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Development of a new holistic process safety management system model based on business continuity and organizational resilience standards

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Abstract

In this study, it was aimed to develop a new holistic process safety management system model based on business continuity and organizational resilience standards. Existing processes and functions were evaluated in terms of business continuity and organizational resilience, potential risks to which the organization was exposed were identified and effective strategies were developed against these risks. The model design, determined by combining organizational resilience and process safety strategies through business continuity, was included in a holistic management system model. Business continuity, on the other hand, combines organizational resilience and process safety strategies and incorporates the model design into a holistic management system model. The relationship between the Safety Management System (SMS) components related to process safety and the features of organizational resilience and business continuity management systems standards was analyzed using Quality Function Deployment (QFD). Through the analysis, the importance ranking of the requirements of both standards was determined and their integration with the criteria of the existing SMS elements was ensured. With the model, it will be possible to determine the main objectives of the organization, to understand the expectations of internal and external stakeholders and to combine business continuity, resilience and safety strategies in accordance with these expectations. In addition, it is foreseen that the resilience of industrial organizations against process accidents will be increased and organizations will gain more effective preparation and recovery capability.

1. Introduction

In today's rapidly changing business environment, business continuity, resilience and security have become an important strategic priority for organizations. Failure to effectively manage these critical elements can expose organizations to various risks and threaten long-term success. Therefore, developing a holistic management system model that combines business continuity, resilience and security is a critical step to ensure that organizations are resilient to future uncertainties.

Identifying critical business activities in the process industry contributes to the development of effective business continuity strategies and plans. It allows operating at an acceptable level and enables the identification and implementation of necessary pre-event actions that result in activities becoming "manageable events". It is important to identify the organizations' business-critical activities in order of priority, specifying the maximum tolerable downtime for each, and to perform analysis, planning and testing to ensure that the resources on which these critical activities rely are fully understood and that appropriate mitigation measures are in place. Resource dependent elements such as plant, people, technology, information systems, supply chain and processes should have planning requirements and strategies that can be developed to minimize the impact of one or more resource losses. Business continuity management is a discipline that provides a proactive approach to incident management, enabling organizations to plan an effective response to the recovery of business operations prior to a significant disruption, thereby reducing the impact. With business continuity management, organizations gain the ability to continue to deliver products and services at a predefined capacity within acceptable timeframes during an interruption.

A business continuity management system is a holistic management process that identifies potential threats to an organization and defines the impact on business operations should those threats materialize, and provides a framework for building organizational resilience through an effective response capability that protects the interests of key stakeholders and creates reputation, brand and value (BSI Standards Publications, 2019).
The business continuity management process should also be used to assess potential events that could result in the unexpected loss of operational dependencies, e.g. infrastructure and assets, employees, supplies and services, and their impact on the organization. It aSMS to make the organization more resilient to potential threats, enabling it to continue its activities under adverse or unexpected conditions. The purpose of business continuity management is to ensure that any adverse event does not lead to unexpected and unwanted interruptions in production or service activities (Bakhtiar, Mahnaz, Mohammad Mehdi, Ali Husseinzadeh, 2022). For example, in operational processes in an oil and gas industry, business continuity planning activities focus on the development, implementation and testing of plans and strategies to ensure that in the event of an incident that results in the loss of office work, technology or information, an effective recovery process is managed and critical business activities are maintained. Organizational resilience is the ability of an organization to anticipate, prepare for, respond to and adapt to increasing change and sudden disruptions in order to survive and thrive (International Standard Organization, 2017). Together with organizational resilience, it focuses organizations on adapting in the face of challenging conditions, moving beyond reacting to disruptions and encouraging them to exploit opportunities and drive sustainable performance improvement. It seeks to achieve this through the requirement of the organization's leadership, capability, resources, awareness, adaptive response and preventive control criteria. Resilience refers to the organization's ability to maintain its capabilities at a stable level despite the challenging business environment in which it operates. It is also associated with the organization's ability to reorganize and self-support after an unforeseen event occurs (Paunescu and Argatu, 2020). The environment in which organizations operate, industry requirements, regulators and service providers expect organizations to have appropriate and continuously evolving capabilities to ensure that they are safe, secure and reliable.
Process safety is a critical component of any organization that handles hazardous substances or conducts hazardous processes. A process safety management system is a comprehensive framework that manages the integrity and process safety risks of operating systems and processes handling hazardous substances and is widely used in process industries to prevent accidents. There are various process safety management system rules to protect assets, people and the environment. When an undesirable event occurs, there are process safety management rules that indicate the level at which the organization should act to avoid and react to this event. In Turkey, the necessity of the process safety management system with a 7-element structure within the scope of the "Regulation on Prevention of Major Industrial Accidents and Mitigation of their Effects" prepared based on Seveso directives and OHS Law No. 6331 and Environmental Law No. 2872. These 7 elements are: organization and personnel, identification and assessment of major accident hazards, operational control, management of change, planning for emergencies, performance monitoring, auditing and inspection. The aim of this study is to develop a new process safety management system model that takes into account organizational resilience and business continuity standards. Using the QFD method, a management system model was designed that integrates the organization's business continuity, resilience and safety objectives.

2. Literature review

The constant changes in business environments today require organizations to find practical responses to effectively address various issues such as security, preparedness, risk and survival. In addition, organizations are constrained by changes implemented in their business models, which creates the need for a continuous efficiency improvement through resource utilization optimization and minimization of wastes or losses to achieve a balance point between efficiency and resilience (Paunescu and Argatu, 2020). Although business continuity management is known to originate from planning and response to information technology disasters, it has evolved over the last 40 years to become a strategically oriented, organization-wide process. Business continuity consists of processes, structures, roles and resources that analyses the business's exposure to threats and provide effective prevention and improvement for the organization that maintains its competitive advantage and the structure of the asset system. It ensures that the organization has the ability to identify, communicate, react to and recover from business risks as well as the ability to be resilient to changing business conditions. Threats within the scope of business continuity can be seen as a threat to the activities, goals and responsibilities of the business (Tokalı, 2018).
In the business continuity management system standard, there is a business impact analysis method, which is a very important and important stage in operation in reducing or eliminating the effects on accidents and incidents that may occur in the process industry. Business impact analysis is a process for analyzing the consequences of a disruptive event on the organization. In business impact analysis, there are recovery point target and recovery time target parameters. The recovery point objective is defined as the point at which the

