UTILIZING CRAVE FRAMEWORK FOR A BETTER VALUE ENGINEERING AND RISK MANAGEMENT INTERGRADATION IN CONSTRUCTION PROJECTS

Kamal Jaafar

UNIVERSITY OF WOLLONGONG IN DUBAI, UNITED ARAB EMIRATES

Bilal Maarouf

PROJECT MANAGER, HELIOPOLIS CONTRACTING, ABU DHABI, UNITED ARAB EMIRATES

Ahmed Elsayeh

DIRECTOR OF PROJECTS AND QUALITY AT SMARTWORLD, UNITED ARAB EMIRATES

Abstract: The construction industry in UAE, companies tend to take informal risk without calculated measures. Companies need to control risk in order to create value and maintain the quality of their services. To accomplish this, risk management team and value engineering team should be working as one team. Through Value Engineering and Risk Management, companies will be succeeded in delivering their project with low risk at a high value. In order to achieve better value for money and quality deliverables, the industry will require an effective management for the risk integrated in their project. Therefore, the integration of value engineering and risk management is essential to maximize the project value and will enrich the consequences of both processes. Furthermore, the integration of both procedures will improve the efficiency of the workshop activity and hereby it will provide a powerful tool management within the construction industry.

There were different terminologies for the integration of value engineering and risk management that is described in this research. The CRAVE terminology which is a combination of Cost Risk Assessment and Value Engineering is one of the processes that integrate value engineering with risk management. Existing research revealed how the CRAVE process was used successfully in the infrastructure and transportation related projects. However, it is evident from the literature that the CRAVE process was not implemented for the construction of different types of buildings. This research will investigate the possibility of implementing the CRAVE process on a residential type building. The construction of high class villas will be used as a case study and will explore the effect of this integration on the value of the project. The author interviewed several engineers, who are the decision makers in the project to study the effect of CRAVE processes on the project and how it should be implemented.

The research concluded the framework of the integration of VE and RM that can be used in the construction projects and showed the following benefits:

- Developing the knowledge of the project's uncertainty and risk
- Better assessment for the VE alternatives.
- Maximizing the opportunities of a project while minimizing their risks.
- Provide an adequate tool to the project team in providing an estimate for cost and time.

Keywords: CRAVE Framework, Value Engineering, Risk Management

INTRODUCTION

This section focuses on identifying the effect of value engineering on risk management in the business environment. The background of the research study and the construction industry are reviewed in this section. The research questionnaire will be constructed in this research for predicting the process of adding value engineering in the process of risk management in the construction project. The research question is based on the research aim formulated in the study.

Background of the research

In the past two decades, public agencies were failing to deliver transportation and infrastructure projects within time and budget (Khalid & Smith, 2012). This created financial consequences which led into reducing the capital investment. Consequently, uncertainty arise in the planning process due to constraints on available funding. That created the need of integrating various techniques and processes like cost risk assessment (CRA) and value engineering (VE) to form a new process called CRAVE. This process helped in delivering the project on time and within budget (Khalid & Smith, 2012). This research will investigate the CRAVE framework and how it could be utilized in different types of projects.

The study in this research project is based on detailed analysis of the value engineering for identifying and managing the risk associated with the industrial projects. The research assesses the application of value engineering as a risk management tool for the business environment. Value engineering and risk management are widely used in the construction industry (Abd Karim et al., 2007). The construction industry analyses the function of each activity and resources required to conduct each activity and the associated risk is identified. Value engineering for construction plays a significant role in risk identification in business activities.

Value engineering is a systematic method that can be utilised to create various feasible alternative solutions to a business environment (Khatib, 2015). Abd Karim et al. (2007) suggested that value engineering assists the engineers to recognise the optimum method of meeting a business need. P. Tang and Bittner (2014) reported significant cost saving by various domains including construction management, infrastructure engineering, manufacturing engineering when value engineering is implemented. This research study will identify the phases of value engineering that deals with the risk associated within a construction project. Value engineering process maintains the sustainability of the construction project by increasing the value of goods and services, reducing the cost of the construction project and deliver the project on time.

This research study identifies the phases of value engineering process. These phases include information and analysis phase, functional analysis, speculation phase, evaluation phase, development phase, and presentation phase (Rao & Ranade, 2014).

Construction industry

The construction industry in the UAE mainly deals with the construction of the residential or commercial building in the real estate, construction of the road, bridges and repairing of the existing construction. It is well known that the construction industry is one of the booming industries in the present business environment and requires producing quality goods and services to the customer. The construction industry requires the value creation in the construction development and it requires proper planning of value engineering for designing the phases of development.

Watfa and Sawalha (2021) stated that the value engineering in the construction industry had been developed far away from its initial objective which was searching for alternatives to the shortages of materials. VE is used at the planning stages by enhancing the value and augmenting the life cycle of a project. Therefore, VE is comprehended to expand client satisfaction and value to the business. The predictability of the cost of construction the project has increased at large extent in last few years with the application of value engineering.

The construction industry has maintained the upward trend in term of assessing the predictability of cost. The predictability of cost is assessed in every phase of the development of the project with the implementation of various phases of value engineering including information and analysis phase, functional analysis, speculation phase, evaluation phase, development phase, presentation phase and risk response action.

Rationale of the study

A value is added to a project by using the Value Engineering process which includes the assessment and analysis of the resources and output of each activity of the construction project. O. Tang and Musa (2011) mentioned that the introduction of Value Engineering process in the construction project enhances the sustainability and customer satisfaction on the goods and services of the project. Hence, it is an important factor in analysing the performance of the construction project and assessing the risk associated with the construction project.

The application of Value Engineering on the construction project helps to predict the cost associated with each activity of the project to reduce the cost of the entire project. In the present economic climate prediction of the feasibility of value engineering process over a construction project is an important factor to eliminate waste and for a more sustainable business completeness.

The application of Value Engineering on a construction project has shown to improve the business performance by adding the values in every phase of the development. McShane et al. (2011) stated that the value added by the business organisation not only in terms of quality but also in terms of less environmental impact, reduced energy consumption, reduction of the overall cost of the project. The value engineering mechanism minimises the risk by adding values to the production process of the business. Tohidi (2011) argued that the value addition to the construction project enhances the customer satisfaction on the goods and services delivered by the business organisation and eliminate the business risk within the construction industry.

Furthermore, this research will identify alternative risk associated with the business including the financial risk, business risk, project risk and technological risk associated with the project and the steps followed in the value engineering process for mitigating the risk assessment of the business.

Research Problem

The value engineering mechanism application determines the performance of the construction project from a financial point of view. Hence, it is important to evaluate the factors considered in the value engineering mechanism for developing the construction project under investigation. On the contrary, the process, which is implemented by the value engineering mechanism for reducing the cost of the activities of the business, needs to be assessed. The phases of the value engineering process for maintaining the sustainability of the construction project is also required careful prediction of the decision maker for managing the risk associated with the construction project. