sum_{n=1}^{\infty} G_n = "X");OR(\sum_{n=1}^{\infty} H_n = "X"); \\ );"Check\ data!";"Document\ OK\ \checkmark") \end{gathered} \tag{1}$$

The RIO model matrix tree follows a systematic logic technique, which attempts to see all possible outcomes of the possible gaps and all faults and to take the initiative [10]. The challenging part of the matrix is to foresee the impact of various potential events due to the complexity and uniqueness of most project targets where structured risk key owners enforce quality control correction before the document is applied to the model. The owner's possibility is to acknowledge the final document and to present the following outcomes through the model. The presented results or mitigation criteria are given to functional area managers (FAMs) or stakeholders for the final review and approval before any further steps are taken. Therefore, a possible fault is automatically mitigated since there are a few steps of quality control before the document is applied to the model. From the other point of view, the fault is mitigated by the involvement of functional area managers and their contribution to the mitigation selection and the possibility of decisions of where and when some of the steps need to be repeated to achieve realistic or correct results.

The main model breakdown of the risk management assessment and how the risks may be measured is given in [13]:

- In costs (budgetary risks)
- In time (delay risks for time management)
- Or quality (usually affecting contracts through the budgetary cost of improvement)

The focus of the paper is the time per given tasks and the delays. The model allows a (stage-gate) strategy for managing risk by selective elimination based on relevant available criteria (considering unforeseen events), considering objective probability.

This integrated approach and the final results show that the model generates systematic risk treatment as smoothly as possible, improves, and clearly indicates the sensitivity transformation parameters of the project time impacts. The paper does not deal with the impact of software solutions qualitatively in relation to quantitative, but only the quantitative approach is applied [19]. The expected results of the proposed approach will enable functional managers and clients to develop a project risk-based management function built on good practice, raising awareness of early risk detection [8].

The structure of the risk model matrix tree is explained and defined based on two main elements:

1. Methodological evaluation of factors that include a set of criteria for each step
2. The level of evaluation for each factor and its dimensions.

The presented model tree will have three main corrective groups:

- First group *: Systematic process map with stage gates one (1) through five (5)
- Second group **: Risk registration and control flow plan
- Third group ***: Risk documents and data with the applicable risk management existing tools

Each group of risk data files (***) must pass through the (**) risk registration and control flow plan before moving to the next step. The systematic process map (*) is developed in detail (each step has a note/task of explanations) to create more criteria for the decision of the flow plan (**) and supported by the risk data and the applied methods (***). At every step, risk documents will go through different risk data criteria sets. These documents aim to reduce the expansion of documentation and to make the existing documentation as simple and useful as possible. The advantage of the RIO model is that the tree is not significant and complicated, and it helps in visualizing the analysis, considering combinations of corrections, and determining occurrence probability for complex corrections. In the RIO, risk assessment is performed using quantitative methods, but also some aspects of qualitative methods, too.

Fig. 1 shows the stage-gate No. 1 and the first step in the risk management model process, where all stakeholders are involved from the beginning [14]. At this stage, all related project risks (known and unknown) are listed. Also, the historical documents of a previous project relevant to the scope it's included, as well. In stage-gate No. 1, risks are grouped by category, presenting the details of risks, the strategy of mitigation, the probability of occurrence, responsible individuals with their roles and responsibilities. Further down through the decision tree, risks are given a rating scale from the high-high to the low-low and categorized from the knowns, unknowns, and new risks. Costs are associated with each of the identified risks. At the end of the stage-gate No. 1, all risks are acknowledged by the stakeholders, with all the needed criteria that include the initial RWBS and schedule. Before any further step is taken, the owner of the risk assessment team confirms authorization towards the next stage gate.

Fig. 2 is the stage-gate No. 2, a step where only the unknown risks are treated. The stage-gate is developed based on certain flow steps with the possibility of checkpoints and corrections (workshops, decision tree analysis with an integrated approach, including brainstorming, checklist, probability impact matrices, objective judgment). A set of documents such as RWBS, RR, PI, AHP, FTA is prepared and implemented through the process [23]. The outcomes of the stage-gate No. 2 are: all identified risks at the end of the stage-gate are established as unknowns, including new risks that are selected as unknown and all applicable history unknown risks. The stage-gate provides the first summary of the unknowns results with the first estimated cost. At this stage-gate, all project unknowns are acknowledged.

Fig. 3 shows stage-gate No. 3, a step where only known risk is treated. The stage-gate is developed based on the firm flow steps with the possibility of checkpoints and corrections. A set of documents is introduced through a process that is almost identical to the stage-gate No. 2. The stage-gate outcome is: all new risks are selected as known, including all applicable history data of known risk [23]. At this stage-gate, all project knowns are acknowledged.