information used by an activity must be restored to enable it to function when it is restarted, or the amount of data loss that is acceptable at the time of a potential disruption. The recovery time objective is the target time taken by the organization to recover its applications and processes after an incident has occurred. Restarting the product or service level and activities is like recovering resources. These parameters are determined by the company according to the level of service provided to its customers and interested parties and a risk assessment of the business is performed. In business impact analysis, product and service level impacts are evaluated in the categories of financial, reputation, laws and regulations, contractual terms and business objectives. Business impact analysis is widely used in cyber-attacks, but it can also be used for process accidents that can damage facilities and cause financial losses and reputational damage (Neto, 2021). Business continuity management and organizational resilience provide a framework for building an effective ability to respond to internal and external threats. Organizational resilience also helps to be aware of the company's strengths and weaknesses and then identify key considerations for business continuity planning. Organizations that have established an organizational resilience framework are able to ensure that they are able to perform their core processes at the minimum level of business continuity objectives and have a high ability to comply with the maximum tolerable downtime (Paunescu and Argatu, 2020).

In the process industry, the management of industrial risks and business risks can be optimized in combination with process safety management, business continuity and organizational resilience perspectives (Neto, 2021). In an assessment of a process accident that occurred in March 2015, after a distillation tower was filled with hydrocarbons, overpressure caused an eruptive release from a vent stack. In the ensuing explosion, 15 employees were killed and 180 were injured. Post-accident investigations and inspections revealed that the organization was an old plant with a complex history and that there had been numerous changes in management, both at the refinery management level and at the corporate level. It was found that organizational changes that could adversely affect the process, such as budget cuts following changes in the management structure, were often not considered and there was a lack of resilience to incremental change. It was observed that instrument technicians did not indicate that the unit instrumentation needed maintenance and raffinate separator instruments were not included in the list of critical instruments. In addition, it was found that the procedures did not reflect the actual practices, the number of personnel was insufficient, and the trainings for emergency and contingency management were inadequate. Consequently, it is very important to define organizational resilience and business continuity methods in process safety management. Events occurring in the process industry are difficult to control and the question arises as to what can be done to minimize the damage that these events may cause. It is also important to develop strategies to prevent the cessation of operations, to reduce the risks of loss and damage under conditions of interruption and crisis, and to prepare and adapt the organization (Bakhtiar et al., 2022).

Process safety includes hazard identification, risk analysis and mitigation, incident modelling, consequence analysis and many other actions. Despite many years of research on organizational resilience, business continuity and process safety, comprehensive and operational understanding has still not been developed in various scientific fields, including crisis management (Neto, 2021). Process safety management systems have multiple safety barriers: some are designed, some are people-based, and some are based on procedures and managerial controls. Safety barriers should be considered as all elements of the system necessary to perform the safety function, including utilities or tools, and as part of the safety-related system. They consist of a large number of components, from people to sensors, actuators and communication equipment. Business continuity does not address how a barrier will fail. It asks the question of what the impact of the failure is and goes beyond that to determine what the business consequences are and what is required to get the system working again. It analyses the risks that any failure in the critical system will bring to the business and carries out risk mitigation practices.

Conducting research and studies in the fields of organizational resilience, business continuity and process security is a very important new field of study and a subject of the process industry, especially for organizations in the process industry. Increasingly changing working environment and environmental conditions such as recent climate changes, cyber security attacks, epidemics, changes in national and international legislation, resource use limitations and resource allocation difficulties have brought about the need for organizations to implement different strategies and policies and review existing management systems.

Research studies on organizational resilience in the oil and gas industry have been reviewed in five main categories: conceptualization, identification of study methods, context and analysis studies, and the relationship between resilience and safety (Bento, Garotti, Mercado, 2021). As current practices in process industries become more complex, it is understood that the assessment and management of the resilience of technical systems is becoming increasingly important (Chen, Li, Zhao, 2023). It has been stated that businesses face a variety of unexpected and unpredictable events and disruptions that can seriously jeopardize their operations and assets. It has been stated that the ISO 22301 standard will provide guidance on how to ensure the continuity of basic operations and business continuity during and after an unexpected event. In the event of a business interruption, the effectiveness of mitigating business continuity risks and maintaining critical business

functions for the survival of a business in the event of a business interruption is considered to depend on the organization's approach and capacity regarding the business continuity management system and its ability to build organizational resilience (Radjenovic and Zivkovic, 2022).

