ISSN 1330-3651 (Print), ISSN 1848-6339 (Online)
UDC/UDK 658.512.2.011.3:005.8

POTENTIAL RISKS AND THEIR ANALYSIS IN THE APPLICATION OF GEOGRAPHIC BASED ENGINEERING PROJECTS

Hikmet Erbıyık, Eray Can, Şenol Kuşçu

Original scientific paper
Numerous different problems can be encountered either on project linked data or on the design works that are generated on the basis of these data during the realization of geographic based engineering projects (GBEP). Among the failures in this regard are failures originating from the horizontal and vertical position relevant design and implementation for the realized GBEP, failures relevant to project due to insufficient definition of land usage suitability, stability problems that are relevant to the implementation field of the Project, etc. For the solution of these problems it is essential to carry out necessary geometric controls at each stage of these projects, as well as to do risk management in an appropriate way for the basic elements that are causing these problems. In our article, it is attempted to analyze these potential failures and risks with Failure Mode Effect Analysis method and Pareto Charts.

Keywords: *engineering measurements, Failure Mode Effect Analysis (FMEA), Geographic Based Engineering Projects (GBEP), Pareto charts, risk management*

Mogući rizici i njihova analiza u primjeni geografski temeljenih tehničkih problema

Izvorni znanstveni članak
Mnogo je različitih problema na koje se može naići kod podataka vezanih uz projekte ili uz projektne radove nastale na osnovu tih podataka tijekom realizacije geografski utemeljenih tehničkih projekata (GBEP). Među takvim greškama su greške nastale zbog projekata vezanih uz horizontalan ili vertikalan položaj i implementaciju GBEPa, greške zbog nezadovoljavajuće definicije o odgovarajućem korištenju zemljišta, problema stabilnosti vezanih uz područje implementacije projekta itd. Kako bi se ovi problemi riješili bitno je provesti odgovarajuće geometrijske provjere na svakom stadiju projekata kao i analizu i upravljanje rizicima osnovnih elemenata koji dovode do tih problema. U našem se članku te potencijalne greške i rizici pokušavaju analizirati metodom analize utjecaja posljedica kvara (FMEA) i Pareto tablicama.

Ključne riječi: *analiza utjecaja posljedica kvara (FMEA), geografski temeljeni tehnički projekti (GBEP), Pareto tablice, tehnička mjerenja, upravljanje rizicima*

1 Introduction

Generally, most important part of the information, document and data that will form the geographic based engineering projects, consists of location, form, dimension etc. geometric features of the land based projects on the earth and underground [4, 5]. However, some other parts of these features are relevant to the design criteria of the land based projects, namely, land related topographic, geologic, geotechnical, etc. data that are obtained from the limited numbers of the measurements and observations. It is also apparent that many points of the land have different natural and geomorphologic features and the design works that are carried out upon the design input that consists of limited numbers of relevant data, may not always be compatible with the natural or even cultural structure of the concerned land. For that reason, in the realization of this type of geographic based engineering projects, it is essential to consider controlling the suitability of the natural and cultural features of the land of the implemented project regularly and to carry out relevant risk analysis alongside with the compliance to the Project [2, 5, 7, 9]. After these controls and Failure Mode Effect Analysis (FMEA), it is quite important to try to improve the intended suitability on every stage of the project, furthermore it could be even inevitable for the coherent progress of the project. As the result of the geographic based project implementation processes during project realization, for example, in case when a non-conformity is encountered with regard to highway or railway crossing or construction and if it is found as incompatible with the real topographic and/or geologic structure of the land, then further revisions and precautions have to be made for bringing the project in a more applicable state with regard to the results of risk analysis and controls [12, 13, 14]. These types of problem cases will necessitate the typical application of the FMEA methodology. The construction sites that are the implementation fields of the geographic based engineering projects (GBEP) are such locations that have the inter-related activities. Hence the expected solutions are obtained with systematic multi-disciplined team works [15]. As far as we are concerned with the team works over geographic based engineering projects, (GBEP) proper realization of the project as in compliance with location, dimension, and form, will depend on the land topography, ownership, over ground and under ground land usage properties. Failure Mode Effect Analysis (FMEA) studies will be made in this regard as in line with the surveying and other geographic based engineering. Team work and discipline in surveying and other geographic based engineering will be critical issue in utilizing FMEA projects.