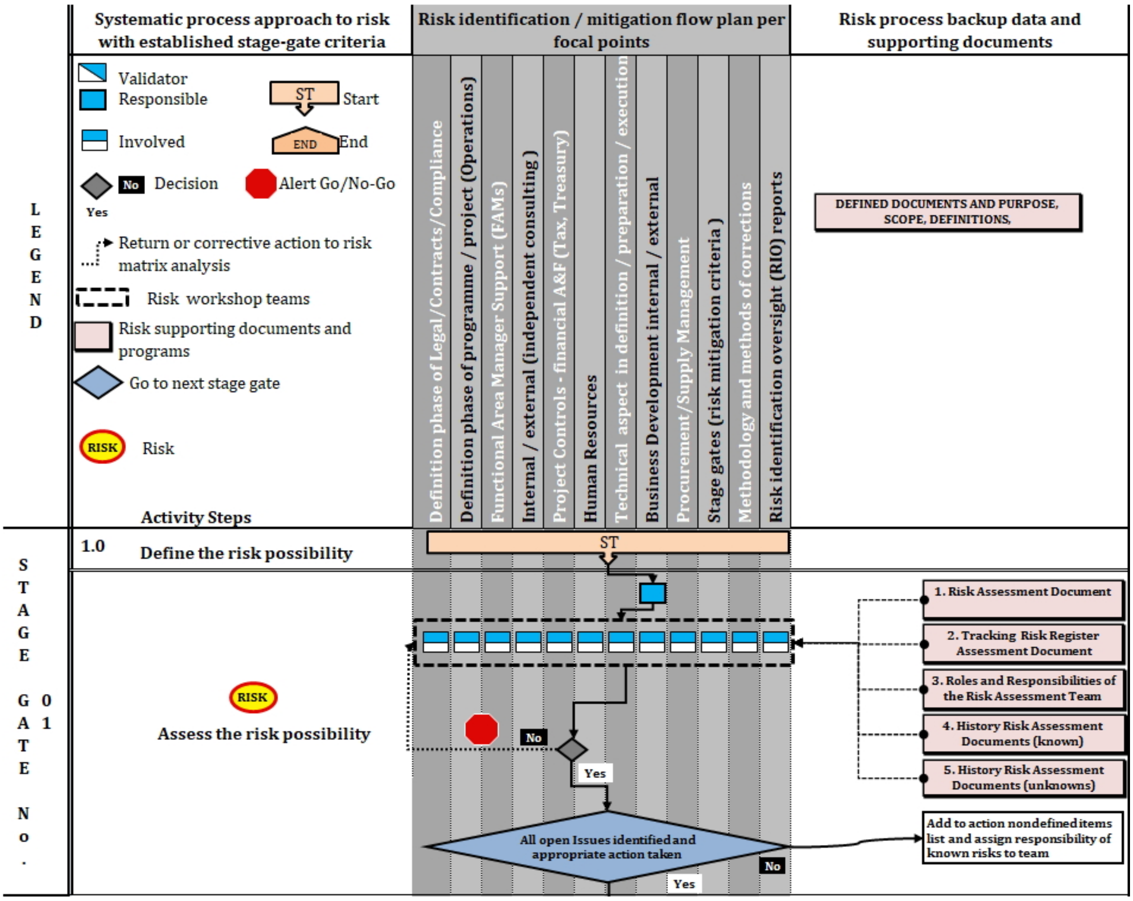

Fig. 1 Stage-gate matrix No. 1

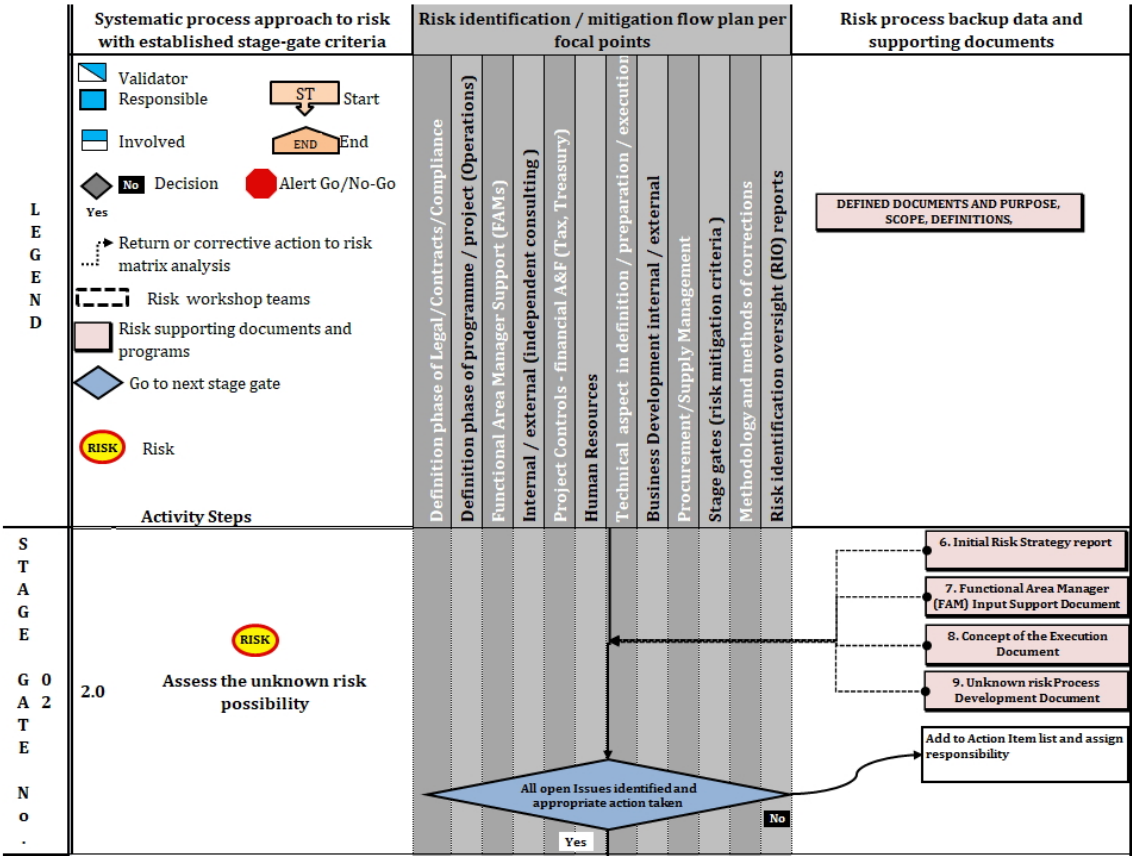

Fig. 2 Stage-gate matrix No. 2

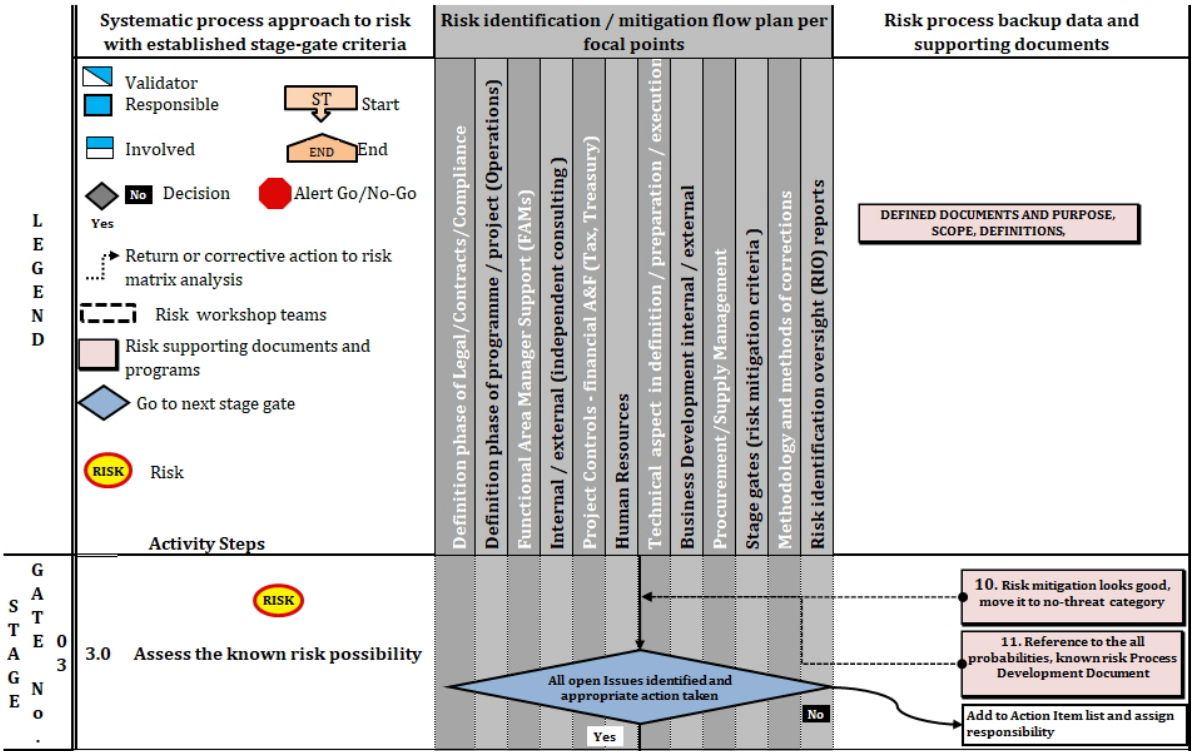

Fig. 3 Stage-gate matrix No. 3

Fig. 4 shows stage-gate No. 4, where all initial reports are obtained, and deeper systematization and synthesis of risk are acquired, the result of which is greater knowledge about the project. The proposed analysis of risk mitigation is focused on the initial WBS and the proposed schedule timelines. All possible deviation, exceptions, and impacts are explained. The link between any documents, but with the emphasis on documents related to scheduling, is achieved using the built-in excel functionality that automatically searches for the source of data needed and used in the current stage gate. Each time the document is currently in use, its opening will require an update. This is achieved using formulas "Formulas> Edit links." All major risk impacts reflecting the schedule are updated, and the first mitigation on all knowns and unknows is applied.

The formula for the validation of risks:

IF (AND(^="✓"), AND(NOT(^=""),NOT(^=""))),"OK","")

IF (AND(^="✓"), AND(NOT(^=""),NOT(^=""))),"OK","") (2)

where the ^ is the excel file cell location.

Risk exposure factor using unified formulas [33]:

$$E = P \cdot I \tag{3}$$

where E is risk exposure, P risk probability, and I risk impact.

Risk exposure factor and the risk mitigation cost using unified formulas [34, 35]:

$$E = P \cdot I \left(\frac{RV}{PSF/8}\right) \cdot IC \tag{4}$$

where RV is risk weight, IC initial cost, and PSF proportional scale factor.