Resilience to risk is defined in terms of assets, organizational processes and normal operating conditions versus crisis conditions. The ability of organizations to plan to respond to disruptions and to determine which approach will be most beneficial as they encounter them can support organizations to ensure continuity, avoid crises or shorten the time it takes for an organization to recover from a crisis (Galaitsi, Pinigina, Keisler, 2022). The resilience of process plants, including oil and gas refining, chemical production, power generation plants and many more, has been analyzed and it has been stated that safety is important in many aspects, such as the protection of the workforce and the population around the plant, but it should also be considered in terms of economic and sustainability. It was considered that risk assessment in ensuring process safety can be misleading due to various uncertainties, or at least inaccurate due to missed or unknown threats. Measures can be taken up to a certain limit to protect organizations against threats. It was pointed out that human and technical factors brought together in a sociotechnical system can be realized through a broader understanding of facility security that provides more effective risk control and increased resilience (Pasman, Kottawar, Jain, 2020). In the study by Paunescu and Argatu (2020) covering Romanian companies, it was stated that critical functions that are vital for organizations to maintain basic operations and build organizational resilience in the event of disruptive events should be established. Xing and Zio (2016), in their study on establishing an integrated framework for business continuity management of critical infrastructures, stated that critical infrastructures are exposed to various hazards related to business continuity, random failures, malicious threats, natural disasters and accidents such as human errors that can cause serious consequences (death, injury, environmental damage, business interruption and loss of company reputation). The business continuity management process is conceptualized as the integration of four phases: prevention, mitigation, emergency and recovery. An integrated framework is proposed with business continuity management based on the Bow-Tie model, which consists of four phases: prevention, mitigation, emergency and recovery, to efficiently and effectively prevent and mitigate the potential consequences of an accident by appropriately designing and strengthening safety barriers to prevent and mitigate accidents and making safety decisions for emergencies. With this proposed framework, critical activities and factors in the accident analysis and analysis process of the oil and natural gas pipeline accident that occurred in 2013 were identified. A literature review covering bibliometric and content analysis and organizational capabilities based on Web of Science and Scopus databases for the period between 1998 and 13 May 2021 was conducted to develop sustainability and resilience-based business continuity management. The results of the analysis showed that there are four groups of relationships: the contribution of business continuity management and organizational resilience to risk management, resilience and business continuity practices, the contribution of business continuity to innovation and sustainability, and dynamic capabilities for organizational sustainability and resilience to improve business continuity management. The study also identified that organizational sustainability and resilience capabilities have different stages to understand the impact on business continuity management when faced with disruptive events (Estrada, Santos, Torres and Lopez, 2021). In the Deepwater Horizon (DWH) Macondo blowout in April 2010, they examined the accident that resulted in the death of 11 people in the Deepwater Horizon (DWH) Macondo explosion, which resulted in the discharge of approximately 5 million barrels of crude oil into the ocean and the US government shutdown of the well 5 months after the explosion, in the study of business continuity management in a dynamic environment. In July 2015, British Petroleum (BP) was fined $18.7 billion for this explosion. This incident demonstrated the importance of business continuity management to include disaster recovery, business recovery, crisis management, incident management, emergency management and contingency planning, and to provide a framework to identify risks, threats and vulnerabilities that could affect the organization's ongoing operations, and to build organizational resilience and the ability to respond effectively. Following the disaster, BP focused on the efficiency and effectiveness of crisis management, disaster recovery and contingency planning in changing environments (Ajimoko, 2016). In the study of applying data mining to investigate business continuity in petrochemical companies, they investigated the risk factors in the scope of business continuity in the Iranian petrochemical industry, the disruptions experienced, the effectiveness of countermeasures, and the scope of business continuity management implementation. In addition, they applied data mining techniques to investigate relevant characteristics among petrochemical companies, analyze empirical data, and discover useful information and relationships among these characteristics based on the standard process across industries (Maboudian and Rezaie, 2017).

Organizational resilience is critical for managing hazardous materials and oil spill risks in order to create long-term value for organizations that constantly face many obstacles in rapidly evolving and uncertain environments. The organizational resilience potential of a group of Seveso organizations in Turkey was assessed through a 5-point Likert scale questionnaire designed to measure dynamic capabilities in four key dimensions, including foresight capabilities, adaptive culture, networking capabilities and organizational learning. Both the survey and the follow-up interview assessments showed the complexity of potential

organizational resilience development and the many facets of resilience. It was also evidenced in their study that organizations with higher resilience potential are more likely to manage challenges effectively (Sengul, Marsan and Gun, 2018). In their qualitative study of indicators of organizational resilience in critical sociotechnical systems and complex processes such as the refinery process, it was concluded that organizational resilience is an important component of the ability to plan for, respond to, and recover from organizational accidents and crises. In their study, using expert opinion and literature review, they examined the indicators that affect the resilience of refinery processes in the organizational dimension in two categories; technical and human indicators. Using these indicators, it was found that organizational resilience as an important dimension of overall resilience is condition assessment and improvement. As a result, it was concluded that oil refineries are a critical sociotechnical system and the consequences of accidents will negatively affect the economic, social and environmental aspects of this system (Jafari, Nodoushan and Shirali, 2018).
In the study to develop an excellence model to effectively implement SMS in the oil and gas industry, it was stated that SMS is the framework that guides an organization to maintain a safe working environment as well as fulfilling its obligations to its employees, assets and the environment, and the leadership of an organization is responsible for determining the best approach to help the safety management system meet the expectations and needs of the SMS. Effective implementation of SMS is crucial for business continuity, especially in a high-risk industry such as oil and gas fields (Al Hakami and Al Salah, 2023). In the study on the impact of the pandemic on Iranian oil and gas industry planning and business continuity challenges, it was evaluated that the pandemic has severely affected various aspects of life and has had increasing effects on many industries and companies. They also noted that the pandemic may pose risk management and business continuity management challenges for the oil and gas sector and its major companies. In Iran's Pars oil and gas company, various impacts of the pandemic on the oil and gas industry were investigated and the study found that the pandemic caused significant operational, financial and legal impacts in terms of operational risks and business continuity by disrupting routine maintenance, reducing the availability of human resources under public health measures and restrictions, increasing operating and delivery times and costs, reducing revenues and delaying contracts (Razavi, Asgary and Khaleghi, 2022). Studies in the fields of organizational resilience, business continuity and process safety, the interrelationships of sociotechnical system-based structures and studies focusing on the conceptual framework and model have been seen in the literatures.

3. Method

By integrating the requirements of the business continuity management system and organizational resilience standards with the requirements of the process safety management system, taking into account the relationship between the standard requirements and the elements of the QMS and the desired improvement areas were analyzed with the quality function migration analysis technique. The basis of the quality function migration is the transformation of what customer needs are for each stage of product development and production into appropriate technical specifications, i.e. how-to's. With this method, first the customer needs and then how to meet these needs are determined in a systematic way. The stages of the method are explained as follows:
Phase 1 consists of identifying customers, deciding on the product and setting up the QFD team. The first step in planning is to clearly define the customers. If customers are not clearly defined, conflicts will arise, starting from the identification of customer requirements. The first reason is that the team members do not know the customers and the second reason is that each team member focuses on a different customer group.

Phase 2 is the identification of customer needs. Customer needs and expectations are the basic data when starting the QFD study. A systematic customer communication study is required to collect this data. The information to be obtained at the end of the study is expressed by the term "Voice of the Customer". After defining the customer identification phase, the company needs to plan how to get in touch with the customer and how to involve the customer in the design phase; in general terms, how to hear the voice of the customer. In order to structure customer needs and manage customer needs, they need to be structured in a hierarchy by the team. Prioritizing customer needs means that customers want their needs to be fulfilled, but some needs are more important than others. Prioritizing needs helps the QFD team to balance the cost of satisfying a need against the benefit to the customer.

In Phase 3, the creation of the QFD is obtained by using four different pieces of information. This information consists of answers to the following questions.

- What are the critical factors for customers?
- How to obtain factors that are critical for customers?
- Is there a relationship between what and how, and if so, what is the impact?

- How much should the hows be utilized to meet customer needs?