2 Failure Mode Effect Analyses (FMEA)

This type of risk analysis method is utilized to detect the failures or defects in the implemented projects before they turn into a hazardous state, and to identify and control the priorities in remedying the failure problems and to eliminate the potential failures and risks before they happen [1, 8]. In addition to the other risk analysis methods, FMEA enables us to detect and evaluate the hazards and accidents in advance. Failure Mode Effect Analysis (FMEA) has a wide range of usage field; it is also a strong analysis technique toward preventing the failures by estimating the relevant risks [3, 8, 11]. This technique can both be utilized during the design review stages of the project and in implementation and installation stage. However it is more appropriate to use the technique in design review stages because reduction of relevant costs of the resources for corrections/revisions of potential failures can be made most effectively in design review stages when comparing the whole implementation period. The intended precautions as the result of the FMEA studies can only be achieved with the least cost at design review stage. The corrections/ revisions that are made in the post design period could cause multi fold increase in the cost. To use detectability factor alongside the probability and severity factors in the method shows an important aspect of the system. In the Failure Mode Effect Analysis (FMEA) study, estimations of probability, severity and detectability are made for all defined potential failures and defects. At the end of these estimations, relevant solutions are searched by giving priority to the relatively bigger risks. The advantages of the system are given below:

- To improve the quality, reliability, and safety of the product or project.
- To enhance the customer satisfaction.
- To reduce the product or project development period and cost.
- To ascertain the priorities in design or process development activities.
- To discover the whole potential failures modes, their effects and similarities for all products/processes.
- To assist in analysis of the design requirements and design alternatives.
- To assist in definition of potential, critical and important characteristics.
- To assist in analysis of new production or project stages.
- To maintain important media for failure prevention.
- To enable the definition of corrective & preventive actions.
- To certify and monitor the risk reducing activities, etc.

3 Failure Mode Effect Analysis (FMEA) Elements and Calculation Method

In FMEA studies, a suitable work team has to be assigned in accordance with the selected project because the definition of the problems and risk priority values in the studied project requires qualified personnel as well as knowledge and experience. At the same time, the work team has to consist of selected personnel having different job profiles and from different departments. The personnel that takes part in the FMEA team, has to possess sufficient competencies to carry out FMEA activities effectively. During Project design stages, the defects and failures that are taken into consideration are handled within a unique system and Formula. However, to define the priorities of risks and failures in this analysis, there are 3 basic elements. These are cited as: **Occurrence, Severity** and **Detection** [1, 3, 8, 16]. Among these elements, occurrence shows the existence probability, defect frequency, severity or weight, indicates the seriousness (effect) of the failure-defect. Detectability means the level of difficulty in detecting the failure. However, the detectability element is also important due to its advantage in representing the failure's definition before happening. There are many methods for defining the values of these elements. However the customary way is to use numerical calculation tables (risk value tables). When the above mentioned three risk factor elements are assessed altogether, it represents the risk priority level (*RPL*) for each failure-defect type. And this value defines the numerical level of critical risk [8, 10]. In calculation of risk priority level (*RPL*), the assigned values of risk factors are taken, that remain in a certain numerical range. While the risks are defined for each failure type starting from the biggest risk priority level (*RPL*), the intention is to reduce this risk level to an acceptable lowest level for a short term. On the other hand over the long term for eliminating these risks the relevant and suitable corrective actions are intended. Risk priority levels (*RPL*) for FMEA are calculated by multiplying the Occurrence (*O*), Severity (*A*), and Detectability (*S*) levels [1, 3, 10, 16].

$$RPL = O \cdot A \cdot S. \tag{1}$$

The reference selection tables are given below for calculating the Risk priority levels (*RPL*). Tab. 1 shows the Occurrence level and frequency *O* (Occurrence) of concerned failure-defects encountered in the projects.