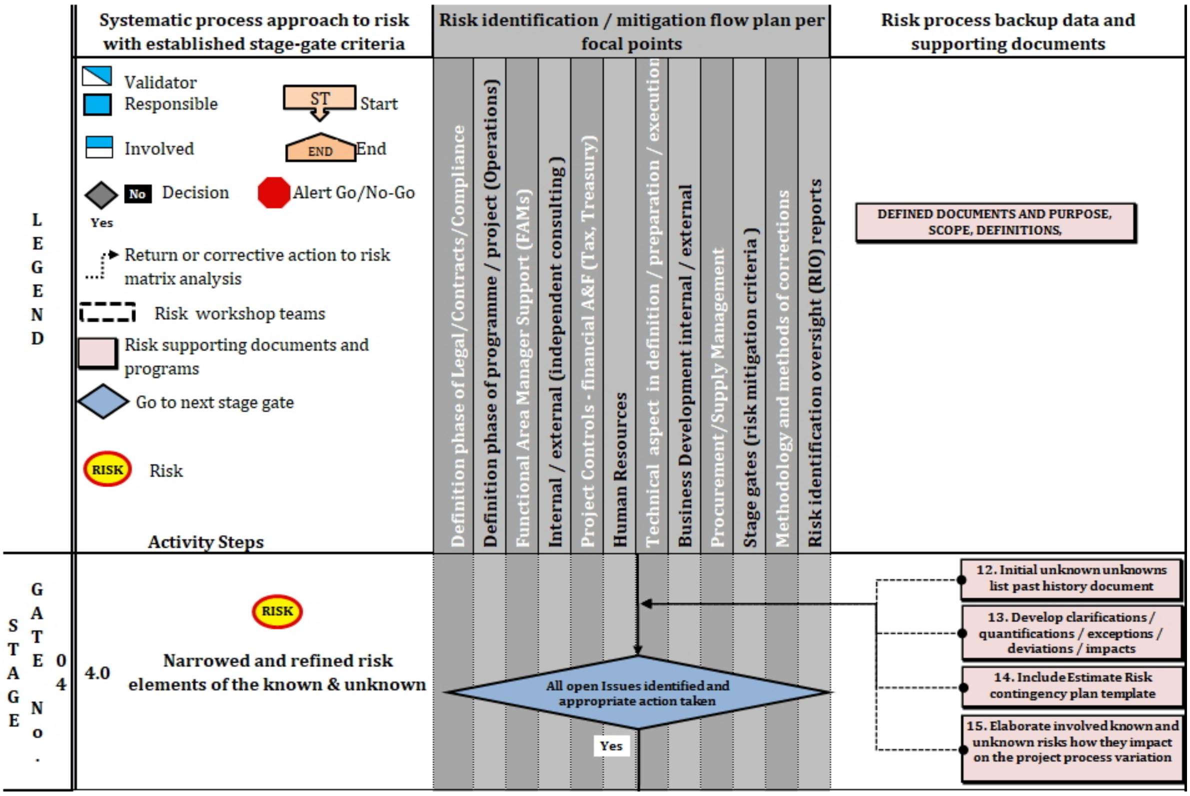

Fig. 4 Stage-gate matrix No. 4

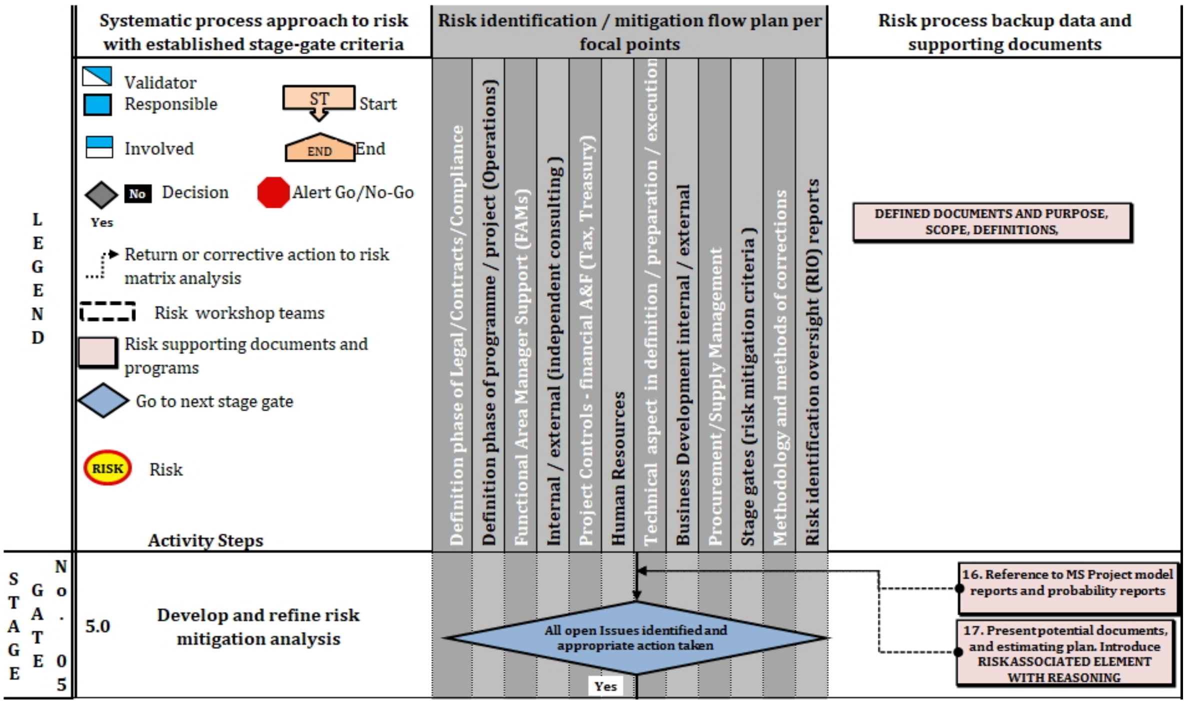

Fig. 5 Stage-gate matrix No. 5

Fig. 5 is stage-gate No. 5, where all data is obtained. The first set of results and reports is examined. The acknowledgment of risk mitigation is derived from the stakeholders, and further actions and analyses are proposed.

All known and unknown risk final impacts are highlighted through the continued workshops [32]. At this stage, the focus is on the high-risk mitigation/probability corrections and the effects on the schedule-timeline built from the initial work breakdown structure and schedule. All possible deviations are presented and explained. The selected risk volumes are moved from the work breakdown into schedule tool reports. At this stage, the results for the critical risks are confirmed with the data presented in Table 1 & Table 2 - Major risks for Project No. 1 & No. 2.

Fig. 6 shows stage-gate No. 6, where the results are combined, and all project-related risk results locked. At this stage, numerous reports are prepared, and data are archived and stored on the shared drive.

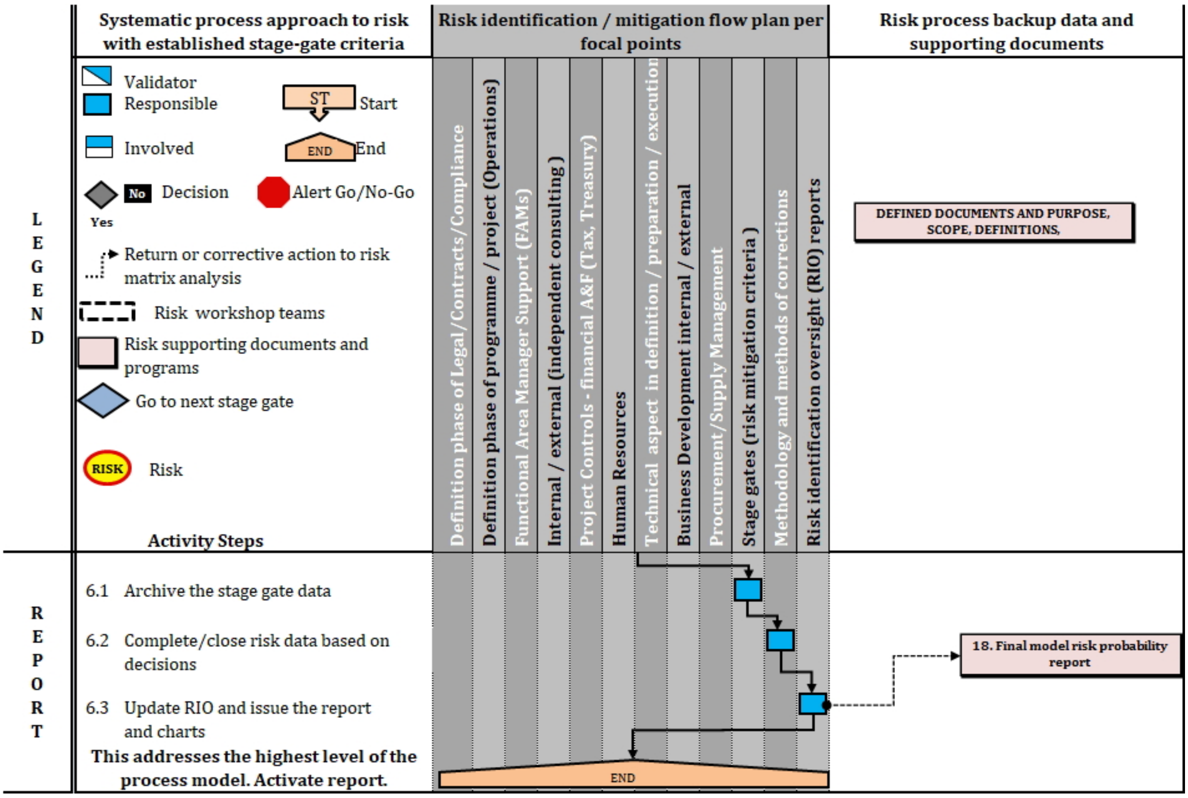

Fig. 6 Stage Gate Matrix No. 6

3. Case studies

3.1 Case study No. 1

Case study No. 1 is an industry project of a drilling platform reconstruction. The project consists of one hundred six scopes of work with the major reconstruction considering all relevant engineering disciplines. Project risk identification and assessment were performed through a set of documents such as RWBS, RR, PI, AHP, FTA, and integrated through the systematic process of the presented model [23, 31]. Starting with the initial three hundred two (302) identified risks, through data analyses, with the comparison of data which have been extracted from the existing history data file and processed through the matrix iterations and mitigation of changes, the final result was fifty-one (51) major selected risks. Fifty-one selected risks use the form of scheduling connection and the initial work breakdown structure (WBS), following the logic. All data is analyzed only concerning the schedule-timeline impacts. The presented changes use the embedded excel formula and pivot analysis of data on certain tasks in which changes occurred. Such a connection drives the preceding data to obtain the final excel table and graph views. As it can be seen in the column differences, going through the systematic model in the early project initiation phase, significant gaps regarding time durations can be observed.