The analysis created in the QFD method, which is based on customer needs and expectations, consists of two important sections. On the horizontal axis is the customer section, which contains information about customers, and on the vertical axis is the technical section that responds to customer information. The customer section is the section created from the information utilized from customer needs and expectations. The main input for the start of the QFD method is customer wants. Customers express their wants and needs in their own frames. The organization needs to analyze and evaluate these statements and transform them into measurable statements. The technical part of the matrix is how the organization will respond to the wants and needs expressed by customers in their own frames. The technical and design requirements that the organization will use to define and measure customer requirements are placed along the top of the matrix.

The degree of importance of customer expectations is directly proportional to the assigned value. If the assigned value is low, the degree of expectation is low and if it is high, the degree of expectation is high. In determining the degree of importance, the analytical hierarchy process method can be used as well as the scale. In the representation of the degree of relationship with the scoring method, the degree of relationship, strong relationship has a value of 9, medium relationship has a value of 3, weak relationship has a value of 1. The degree of relationship is shown in Table 1, and in this study, the American Point System was preferred in the selection of the relationship degree score.

Table 1. QFD rating values (Eymen, 2006)

Relationship degree	American Point System	Japanese Point System
Strong	9	5
Medium	3	3
Weak	1	1

These values are used in the calculation of absolute importance levels. The degree of technical importance is calculated by summing the "percent importance" values calculated in the matrix for each technical characteristic and the product of the relationship scores (Eymen, 2006).
The correlations section expresses the positive or negative relationships between the technical requirements in the roof part of the KFG. Positive and negative relationships and contradictions identified in this section are eliminated and technical requirements are revised if necessary. The symbols shown in Table 2 are used in the correlation section to analyze the technical requirements that are positively or negatively affected.

Table 2. Correlation table (Eymen, 2006)

Correlation	Symbol
Strong positive correlation	++
Positive correlation	+
No correlation	0
Negative correlation	-
Strong negative correlation	--

The QFD uses a matrix format that includes many criteria that are critical to the implementation and planning process. The matrix provides a general framework in which these issues are examined in a multifaceted way from the organization's available information. Figure 1 shows an overview of the QFD.

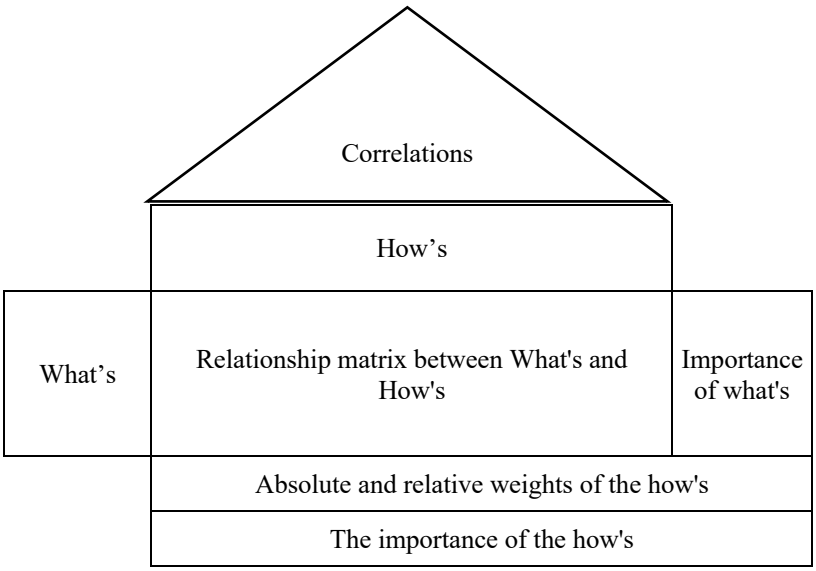

Figure 1. QFD general structure (Yurderi, 2019).

The left vertical section of the matrix contains information about customers, while the upper horizontal section contains engineering criteria, i.e. technical information, which responds to customer information. QFD starts with an assessment of customer needs and expectations and customer competition, which are translated into technical criteria. QFD relates not only customer needs and expectations but also technical requirements and competitive analysis, and the relationship matrix of this method shows the relationship between customer expectations and technical criteria (Yurderi, 2019).

4. Findings

The relationship between BEKRA SMS elements and subcomponents, ISO 22316 organizational resilience features and ISO 22301 business continuity management system requirements were analyzed separately using the QFD method.

A systematic approach has been adopted in meeting the relationship between the SMS elements and subcomponents and ISO 22316 organizational resilience standard features. In the QFD analysis, BEKRA SMS elements subcomponents were defined as customer needs and technical requirements were considered as organizational resilience features. Since the subcomponents of the SMS elements assigned as customer needs are a legal requirement under the BEKRA regulation, the importance rating scale of each SMS elements subcomponent was selected as 5 in the analysis study. Bilge (2019) stated that these rating values are used to effectively identify the needs and improvement process. The degree of relationship between SMS elements and organizational resilience standard attributes; assignments were made according to the values of strong relationship 9, medium relationship 3, weak relationship 1.

The weight score of each subcomponent of BEKRA SMS elements is obtained by multiplying the degree of relationship between the importance of the SMS subcomponent and the qualities of the organizational resilience standard by the total score. This process is repeated for all SMS elements and the total weight score is calculated by summing all weight scores. For example, the duties and responsibilities of the employees responsible for the prevention of major industrial accidents at all levels of the organization belonging to the organization and personnel element, the provision and provision of the necessary training for all employees in the organization, including subcontractors, and the measures taken with a continuous improvement perspective, as well as the component of increasing safety awareness and awareness in the organization, and the clarity of common vision and purpose, understanding and influencing the context, effective and strong leadership, safety culture and shared knowledge and experience in the attribute requirements for organizational resilience. Resource management and control, development of management disciplines and coordination, continuous improvement, and the ability to anticipate and manage change were rated as a medium relationship and assigned 3 points for each attribute. In total, 57 points were assigned for the sub-component of this element, and the weight score was calculated as 285 by assigning an importance score of 5. To calculate the total weight

score, the weight score of each subcomponent is calculated using the method described above to determine the total weight score. The correlations between the technical requirements in the framework of the QFD were analyzed. According to the results of the analyses, for example, there is a strong positive correlation between the attributes of effective and strong leadership and safety culture. There is a positive correlation between the attributes of clarity of shared vision and purpose and shared knowledge and experience.
The technical importance score is assigned as the sum of the relationship scores of the organizational resilience attributes assigned as technical requirements multiplied by the importance score of the subcomponents of the BEKRA SMS elements. Priority ranking according to technical importance scores is calculated by proportioning the total technical importance score of each technical requirement to the total weight score. As a result of the detailed calculations, QFD for organizational resilience and BEKRA SMS components were created (Annex-1). The results of weight scoring of the relationship between SMS components and organizational resilience characteristics are shown in Table 3.