Table 1 Occurrence level and frequency, *O* (Occurrence) [1, 10, 16]

Occurrence level of failure	Failure occurrence level	Frequency rating
Very High-Inevitable	½ 'more than	10
	1/3	9
High-Recurring Failure	1/8	8
	1/20	7
Medium-Rarely Failure	1/80	6
	1/400	5
Low-Relatively low failure	1/2000	4
	1/15000	3
Very low-Less likely failure	1/150000	2
	1/150000 'more less	1

Tab. 2 shows classification of weight or severity levels effect (*A*), in calculating Risk priority levels (*RPL*). Tab. 3 shows the detectability level (*S*), Tab. 4 shows Risk priority levels (*RPL*). Risk priority levels (*RPL*) provide the definition of failures to be given priority in failure improvement studies by making priority rating. Risk priority levels (*RPL*), while enabling the priority rating of failures, provide a useful guidance for the relevant people who take part in the post assessment FMEA analysis, *RPL* values improvement studies.

Table 2 Classification of weight or severity levels effect (*A*) [1]

Effect	Effect of weight-severity	Severity rating
High Level Hazard coming without notice	Error having the potentially catastrophic impact, and without notice.	10
Hazard coming without notice	Error having the potential damage with high-impact, and without notice.	9

Table 2 Classification of weight or severity levels effect (*A*) [1] (Continuation)

Effect	Effect of weight-severity	Severity rating
Very High	The type of error with detrimental effect that allows the entire system to have a complete damage that can result in serious injury.	8
High	The type of error which causes damage to the entire equipment, has fatal impact leading to death, poisoning, 3rd degree burns, acute death, and so on.	7
Medium	The type of error that affects the performance of the system and leads to the loss of limb or organ, severe injury, cancer and so on.	6
Low	The type of error that can lead to fracture, permanent small unfitness, 2nd degree burns, concussion and so on.	5
Very Low	The type of error that influences injury, minor cuts and abrasions, bruises, and so on and causes minor injuries to the short-term disturbances.	4
Small	The type of error that slows down the operation of the system.	3
Very Small	The type of error that may cause confusion in the operation of the system.	2
No effect	Without effect.	1

Table 3 Detectability level (*S*) in calculating the risk priority level (*RPL*), [1]

Detectability	Probability of Detectability	Rating
Imperceptible	Detectability of potential cause of failure and the following failure is not possible	10
Very far	Detectability of potential cause of failure and the following failure is very far	9
Far	Detectability of potential cause of failure and the following failure is far	8
Very low	Detectability of potential cause of failure and the following failure is very low	7
Low	Detectability of potential cause of failure and the following failure is low	6
Medium	Detectability of potential cause of failure and the following failure is medium	5
Above medium	Detectability of potential cause of failure and the following failure is above medium	4
High	Detectability of potential cause of failure and the following failure is high	3
Very high	Detectability of potential cause of failure and the following failure is very high	2
Nearly sure	Detectability of potential cause of failure and the following failure is for sure	1

Table 4 Risk priority levels (*RPL*) [1]

Risk priority levels (*RPL*)	Precaution
$RPL < 40$	No need to take action.
$40 \leq RPL \leq 100$	Medium risk measures can be taken.
$RPL > 100$	Caution needs to be taken, high-risk.

4 Calculation of Risk Priority Levels (*RPL*) and FMEA Implementation in Geographic Based Engineering Projects (GBEP)

It is essential to do the geometric, positional, geologic, geotechnical, geomorphologic, etc. controls on every stage of geographic based engineering projects, for the solution of potential risks and problems to be encountered at design review and implementation of GBEP.

In addition to this fact, a systematic risk management has to be made as well, for the factors that cause these problems or failures. This analysis and controls will enable the smooth progress of applied geography-based projects while providing a healthy way for the future projects to be designed on a more solid foundation.

Tab. 5 provides a comprehensive analysis of potential risks and failures to be encountered during the geography-based projects implementation and on the relevant engineering measurements for these projects, calculating by Failure Mode Effect Analysis method (FMEA) and in accordance with experience from Risk Priority Levels (*RPL*) tables.

In this table (Tab. 5), 12 control issues that may cause risk factors are considered during the construction of geography-based engineering projects. Among these 12 control issues that may cause risk factors 6 are found as high risk level and the remaining 6 are determined as medium risk level.