Table 1 Major risks for the case study No. 1

Task ID No.	Description		Duration per tasks	
	Task	Baseline duration	Estimated duration	Difference in days
1	Painting specialist consulting	216	271	55
2	Painting specialist consulting WBS – Phase 1	62	57	-5
3	Painting specialist consulting WBS – Phase 2	62	50	-12
4	Painting specialist consulting WBS – Phase 3	62	56	-6
5	Procurement LLI	272	394	122
6	Procurement Other	142	432	290
7	Project team – mobilization	13	15	2
8	Legs scopes of work	171	201	30
9	Leg #3	171	202	31
10	Leg #2	144	159	15
11	Leg #1	144	142	-2
12	Main deck - steel renewal	129	208	79
13	Removal of areas & welding of new steel	89	80	-9
14	Removal of areas & welding of new steel Phase 1	27	15	-12
15	Removal of areas & welding of new steel Phase 2	29	21	-8
16	Removal of areas & welding of new steel Phase 3	31	22	-9
17	Preload tanks	98	143	45
18	Bow	70	86	16
19	Tank #1	54	82	28
20	Tank #2	58	83	25
21	Tank #3	64	86	22
22	STDB	71	90	19
23	Tank #13	64	86	22
24	Tank #17	69	93	24
25	Tank #12	72	72	0
26	Tank #14	74	63	-11
27	Cable trays & supports – renewal	93	85	-8
28	Refurbishment of cable trays and supports – phase 2	32	24	-8
29	Refurbishment of cable trays and supports – phase 3	23	15	-8
30	Helideck installation	77	36	-41
31	Marine equipment & systems	123	218	95
32	Jacking system	14	20	6
33	Preload system – piping & dump valves repair/replacement	98	139	41
34	Preload system – Phase 1	48	94	46
35	Preload system – Phase 2	49	40	-9
36	Drilling equipment & systems	114	151	37
37	Top drive – overhaul	85	72	-13
38	Top drive Trolley Beams	55	44	-11
39	Well testing lines – repair / replacement	18	11	-7
40	Mud pumps – overhaul	60	40	-20
41	Safety equipment & systems	124	137	13
42	Fast rescue boat – refurbishment	35	28	-7
43	Installation of new davits, lifeboat stations 3 & 4	50	35	-15
44	Fire alarm system upgrade	55	45	-10
45	Deck cranes	125	65	-60
46	STBD crane	41	31	-10
47	Aft crane	41	37	-4
48	Port crane	41	37	-4
49	MCC – upgrade	112	100	-12
50	Communications & data processing	86	259	173
51	TV system – 'receiver's replacement	14	12	-2

3.2 Case study No. 2

Case study No. 2 is an industry project of a drilling rig modernization. The project consists of forty-seven scopes of work with significant modernization considering all relevant engineering disciplines. Project risk identification and assessment were performed using the specific set of documents, as in case study No. 1, following the systematic model process [23, 31]. Starting with the initial two hundred fifty-two (252) identified risks, through data analyses, with the comparison of data which have been extracted from the existing history data file and processed through the matrix iterations and mitigation of changes, the result was thirty (32) major selected risks. Thirty introduced risks use a form of scheduling connection with a comparison of the initial WBS, and the analyzed results reflect only schedule-timeline impacts. The changes show differences in days between the initial estimation in the work breakdown structure WBS, then corrected based on the applied action of the model in the schedule, with an emphasis on durations with a negative impact, but in most cases with a positive impact on the scheduled durations. In every way, this corrective tool shows a realistic status of the planned activities.

Table 2 Major risks for the case study No. 2

Task ID No.	Description		Duration per tasks	
	Task	Baseline duration	Estimated duration	Difference in days
1	Project preparation phase	228	237	9
2	Wind wall	60	272	212
3	Triplex pumps	126	256	130
4	Third-party inspections	11	163	152
5	Substructure	61	118	57
6	R/U electrical power supply	167	121	-46
7	Procurement of rig	350	123	-227
8	Procurement of solids control equipment	160	193	33
9	Procurement of BOP control unit	276	209	-67
10	Procurement of BHA elements	226	117	-109
11	Outdoor high voltage and lighting system execution works	165	111	-54
12	Nested water tank manufacturing	140	184	44
13	MCC container manufacturing	144	113	-31
14	Mast and substructure	120	98	-22
15	Manufacturing of mud tank system	197	133	-64
16	Low pressure mud system	18	15	-3
17	Instrumentation system	95	-8	-103
18	Instrumentation and data system	130	55	-75
19	Install the HP lines & H. manifold	13	35	22
20	Hydraulic system modification	125	72	-53
21	High pressure mud system manufacturing	197	76	-121
22	Fuel tank system manufacturing	258	50	-208
23	Foldable mobile house manufacturing	114	85	-29
24	Finalize social & office containers.	81	86	5
25	Diesel supply system	114	13	-101
26	Caravan manufacturing	183	120	-63
27	BOP transport and testing skid	32	62	30
28	Air supply unit manufacturing	140	34	-106
29	Works prior to mast erection	13	74	61
30	Mast erection partial jobs	20	49	29

4. Results and discussion – Sensitivity transformation of the case studies

Lack of precision can lead to misleading conclusions. The RIO model excludes the possibility of precision errors. Therefore, if the risk assessment and treatments being taken in an inconsequential way by not following all predefined steps, it 'wouldn't be possible to treat the all-risk elements correctly through the RIO model process. In such a case that defined steps in the RIO model matrix have skipped the outcome of the results will lead to significant deviations. The RIO model sensitivity transformation clearly shows how much systematic approach is needed. In case that such inconsequential way is continued through the entire RIO model matrix, it will be evident misguidance of the data. By enabling a more accurate, systematic treatment of the risks input and output sizes by reducing all possible faults, additional extended learning and vast correction processes can be prevented. Based on that, the accuracy and sensitivity of the model are shown in Fig. 7 to Fig. 10.

Fig. Seven and Fig. 8 show the graph and the amplitudes of the deviations for Project No. 1 and Project No. 2. Graphs in Fig. 9 and Fig. 10 are linked with Table 1 and Table 2 – Major risks for Project No. 1 and 2, where:

- the blue line shows task durations after all five stage gates,
- the red line shows the estimated durations from the initial WBS and schedule,
- the green shows achieved differences in days per task after the RIO process has been applied.