Table 3. SMS elements and organizational resilience features as a result of technical importance score

	Technical importance points	Importance, %	Prioritization
Clarity of shared vision and purpose	520	8	7
Understanding and influencing the context	485	8	8
Effective and strong leadership	915	15	1
Safety culture	900	15	2
Shared knowledge and experience	735	12	3
Resource management and control	475	8	9
Development and co-ordination of management disciplines	735	12	3
Continuous Improvement	715	12	5
Ability to anticipate and manage change	695	11	6

Firstly, effective and strong leadership attribute with 915 technical importance points, which has the highest technical importance score in Table 2, is evaluated as the improvement criterion that should and must be integrated into the SMS elements. Safety culture, shared knowledge and information, and the development of management disciplines and coordination attributes were evaluated for integration, respectively. The technical importance score indicated in Table 2 is based on the Pareto analysis method, which is used to identify and prioritize the criteria that affect the problems or performance in a system and to ensure efficient use of resources, and is ranked according to the SMS components and organizational resilience standard attributes as shown in Figure 2.

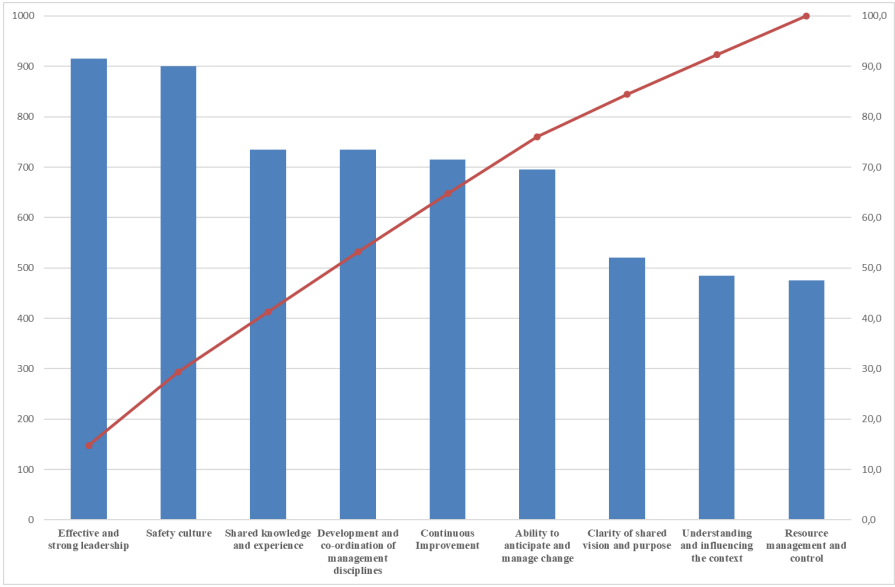

Figure 2. Pareto analysis of SMS components and organizational resilience

Similar steps as in the previous analysis study were applied, and since the subcomponents of the SMS elements were evaluated within the scope of legal requirements, the importance scale was selected as 5. The degree of relationship between SMS elements and business continuity management system standard requirements; assignments were made according to the values of strong relationship 9, medium relationship 3, weak relationship 1. For example, determination of methods for investigating corrective actions in case of compliance or non-compliance with the targets set in the SMS for the element of performance monitoring, reporting of major accidents and near miss incidents due to the failure of the measures taken, and investigation, examination, analysis and follow-up of these within the scope of the lessons to be learned from these incidents are considered as a strong relationship between the requirements of performance evaluation (monitoring, measurement, analysis and evaluation), business impact analysis and risk assessment in the standard requirements for the business continuity management system and 9 points are assigned for each requirement. Establishing and communicating the Business Continuity policy, Mission, roles, responsibilities and authorities, identifying and selecting Business Continuity strategies and solutions, implementing solutions, business continuity plans and procedures (response structure, alerting and communication, recovery) and internal audit were assessed as a medium relationship and 3 points were assigned for each requirement. For the requirement of determining the business continuity management system, it was assessed as a weak relationship and 1 point was assigned. The total score for the subcomponent of this element was calculated as 43, and the weight score was calculated as 215 by assigning an importance level of 5. In order to calculate the total weight score, the weight score of each subcomponent of each element was calculated by the method described above and the total weight score was determined. When the correlations are analyzed, for example, there is a strong positive correlation between the requirements for task, roles, responsibilities and authorities and leadership and commitment. There is a positive correlation between internal audit and business impact analysis requirements. The calculation in determining the relationship between organizational resilience and BCMS and the calculation of the relationship between business continuity management system was carried out in a similar way. Business Continuity Management System and SMS components QFD table is presented in Annex-2. The results of the relationship weight scoring between the components of the SMS and the criteria of the business continuity management system standard are shown in Table 4.

Table 4. SMS elements and business continuity management system requirements technical importance score result

	Technical importance points	Importance, %	Prioritization
Legal and regulatory requirements	165	4	10
Establishing and communicating the BC policy	175	4	9
Duties, roles, responsibilities and authorities	465	11	2
Determination of the BCMS	145	3	11
Leadership and commitment	395	10	8
Business Impact Analysis	425	10	5
Risk Assessment	425	10	5
Determination of business continuity strategies and solutions and their selection and implementation of solutions	445	11	4
BCPs and procedures (Response structure, Warning and communication, rescue)	410	10	7
Performance evaluation	630	15	1
Internal audit	465	11	2

According to the technical importance score indicated in Table 3, the Pareto analysis is ranked as shown in Figure 3.