The suggested precautions that are to be considered for reducing the high and medium risk values that are defined by giving reference in the implemented FMEA. Risk Priority Level values are intended to be reduced provided that relevant precautions defined in the FMEA are taken properly at relevant geography-based engineering projects. Thus, it is aimed that high and medium level risks are eliminated for the sake of progress of the Projects in a healthy way. In addition to the Failure Mode Effect Analysis, the Pareto Analysis is also utilized aiming to 75 ÷ 80 % critical threshold risk value.

Table 5 Comprehensive Analysis of Potential Risks and Failures to be Encountered During the Geography-Based Projects Implementation [6, 18, 19]

Process No	FMEA ANALYSIS FORM IN IMPLEMENTATION OF GEOGRAPHIC BASED ENGINEERING PROJECTS			Döküman adı:FMEA FORM Tarihİ : 2013 REV:0
	RPL=OCCURRANCExSEVERITYxDETECTIBILITY			
	OCCURRANCE	SEVERITY	DETECTIBILITY	RPL VALUE (Risk Priority Level)
	1-2 Very Low	1-2 No effect or slightly	1. Sure 2.Very High	RPL<40 No need to take precaution LOW RISK
	3-4 Low	3-4 Slightly	3. High 4. Above Average	40≤ RPL ≤100 Caution can be taken MEDIUM RISK
	5-6 medium	5-6 Medium	5. Medium 6.Low Level	RPL >100 Caution must be taken. HIGH RISK
	7-8 High	7-8 Serious	7. Very Low 8. Little	
	9-10 Very High	9-10 Very serious	9.Very Little 10. Undetectible	