The tables show the main tasks, initial duration based on the WBS, and then the corrected and estimated length based on the RIO model mitigation. Fig. Seven and Fig. 8 clearly show the positive and negative deviations that have a direct impact on the schedule. Based on the results, it is clearly demonstrated that in the early stage of the project definition, risk management has a significant correction impact.

To present one more evidence of how much a systematic risk management tool is needed, Fig. 9 and Fig. 10 show sensitivity graph amplitudes, where some of the steps in the RIO risk matrix decision tree were overlooked and neglected. This shows that the presented model has to follow a precise systematic way of the predefined three steps [15]. Performance cases for both of the projects are negative, or projects are underperformed based on the initially given objectives. If the problem is addressed trivially, by taking only a few significant risks out of the total number of risks, to show deviation in cases when some steps are skipped, it is not possible to treat risk through the process [15]. There is abundant evidence that the early systematic model is needed [9]. A comparison of the graphs for each of the projects clearly shows a significant negative impact and deviation on the project task durations.

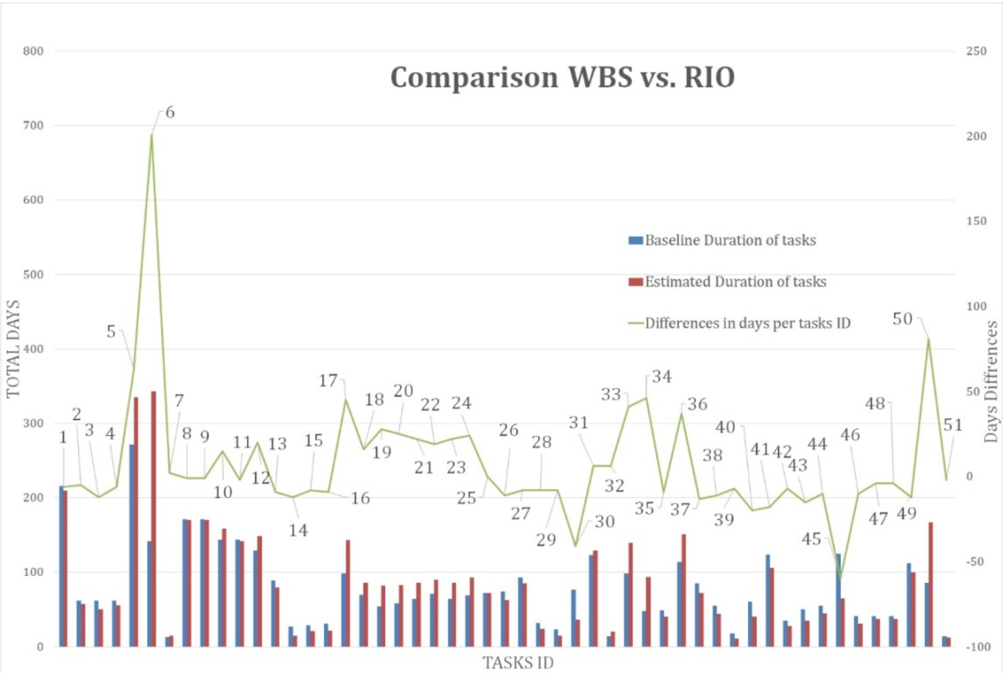

Fig. 7 Major risk deviations case study No. 1

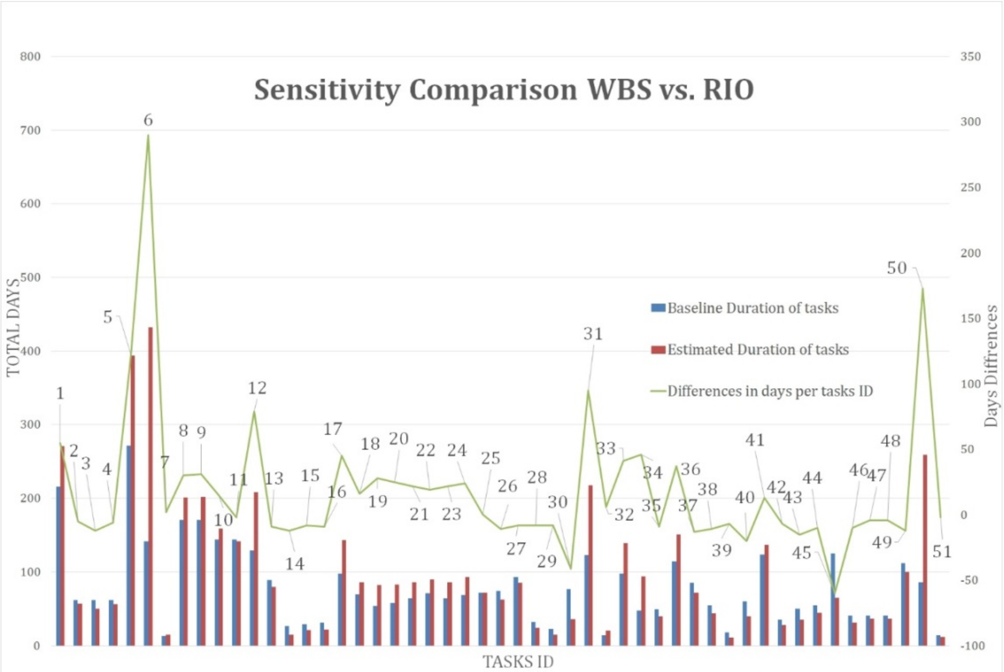

Fig. 8 Sensitivity of major risk deviations case study No. 1

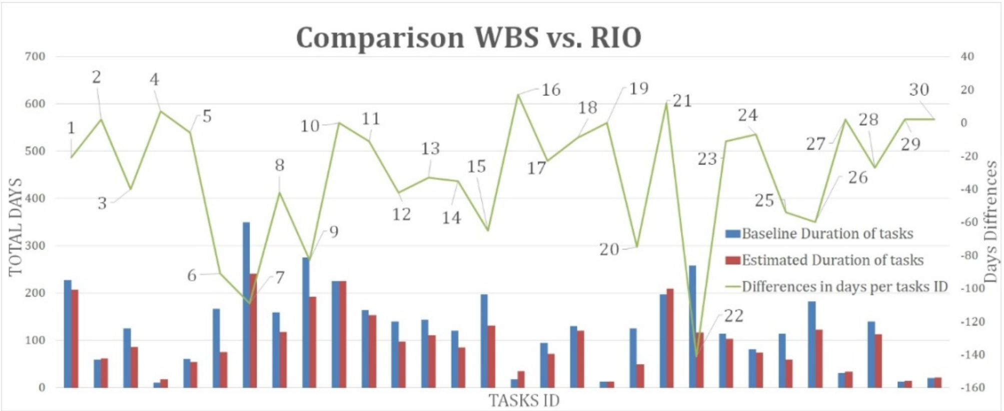

Fig. 9 Major risk deviations case study No. 2

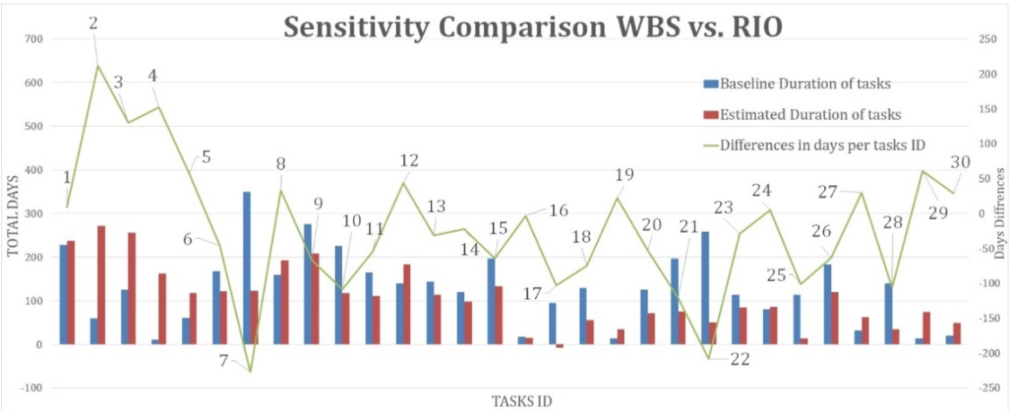

Fig. 10 Sensitivity of major risk deviations case study No. 2

5. Conclusion

Systematic risk management is an ongoing process that should be implemented through all phases of projects [12, 32]. Thus, the lack of systematic formality is an obstacle to successful project implementation. The objective of this paper was to examine the sensitivity of the systematic risk management model with the involvement of stakeholders throughout the entire risk management process [14, 22]. This paper represents the development of the systematic risk model with references, collaboration quantitative tools system, and the impact of the mentioned systematic system on resolving the gaps and faults and organizational performance, which is based on the model of risk management system success. The paper clearly outlines what is needed in the industry for project management companies to successfully measure the effects of risk threats in any industrial technology [12]. It clearly shows an increased awareness of the sensitivity tools where only a few missed steps can have significant deviations from the original objectives [20]. The sensitivity of results opens a new area of research, but also provides organizations with additional knowledge that needs to be addressed with a systematic definition of the effectiveness of the adopted or existing models. Also, new systematic sensitivity effectiveness improvement of the collaboration system is influenced by the quality of the system model, user-friendliness, end-user involvement, and results in benefits. The paper shows how successful awareness and risk perceptions are necessary to improve future project preparation and future execution. The model uses a mixed approach to data collection with common and acknowledged risk management processes, with the objective parameters in combination with the subjective attitudes of the