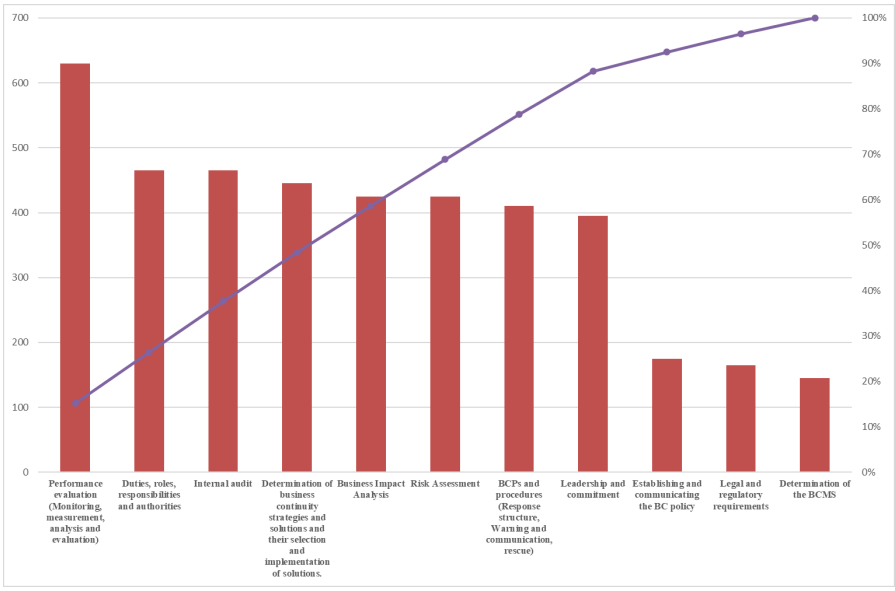

Figure 3. Pareto analysis of SMS components and business continuity management system requirements

5. Discussion

There are organizations of different sizes and scales in the process industry. Due to the processes carried out in the organizations, events that may cause serious accidents and environmental impacts may be encountered. These organizations need a system to carry out and manage their processes in a safe and secure manner. In Turkey, SMS is explained with a 7-element structure within the scope of BEKRA regulation prepared based on Seveso directives and OHS Law No. 6331 and Environmental Law No. 2872. Both the OHS Law No. 6331 and the Environmental Law No. 2872 and other regulations do not require organizations to establish a system. Although process industries have different practices and processes, it is important to operate the system on the basis of a management system. This means that organizations can measure and evaluate the success or failure of their processes in terms of safety management and take them under control with necessary actions. In this study, both organizational resilience and business continuity management system requirements and SMS components were associated. Establishing a BCMS standard in Turkey from the perspective of the standards issued by the international standards organization can help organizations to provide a universal common language and standardization in managing BCMS.

Guiding the organization to fulfil its obligations to its employees, assets and the environment, maintaining a safe working environment, the leadership of the organization, the approach to meeting the expectations of the SMS and its effective implementation were found to be important for business continuity, especially in a high-risk sector such as oil and gas fields (Al Hakami and Al Salah, 2023). The relationship between resilience, business continuity and risk is of great importance for better management against crises and disruptions in organizations (Ostadi and Sadrabadi, 2023). Studies aiming to provide a classification and conceptual framework in the fields of business continuity, resilience and risk support the results of this article.

In today's changing conditions, the strategies of organizations change rapidly. Organizations will be more effective in determining their strategies and ensuring the participation of the whole organization by setting vision and goals for these strategies. This will ensure the participation of all stakeholders and elements in the SMS. Especially with the integration of the requirements of the business continuity management system, the financial, corporate and reputational risks of the organizations can be evaluated and the interruptions that may occur under changing conditions can be responded more quickly and their effects on the business and processes of the organization can be minimized.

6. Results

The relationship between the SMS, which has a 7-element structure within the scope of BEKRA regulation, and the requirements of ISO 22316 organizational resilience and ISO 22301 business continuity management system standards was analyzed using the QFD method. In the QFD based approach, the needs part is

determined as the components of the SMS. These needs were transformed into appropriate technical specifications, namely organizational resilience features and business continuity management system requirements. As a result, it has been determined in a systematic way that the SMS components will be met by the organizational resilience and business continuity management system requirements of these components.

In the QFD analysis, the standards related to the SMS components were analyzed separately. According to the results of the analyses, scoring of the standard requirements of the SMS components according to their degree of relationship and technical importance scores were obtained. According to the Pareto analysis between SMS and organizational resilience attributes, the ranking of the first four technical attributes is listed as follows.

- Effective and strong leadership
- Safety culture
- Shared knowledge and experience
- Development and coordination of management disciplines

Similarly, according to the Pareto analysis, there is an association between SMS and business continuity management system standard requirements and the first four rankings;

- Performance evaluation (Monitoring, measurement, analysis and evaluation)
- Duties, roles, responsibilities and authorizations
- Internal audit
- Determination of business continuity strategies and solutions and their selection and implementation of solutions.

Having a 7-element structure, SMS elements and subcomponents are integrated with both organizational resilience features and business continuity management system standard requirements. With the proposed structure, it is envisaged that organizations will be able to respond quickly to changes and increase the ability of the organization to be more agile in its sector and adapt to changing conditions; it is envisaged that the organization will provide a systematic approach and thinking in the assessment of risks and opportunities.

Contributions of Authors

Mustafa Alper DEMİRCİ: Investigation, Methodology, Writing – original draft, **Saliha ÇETİNYOKUŞ:** Conceptualization, Supervision, Writing - review and editing.

Conflict of interest

No conflict of interest was declared by the authors.

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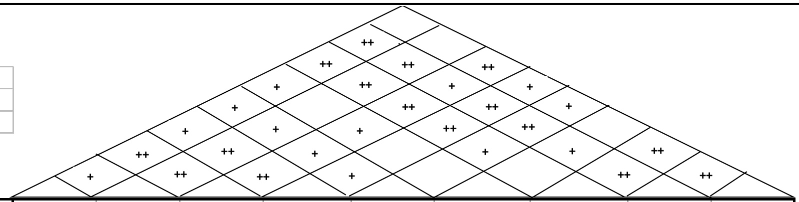
Annex

Annex-1. Organizational resilience and SMS elements QFD table

QUALITY FUNCTION DEPLOYMENT

Project Title Organisational Resilience and Safety Management System Elements
Project Leader Mustafa Alper Demirci
Date