Process No	POTENTIAL CAUSES OF FAILURE			RISK EVALUATION					PRECAUTION ACTIVITY	RESPONSIBILITY	RISK EVALUATION				
	Failure	Limit	Reference	Occurrance	Severity	Detectibility	R.P.L	Importance			Occurrance	Severity	Detectibility	R.P.L	Importance
10	The errors, arising from the vertical and horizontal position, the size and geometry of the design and implementation issues of the realized Project	Item 10-43 Geodetic studies Item 44-50 detailed measurements	Large Scale Map and Map Information Production Regulation	6	9	5	270	UNACCEPTABLE HIGH RISK	If exceeds the tolerance limits prescribed in regulations, special and technical specifications, then relevant corrections and corrective actions are made in accordance in the relevant regulations, special and technical specifications.	Design and construction of the project team (project manager, surveying and / or civil engineers	2	4	3	24	LOW RISK
20	The errors and failures, arising from the lack of proper definition of the land topograhy and land usage appropriateness for the concerned Project.	Item 10-43 Geodetic studies Item 44-50 detailed measurements Item 83 Application works	Large Scale Map and Map Information Production Regulation	6	8	5	240	UNACCEPTABLE HIGH RISK	It is attempted to place in right positon in accordance with the present and possible conditions of the project by consideration of the terrain geometry and the topographic structure of the land.Operation is performed according to the laws and regulations when it comes to the expropriation of private property.	Design and construction of the project team (project manager, surveying and / or civil engineers	3	3	3	27	LOW RISK
30	The errors and failures, arising from lack of control on the stability and landslide control issues for implemented area of the Project.	Item 10-43 Geodetic studies	Large Scale Map and Map Information Production Regulation	5	7	4	140	UNACCEPTABLE HIGH RISK	Any possible difference is evaluated in the horizontal and vertical positions by geodetic measurement and observations. And due progress is continued for geographic base project upon evaluated results. If any difference in positions is detected, improvement actions are taken toward effective solution of the project. Ref: ISO 9001:2008 ,	Design and construction of the project team (project manager, surveying and / or civil engineers	3	3	2	18	LOW RISK
40	The errors and failures, arising from the lack of controls for appropriateness of the land for the concerned project in terms of geological and geotechnical suitability.		Development plans based on geological and geotechnical surveys regulations	6	9	5	270	UNACCEPTABLE HIGH RISK	If there is a mismatch in the field, with reference to the relevant regulations to be applied to the project in terms of geological and geotechnical characteristics necessary changes should be made	Design and construction of the project team (project manager, surveying and / or civil, gelogical engineers	3	4	2	24	LOW RISK
50	The errors and failures, arising from lack of estimation of expected or probable realization period of Project mile Stones.		Relevant Project technical and administrative specifications.	5	5	4	100	MEDIUM RISK	Force main and sub-programs of work on this issue in accordance with regulations to be revised according to the actual situation and the reasons for the deviation (material supply delays, unexpected weather conditions, delays that occur in the differentiation of financial resources) must be investigated and resolved.	Design and construction of the project team (project manager, surveying and / or civil engineers	3	3	3	27	LOW RISK
60	The errors and failures, arising from deviation from technical specs. and standards relevant to implementation of realized geography based project.	The deviations from the basic criteria listed in sections and appendices	Large Scale Map and Map Information Production Regulation	5	5	3	75	MEDIUM RISK	Posible errors in the work due to deviations from applicable standards have to be considered, failure rates to be defined, due complaince with the relevant standards to be maintained. Ref: ISO 9001:2008 , item 8.3 and 8.5.2, 8.5.3	Design and construction of the project team (project manager, surveying and / or civil engineers	3	3	2	18	LOW RISK
70	The errors and failures, arising from failure to proper planning for realized incoms (progress revenue, production...) and consumptions (manpower, material,tools and equipment...) in implementation		Relevant Project technical and administrative specifications.	6	5	3	90	MEDIUM RISK	Initial project specification, to be examined carefully and possible errors in the labor, materials, tools, planning ..etc are eliminated or reduced. In practice, short periods of sub-programs of work (in 3 months) needs to be revised.	Design and construction of the project team (project manager, surveying and / or civil engineers	3	3	2	18	LOW RISK
80	The errors and failures, arising from failure to calibrate the measuring equipment used in geographic-based projects.		Large Scale Map and Map Information Production Regulation	5	7	5	175	UNACCEPTABLE HIGH RISK	Control and Measurement equipment used for measurements related to the project must be calibrated by the accredited laboratories quite meticulously. Plan is prepared for the annual calibration of all measuring instruments and equipment calibrations carried out during the year by observing the time the plan..: REF:MEASUREMENT AND MONITORING EQUIPMENT CONTROL AND CALIBRATION, ISO 9001:2008 ıtem7.6	Design and construction of the project team (project manager, surveying and / or civil engineers	3	2	2	12	LOW RISK
90	The errors and failures, arising from formation of project organizational structure.		Relevant Project technical and administrative specifications.	5	5	3	75	MEDIUM RISK	Attachments are likely to be examined carefully in the initial project specification and organizational errors are prevented and according to the differences of plans and programs relevant revisions are made. Organization Chart is formed in accordance with the organizational structure of the project in organization chart, the responsibilities and role definitions of the personnel that take part in the project is taken into account. Relevant competency profiles to be defined and documented. REF:ISO 9001:2008 , Item 4.4.1	Design and construction of the project team (project manager, surveying and / or civil engineers	3	2	2	12	LOW RISK
100	The errors and failures, arising from failure to comply with laws and regulations concerning Occupational health and safety issues		New occupational health and safety law (number 6331 dated 20/06/2012) occupational health and safety regulations	7	8	4	224	UNACCEPTABLE HIGH RISK	1) Relevant national and international legislation are determined and documented for geographical based projects. 2) Sequential and detailed risk assessments are made with regard to project progress stages. risk evaluation grid-matrix is created. 3) Relevant actions determined and taken to reduce identified risks according to the level of risk toward solution of the problem. 4) Occupational health and safety (OHSAS MS) processes are realized for the effective implementation and continuous improvement of the project and to achieve this goal OHSAS MS performans targets are observed (accident frequency rate, accident, severity rate, case frequency rate, the periodic number of near misses, the costs associated with OHSAS MS ISG) REFERANS: OHSAS 18001:2007, Items; 4.3.1; 4.3.2; 4.3.3,.....item 4.5.2; 4.5.3	Design and construction of the project team (project manager, surveying and / or civil engineers	2	3	3	18	LOW RISK
110	The errors and failures, arising from failure to proper control of efficiency of manpower and equipment		Relevant Project technical and administrative specifications.	5	5	3	75	MEDIUM RISK	The reasons for the redundancy or deficiencies are investigated, and assessments realized that required by the relevant regulations. An inventory for the workforce and of the equipment must be recorded regularly. Annual Maintenance plan for machine equipment and instruments must be documented, (Planned maintenance, predictive maintenance), OEE (Overall equipment efficiency monitoring system was created and manpower and equipment efficiency losses eliminatedREF: ISO 9001:2008 , Item 6.3	Design and construction of the project team (project manager, surveying and / or civil engineers	2	3	3	18	LOW RISK
120	The errors and failures, arising from endured financial losses due to delay in approved job orders.		Relevant Project technical and administrative specifications.	5	4	3	60	MEDIUM RISK	Emerging communication disorders should be eliminated by the project management team. Effective communication between the interested parties must be maintained in the project. REF: ISO 9001:2008 item 5.5.3,7.2.3,OHSAS (OCCUPATİONAL HEALTH AND SAFETY MANAGEMENT SYSTEM 18001:2007 item:4.4.3	Design and construction of the project team (project manager, surveying and / or civil engineers	2	2	3	12	LOW RISK