involved stakeholders, which allows better use of the documents criteria in the model [13]. The model modifies and complements the existing tools of systematic risk success assessment – effectiveness in the context of the structured, systematic system and provides information regarding relations between the stakeholders [4]. With such a systematic approach with locked steps, involving stakeholders from the beginning of the process, and narrowing down their objectives, it is obvious that the major gaps are covered. This research shows that it represents a valid and reliable step towards improving the measurement of the early systematic risk mitigation systems. The main limitation of the study comes from the level of data that is available at an early stage. The second limitation of the tool is the mitigation strategies identified by the stakeholders to accept risks according to which level of activity risks are controllable per the model stage gates. From the academic point of view, the limitation comes from the fact that RIO tool practice is not widespread in other engineering industries with the applicability through the different sets of risk data assessments. The future study will be made in a way of a methodical web-based application that companies can use and access the web-based tool through servers. If there was a need for it, the application could be further developed.

References

[1] Karimi Azari, A.R., Mousavi, N., Mousavi, S.F., Hosseini, S.B. (2011). Risk assessment model selection in construction industry, *Expert Systems with Applications*, Vol. 38, No. 8, 9105-9111, doi: 10.1016/j.eswa.2010.12.110.

[2] Peckiene, A., Komarovska, A., Ustinovicius, L. (2013). Overview of risk allocation between construction parties, *Procedia Engineering,* Vol. 57, 889-894, doi: 10.1016/j.proeng.2013.04.113.

[3] Aleksić, A., Runić Ristić, M., Komatina, N., Tadić, D. (2019). Advanced risk assessment in reverse supply chain processes: A case study in Republic of Serbia, *Advances in Production Engineering & Management*, Vol. 14, No. 4, 421-434, doi: 10.14743/apem2019.4.338.

[4] Taillandier, F., Taillandier, P., Tepeli, E., Breysse, D., Mehdizadeh, R., Khartabil, F. (2015). A multi-agent model to manage risks in construction project (SMACC), *Automation in Construction*, Vol. 58, 1-18, doi: 10.1016/j.autcon.2015.06.005.

[5] Lu, S.-T., Kuo, Y.-C., Yu, S.-H. (2010). Risk assessment model for the railway reconstruction project in Taiwan, In: *Proceedings of 2010 International Conference on Machine Learning and Cybernetics*, Qingdao, China, 1017-1022, doi: 10.1109/ICMLC.2010.5580622.

[6] Osipova, E., Eriksson, E.P. (2013). Balancing control and flexibility in joint risk management: Lessons learned from two construction projects, *International Journal of Project Management,* Vol. 31, No. 3, 391-399, doi: 10.1016/j.ijproman.2012.09.007.

[7] Purnus, A., Bodea, C.-N. (2013). Considerations on project quantitative risk analysis, *Procedia-Social and Behavioral Sciences*, Vol. 74, 144-153, doi: 10.1016/j.sbspro.2013.03.031.

[8] Bodicha H.H. (2015). How to measure the effect of project risk management process on the success of construction projects: A critical literature review, *The International Journal of Business & Management*, Vol. 3, No. 12, 99-112.

[9] Kardes, I., Ozturk, A., Cavusgil, S.T., Cavusgil, E. (2013). Managing global megaprojects: Complexity and risk management, *International Business Review,* Vol. 22, No. 6, 905-917, doi: 10.1016/j.ibusrev.2013.01.003.