BEKRA SMS Elements	Importance Level (1: low, 5: high)	BEKRA Safety Management System Elements Components - (What) ↓ / ISO 22316 Organisational Resilience Standard Requirements (How) →	Clarity of shared vision and purpose	Understanding and influencing the context	Effective and strong leadership	Safety culture	Shared knowledge and experience	Resource management and control	Development and co-ordination of management disciplines	Continuous Improvement	Ability to anticipate and manage change	Weighted score
		Desired Direction of Improvement (↑,0,↓)	↑	↑	↑	↑	↑	↑	↑	↑	↑	
Organisation and personnel element	5	The enterprise within the scope of BEKRA aims to increase safety awareness by informing its employees about the measures taken to prevent major industrial accidents. In this context, it defines the authorities and responsibilities of its employees involved in the prevention of major industrial accidents and organises the necessary training for all employees, including these employees and sub-employers.	9	9	9	9	9	3	3	3	3	285
Organisation and personnel element	5	Duties, authorities and responsibilities are clearly defined and an organisation chart of the company including the process safety department is created. The company maintains this chart depending on the management system.	9	1	9	9	1		3		9	205
Organisation and personnel element	5	This organisation chart is communicated to the entire enterprise in an appropriate way. All stakeholders in the enterprise (subcontractors, employers with whom temporary labour relations have been established) should be included in the criteria to be included.	9	3	3		9					120
Organisation and personnel element	5	Employee participation should be routinely ensured for the SMS and feedback and improvement targets related to the SMS should be expected from employees. Reward-punishment system related to GYS, GYS performance target monitoring methods and these should be discussed and debated in safety meetings and committees.	9	3	9	9	1	1	3	3	1	195
Organisation and personnel element	5	A structure should be established to follow the development and change in the enterprise. In this context, a system should be established to closely follow developments such as legal regulations, international standards and good practices, lessons learnt and lessons learnt in other enterprises.	3	1	9	9	9	1	9	9	9	295
Organisation and personnel element	5	The enterprise should develop a structure for co-operation, information sharing and co-ordination with the environmental operating conditions in which it operates. In this context, if the enterprise is in an organised industrial zone or industrial zone, it establishes the necessary criteria by determining a method by which it can be in contact with such organisations for emergencies.	3	3	9	9	3	3	9		3	210
Organisation and personnel element	5	If necessary, a communication structure should be established with all employees in the enterprise. In this context, while developing a communication structure, sub-employers and employers with whom a temporary labour relationship is established should also be taken into consideration.	9	9	3	9	9	1	9	3	3	275
The element of identification and assessment of major accident hazards	5	A systematic should be established to identify major accident hazards and to analyse and evaluate these accidents. In this context, the enterprise should determine an appropriate method and methodology that takes into account all normal and abnormal processes.	3	3	9	9	9	3	3	9	9	285

Element of operational control	5	Safe working methods covering the equipment in operation, warning systems, maintenance of the operation and temporary stops should be determined. In this context, a procedure on safe working methods should be prepared. In this procedure, control methods and best practice methods should be considered to reduce the risk of failure and error. A strategy and method should be developed to follow the current status of the equipment for the method and control of aging equipment and corrosion risks in the organisation and measures should be determined and these should be followed systematically.	3	3	9	9	3	9	9	9	9	315
	5	Maintenance plans, maintenance strategy and targets should be determined. In addition, employees responsible for maintenance should develop a method for maintaining and retaining equipment maintenance frequency and records. When necessary, these methods should be explained by the maintenance supervisor.	1	3	3	3	9	3	3	9	9	215
	5	Criteria such as impact, vibration, corrosion, mechanical stresses and chemical deformations must be included in the planned maintenance content.	1	1	9	3	3	9	3	9	9	235
Management of change element	5	Change metrics should be determined for activities such as new facilities, new processes or planned changes that are likely to be made.	1	1	9	9		1	3	9	9	210
	5	A method for planning organisational changes, technical changes, including permanent, temporary or emergency changes, should be determined.			9	9		1	9	9	9	230
	5	In change management; a method should be established to cover each change related to employee changes, technical changes, changes in hazardous substance storage, changes in equipment and changes in the process.	1	3	3	3	1	9	9	9	9	235
	5	The critical change in the determined method should also cover the issues of analysing the risks related to the change, cooperation and coordination with the relevant units.	3	3	9	9	9	3	9	3	9	285
	5	These changes should be followed up with the relevant units and the changes should be recorded.					9				9	90
	5	All employees in the organisation should be informed about the change.	1	9	9	9	9	3	9	1	9	295
Element of planning for emergencies	5	A plan for emergency preparedness should be established. In this plan, emergency situations should be identified, drills should be carried out to prepare for them and special training should be given to the relevant employees for emergency preparedness.			9	9	3	3	3	3		150
Element of performance monitoring	5	A method should be determined for monitoring the compliance with the targets in the SMS. An action plan must be created and followed for targets that result in failure. Measures taken and lessons learnt from accidents and incidents must be analysed, followed up and recorded.		3	9	9	3	3	9	9	9	270
	5	Feasible performance targets should be set for the SMS. Performance indicators should be routinely reviewed each year.	9	9	9	9	3	3	3	9		270
	5	Major industrial accidents and near-miss incidents must be recorded and reported. These reports must be announced to all employees in the enterprise by an appropriate method.			9		9		3	9	9	195
Supervision and inspection element	5	The effectiveness and performance of the SMS should be monitored periodically. The audits conducted by the senior management for the SMS should be analysed and an audit structure should be established to cover any changes.	9	9	9	9	9	9	9	9	3	375
	5	An internal audit structure should be established to evaluate and audit the SMS.	9	9	9	9	9	9	9	9		360
	5	Periodic internal audits should be carried out to audit the elements of the SMS, provided that they do not exceed 2 years. These internal audits should be carried out by officials from the organisation or outside the organisation with the approval of senior management.	9	9	9	9	9	9	9	1		320
	5	An internal audit report is prepared after each internal audit. The report includes audit findings, audit results and recommendations, if any.	3	3		9	9	9	9	9		255
		Technical importance points	520	485	915	900	735	475	735	715	695	6175
		Importance %	8%	8%	15%	15%	12%	8%	12%	12%	11%	100%
		Prioritisation	**7**	**8**	**1**	**2**	**3**	**9**	**3**	**5**	**6**	

Annex-2. Business Continuity Management System and SMS elements QFD table

QUALITY FUNCTION DEPLOYMENT

Project Title: Business Continuity Management System and Safety Management System Elements
Project Leader: Mustafa Alper Demirci
Date:

BEKRA SMS Elements	Importance Level (1: low, 5: high)	ISO 22301 Business Continuity Management System Standard Requirements (How) → / BEKRA Safety Management System Elements Components - (What) ↓	Legal and regulatory requirements	Establishing and communicating the BC policy	Duties, roles, responsibilities and authorities	Determination of the BCMS	Leadership and commitment	Business Impact Analysis	Risk Assessment	Determination of business continuity strategies and solutions and their selection and implementation of solutions.	BCPs and procedures (Response structure, Warning and communication, rescue)	Performance evaluation (Monitoring, measurement, analysis and evaluation)	Internal audit	Weighted score
		Desired Direction of Improvement (↑,0,↓)	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	
Organisation and personnel element	5	The enterprise within the scope of BEKRA aims to increase safety awareness by informing its employees about the measures taken to prevent major industrial accidents. In this context, it defines the authorities and responsibilities of its employees involved in the prevention of major industrial accidents and organises the necessary training for all employees, including these employees and sub-employers.		1	9	1	9					3	3	130
	5	Duties, authorities and responsibilities are clearly defined and an organisation chart of the company including the process safety department is created. The company maintains this chart depending on the management system.			9		9					3	3	120
	5	This organisation chart is communicated to the entire enterprise in an appropriate way. All stakeholders in the enterprise (subcontractors, employers with whom temporary labour relations have been established) should be included in the criteria to be included.		3	9	1	9					3	3	140
	5	Employee participation should be routinely ensured for the SMS and feedback and improvement targets related to the SMS should be expected from employees. Reward-punishment system related to GYS, GYS performance target monitoring methods and these should be discussed and debated in safety meetings and committees.		3		3	3					9	3	105
	5	A structure should be established to follow the development and change in the enterprise. In this context, a system should be established to closely follow developments such as legal regulations, international standards and good practices, lessons learnt and lessons learnt in other enterprises.	9	3	1	1	3	3	3	3	3	3	3	175
	5	The enterprise should develop a structure for co-operation, information sharing and co-ordination with the environmental operating conditions in which it operates. In this context, if the enterprise is in an organised industrial zone or industrial zone, it establishes the necessary criteria by determining a method by which it can be in contact with such organisations for emergencies.	9	1	3	3	3	3	3	3	3	3	3	185
	5	If necessary, a communication structure should be established with all employees in the enterprise. In this context, while developing a communication structure, sub-employers and employers with whom a temporary labour relationship is established should also be taken into consideration.		3	3	1	3	1	1	1	1	3	3	100
The element of identification and assessment of major accident hazards	5	A systematic should be established to identify major accident hazards and to analyse and evaluate these accidents. In this context, the enterprise should determine an appropriate method and methodology that takes into account all normal and abnormal processes.				1	3	9	9	9	9	9	3	260

Element of operational control	5	Safe working methods covering the equipment in operation, warning systems, maintenance of the operation and temporary stops should be determined. In this context, a procedure on safe working methods should be prepared. In this procedure, control methods and best practice methods should be considered to reduce the risk of failure and error. A strategy and method should be developed to follow the current status of the equipment for the method and control of aging equipment and corrosion risks in the organisation and measures should be determined and these should be followed systematically.	3		3	1		9	9	9	9	3	1	235
	5	Maintenance plans, maintenance strategy and targets should be determined. In addition, employees responsible for maintenance should develop a method for maintaining and retaining equipment maintenance frequency and records. When necessary, these methods should be explained by the maintenance supervisor.			1		1	3	3	9	3	1	3	120
	5	Criteria such as impact, vibration, corrosion, mechanical stresses and chemical deformations must be included in the planned maintenance content.					1	3	3	3	3	3	3	95
Management of change element	5	Change metrics should be determined for activities such as new facilities, new processes or planned changes that are likely to be made.			3	1	3	9	9	9	3	1	1	195
	5	A method for planning organisational changes, technical changes, including permanent, temporary or emergency changes, should be determined.			9	1	1	9	9	3	3	3	3	205
	5	In change management; a method should be established to cover each change related to employee changes, technical changes, changes in hazardous substance storage, changes in equipment and changes in the process.			1	3		3	3	3	9	1	1	120
	5	The critical change in the determined method should also cover the issues of analysing the risks related to the change, cooperation and coordination with the relevant units.			9		1	3	3	9	9			170
	5	These changes should be followed up with the relevant units and the changes should be recorded.	3	3	9							9	9	165
	5	All employees in the organisation should be informed about the change.		9	3	3				9	9	3		180
Element of planning for emergencies	5	A plan for emergency preparedness should be established. In this plan, emergency situations should be identified, drills should be carried out to prepare for them and special training should be given to the relevant employees for emergency preparedness.	9		3		3	3	3	9	9	3	3	225
Element of performance monitoring	5	A method should be determined for monitoring the compliance with the targets in the SMS. An action plan must be created and followed for targets that result in failure. Measures taken and lessons learnt from accidents and incidents must be analysed, followed up and recorded.		3	3	1		9	9	3	3	9	3	215
	5	Feasible performance targets should be set for the SMS. Performance indicators should be routinely reviewed each year.		3	3	1	9	9	9	3	3	9	3	260
	5	Major industrial accidents and near-miss incidents must be recorded and reported. These reports must be announced to all employees in the enterprise by an appropriate method.		3	3	1	9	9	9	3	3	9	3	260
Supervision and inspection element	5	The effectiveness and performance of the SMS should be monitored periodically. The audits conducted by the senior management for the SMS should be analysed and an audit structure should be established to cover any changes.			3	3	3					9	9	135
	5	An internal audit structure should be established to evaluate and audit the SMS.			3	3	3					9	9	135
	5	Periodic internal audits should be carried out to audit the elements of the SMS, provided that they do not exceed 2 years. These internal audits should be carried out by officials from the organisation or outside the organisation with the approval of senior management.			3		3					9	9	120
	5	An internal audit report is prepared after each internal audit. The report includes audit findings, audit results and recommendations, if any.								1		9	9	95
		Technical importance points	165	175	465	145	395	425	425	445	410	630	465	4145
		Importance %	4%	4%	11%	3%	10%	10%	10%	11%	10%	15%	11%	100%
		Prioritisation	**10**	**9**	**2**	**11**	**8**	**5**	**5**	**4**	**7**	**1**	**2**	