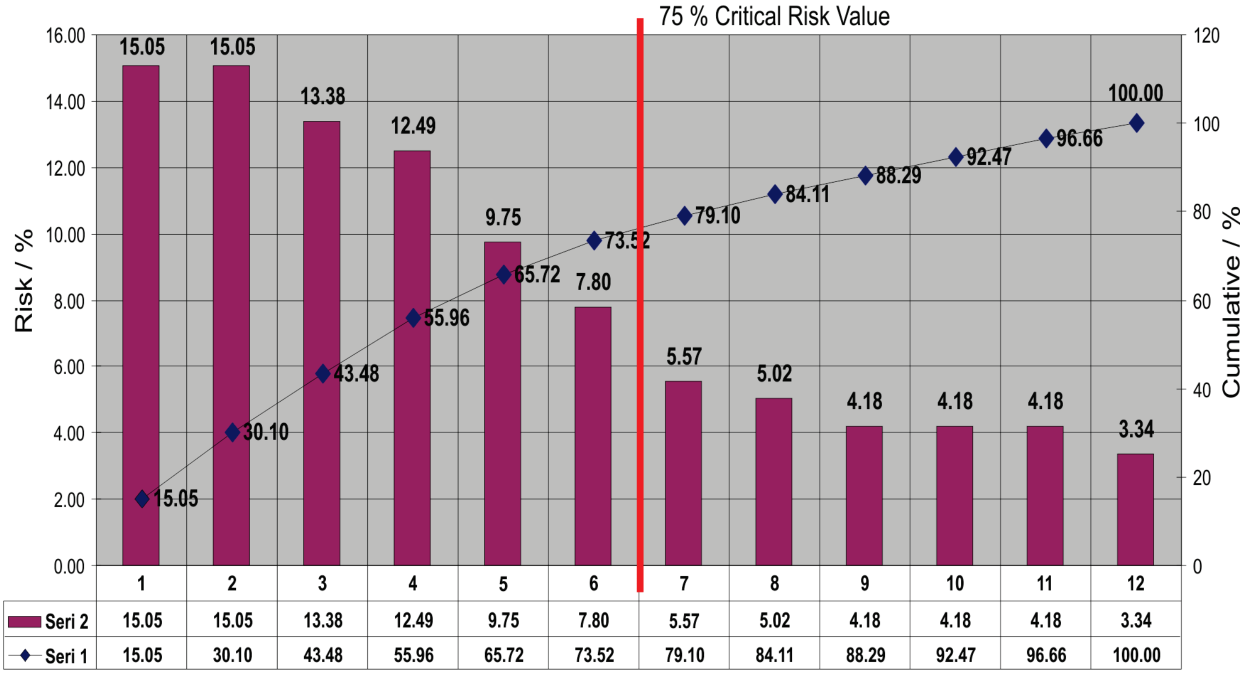

Figure 1 Pareto diagram resulting after Pareto Analysis Data Evaluation

Table 6 Designed Pareto Analysis in Geographic-Based Engineering Projects (GBEP)