[10] Peixoto, J., Tereso, A., Fernandes, G., Almeida, R. (2014). Project risk management methodology: A case study of an electric energy organization, *Procedia Technology,* Vol. 16, 1096-1105, doi: 10.1016/j.protcy.2014.10.124.
[11] Project Management Institute (2011*). A guide to the project management body of knowledge (PMBOK Guide),* 5th edition, Project Management Institute, Newtown Square, Pennsylvania, USA.
[12] Yildiz, E.A., Dikmen, I., Birgonul, M.T., Ercoskun, K., Alten, S. (2014). A knowledge-based risk mapping tool for cost estimation of international construction projects, *Automation in Construction,* Vol, 43, 144-155. doi: 10.1016/j.autcon.2014.03.010.
[13] Benta, D., Podean, M., Mircean, C. (2011). On best practices for risk management in complex projects, *Informatica Economica,* Vol. 15, No. 2, 142-152.
[14] Todorović, M.L., Petrović, D.Č., Mihić, M.M., Obradović, V.L., Bushuyev, S.D. (2015). Project success analysis framework: A knowledge-based approach in project management, *International Journal of Project Management,* Vol. 33, No. 4, 772-783, doi: 10.1016/j.ijproman.2014.10.009.
[15] Dey, P.K., Kinch, J., Ogunlana, S.O. (2007). Managing risk in software development project: A case study*, Industrial Management & Data Systems,* Vol. 107, No. 2, 284-303, doi: 10.1108/02635570710723859.
[16] Porananond, D., Thawesaengskulthai, N. (2014). Risk management for new product development projects in food industry, *Journal of Engineering, Project, and Production Management*, Vol. 4, No. 2, 99-113, doi: 10.32738 /JEPPM.201407.0005.
[17] Baynal, K., Sarı, T., Akpınar, B. (2018). Risk management in automotive manufacturing process based on FMEA and grey relational analysis: A case study, *Advances in Production Engineering & Management*, Vol. 13, No. 1, 69-80, doi: 10.14743/apem2018.1.274.
[18] Dey, P.K. (2012). Project risk management using multiple criteria decision-making technique and decision tree analysis: A case study of Indian oil refinery, *Production Planning & Control*, Vol. 23, No. 12, 903-921, doi: 10.1080/09537287.2011.586379.
[19] Jun, L., Qiuzhen, W., Qingguo, M. (2011). The effects of project uncertainty and risk management on IS development project performance: A vendor perspective, *International Journal of Project Management,* Vol. 29, No. 7, 923-933, doi: 10.1016/j.ijproman.2010.11.002.
[20] Hassanien, S.S., Skow, J.B. (2012). Quantitative risk assessment for projects schedules, In: *Proceedings of the 9th International Pipeline Conference, Volume 1: Upstream Pipelines; Project Management; Design and Construction; Environment; Facilities Integrity Management; Operations and Maintenance; Pipeline Automation and Measurement,* Calgary, Canada, 61-67, doi: 10.1115/IPC2012-90548.
[21] Irizar, J., Wynn, M. (2014). Centricity in project risk management: Towards a conceptual framework for improved practice, In: *Proceedings of CENTRIC 2014: The Seventh International Conference on Advances in Human-oriented and Personalized Mechanisms, Technologies, and Services*, Nice, France, 83-88.
[22] de Carvalho, M.M., Rabechini, Jr.R. (2015). Impact of risk management on project performance: The importance of soft skills, *International Journal of Production Research,* Vol. 53*,* No. 2, 321-340, doi: 10.1080/00207543. 2014.919423.
[23] Burcar Dunović, I., Radujković, M., Vukomanović, M. (2013). Risk register development and implementation for construction projects, *Građevinar,* Vol. 65, No. 1, 23-35.
[24] Berg, H.-P. (2010). Risk management: Procedures, methods and experiences, *RT&A#2,* Vol. 1, No. 17, 79-95.
[25] Renuka, S.M., Umarani, C., Kamal, S. (2014). A review on critical risk factors in the life cycle of construction projects, *Journal of Civil Engineering Research*, Vol. 4, No. 2A, 31-36.
[26] Renault, Y.B., Agumba, J.N., Ansary, N. (2016). An assessment of enterprise risk management process in construction firms, In: *Proceedings of International Conference of Socio-economic Researchers ICSR,* Zlatibor, Serbia, 66-79.
[27] Janekova, J., Fabianova, J., Fabian, M. (2019). Assessment of economic efficiency and risk of the project using simulation, *International Journal of Simulation Modelling*, Vol. 18, No. 2, 242-253, doi: 10.2507/IJSIMM18(2)467.
[28] Yaraghi, N., Langhe, G.R. (2011). Critical success factors for risk management systems, *Journal of Risk Research*, Vol. 14, No. 5, 551-581, doi: 10.1080/13669877.2010.547253.
[29] Moreno, N., Salazar, F., Delgado, S. (2019). Comparative analysis of methodological trends in the management of software projects: Identification of the main variables, *Tehnički Vjesnik – Technical Gazette*, Vol. 26, No. 1, 80-86, doi: 10.17559/TV-20170824233730.
[30] Cagliano, A.C., Grimaldi, S., Rafele, C. (2015). Choosing project risk management techniques: A theoretical framework, *Journal of Risk Research,* Vol. 18, No. 2, 232-248, doi: 10.1080/13669877.2014.896398.
[31] Dey, P.K., Ogunlana, S.O. (2015). Selection and application of risk management tools and techniques for build operate transfer projects, *Industrial Management & Data Systems*, doi: 10.1108/02635570410530748.
[32] Goh, C.S., Abdul-Rahman, H., Abdul Samad, Z. (2013). Applying risk management workshop for a public construction project: Case study, *Journal of Construction Engineering and Management*, Vol. 139, No. 5, 572-580, doi: 10.1061/(ASCE)CO.1943-7862.0000599.
[33] Leopoulos, V.N., Kirytopoulos, K.A. (2004). Risk management: A competitive advantage in the purchasing function, *Production Planning & Control*, Vol. 15, No. 7, 678-687, doi: 10.1080/09537280412331298238.
[34] Roy G.G. (2004). A risk management framework for software engineering practice, In: *Proceedings of Australian Software Engineering Conference*, Melbourne, Australia, 60-67, doi: 10.1109/ASWEC.2004.1290458.
[35] Alberts, C.J. (2006). *Common Element of Risk, Technical Note CMU/SEI-2006-TN-014,* Software Engineering Institute, Carnegie Mellon University, Pittsburgh, USA, 1-26, doi: 10.1184/R1/6572627.v1.