PARETO CHART IN GEOGRAPHICAL BASED PROJECTS						
Sequence No	Failure mode	Process No	*RPL** Value	Risk / %	Cumulative risk / %	Risk state
1	The errors, arising from the vertical and horizontal position, the size and geometry of the design and implementation issues of the realized Project.	10	270	15,05	15,05	UNACCEPTABLE HIGH RISK
2	The errors and failures, arising from the lack of controls for appropriateness of the land for the concerned project in terms of geological and geotechnical suitability.	40	270	15,05	30,10	UNACCEPTABLE HIGH RISK
3	The errors and failures, arising from the lack of proper definition of the land topography and land usage appropriateness for the concerned Project.	20	240	13,38	43,48	UNACCEPTABLE HIGH RISK
4	The errors and failures, arising from failure to comply with laws and regulations concerning Occupational health and safety issues.	100	224	12,49	55,96	UNACCEPTABLE HIGH RISK
5	The errors and failures, arising from failure to calibrate the measuring equipment used in geographic-based projects.	80	175	9,75	65,72	UNACCEPTABLE HIGH RISK
6	The errors and failures, arising from lack of control on the stability and landslide control issues for implemented area of the Project.	30	140	7,80	73,52	UNACCEPTABLE HIGH RISK
7	The errors and failures, arising from lack of estimation of expected or probable realization period of Project mile Stones.	50	100	5,57	79,10	MEDIUM RISK
8	The errors and failures, arising from failure to proper planning for realized incomes (progress revenue, production…) and consumptions (manpower, material, tools and equipment...) in implementation.	70	90	5,02	84,11	MEDIUM RISK
9	The errors and failures, arising from failure to proper control efficiency of manpower and equipment.	110	75	4,18	88,29	MEDIUM RISK
10	The errors and failures, arising from deviation from technical specifications and standards relevant to implementation of realized geography based project.	60	75	4,18	92,47	MEDIUM RISK
11	The errors and failures, arising from formation of project organizational structure.	90	75	4,18	96,66	MEDIUM RISK
12	The errors and failures, arising from endured financial losses due to delay in approved job orders.	120	60	3,34	100,00	MEDIUM RISK

RPL VALUE*- Risk Priority Level Value

Table 7 Components of High Risk Error by 75 % Threshold Value of the Risks in the generated Pareto Chart

PARETO CHART IN GEOGRAPHIC BASED PROJECTS (HIGH RISKS)						
Sequence No	Failure mode	Process No	*RPL** Value	Risk / %	Cumulative risk / %	Risk state
1	The errors, arising from the vertical and horizontal position, the size and geometry of the design and implementation issues of the realized Project	10	270	20,47	20,47	UNACCEPTABLE HIGH RISK
2	The errors and failures, arising from the lack of controls for appropriateness of the land for the concerned project in terms of geological and geotechnical suitability.	40	270	20,47	40,94	UNACCEPTABLE HIGH RISK
3	The errors and failures, arising from the lack of proper definition of the land topography and land usage appropriateness for the concerned Project.	20	240	18,20	59,14	UNACCEPTABLE HIGH RISK
4	The errors and failures, arising from failure to comply with laws and regulations concerning Occupational health and safety issues.	100	224	16,98	76,12	UNACCEPTABLE HIGH RISK
5	The errors and failures, arising from failure to calibrate the measuring equipment used in geographic-based projects.	80	175	13,27	89,39	UNACCEPTABLE HIGH RISK
6	The errors and failures, arising from lack of control on the stability and landslide control issues for implemented area of the Project.	30	140	10,61	100,00	UNACCEPTABLE HIGH RISK

RPL VALUE*- Risk Priority Level Value

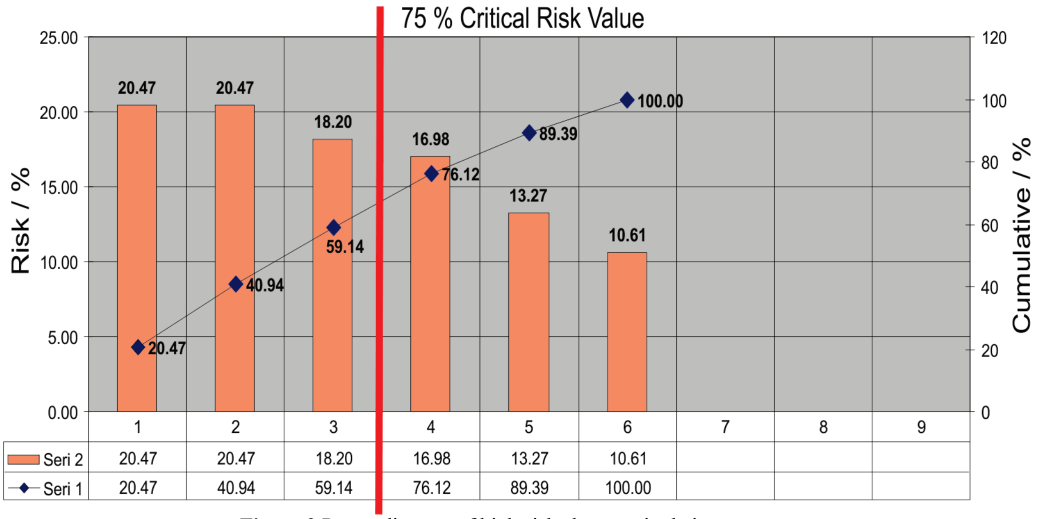

Figure 2 Pareto diagram of high-risk elements in their own error

In our implementation critical threshold risk value is chosen as 75 %. Pareto analysis carried out based on failures and risks that may occur when designing geography-based engineering projects and ranked according to the severity of the risk factors with regard to the nature of each risk factor, and calculated values of relevant percentage % is shown [17] In the geographic-based engineering projects that require team work, it is one of the benefits of the analysis as reaching to a joint decision that provides precautions against the potential failures having high risk that are calculated on the basis of the Risk Priority Level (*RPL*) values table. Information about the Pareto Analysis is shown in Table 6, and relevant chart is shown in Fig. 1. Accordingly, in order of importance when designing geographically based engineering projects (GBEP), the following errors and failures are considered firstly in priority:

1. The errors, arising from the vertical and horizontal position, the size and geometry of the design and implementation issues of the realized Project.
2. The errors and failures, arising from the lack of controls for appropriateness of the land for the concerned project in terms of geological and geotechnical suitability.
3. The errors and failures, arising from the lack of proper definition of the land topography and land usage appropriateness for the concerned Project.
4. The errors and failures, arising from failure to comply with laws and regulations concerning Occupational health and safety issues.
5. The errors and failures, arising from failure to calibrate the measuring equipment used in geographic-based projects.
6. The errors and failures, arising from lack of control on the stability and landslide control issues for implemented area of the Project.

The above-mentioned problems are observed that remain in the high-risk group. While re-assessing the high risk based error sources among themselves in Pareto analysis, in accordance with 75 % threshold risk value, the first 3 error sources are in the forefront. The values in this analysis are given in Tab. 7, relevant chart for this analysis is given in Fig. 2.

5 Results

Highways, railways, tunnels, dams and other geographic-based engineering projects (GBEP) are the activities that are carried out depending on a program, a project and a contract. This is why in all stages of these activities in particular the control, inspection and failure analysis in design stages play a major role in being successful in this kind of projects. For this reason, a team of experts in the control and analysis of engineering projects that do not only control the operation and error analysis for the assessment of subject matter, but also maintain the future success of the business and operations for the execution of similar projects seem to be necessary in terms of gaining experience and knowledge. FMEA analysis in the geographic-based engineering projects (GBEP), plays an important role especially during the design phase of projects in order to provide for the risks to be based on the priority order of importance and for the improvement works for them to be made quickly. However, in the geographic-based engineering projects, Risk Priority Level (*RPL*) values play an important role. In post analysis and evaluation of FMEA they will be a good guidance for the experts in their field that carry out improvement studies. FMEA analysis, which can be applied in any area, is in our study attempted to be implemented on the basis of the geographic-based engineering projects. As a result of the study, high-risk groups of errors-failures are defined that are ultimately referred to the content of this article.

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Authors' addresses

Hikmet Erbiyik
Yalova University, Engineering Faculty,
Department of Industry Engineering,
77100, Yalova, Turkey
hkerbiyik@gmail.com

Eray Can
Yalova University, Engineering Faculty,
Department of Transportation Engineering,
77100, Yalova, Turkey
can.eray@hotmail.com

Şenol Kuşçu
Retired Academic Staff From Bulent
Ecevit University, Engineering Faculty,
Department of Geomatics Engineering,
67100, Zonguldak, Turkey
senolkuscu@yahoo.com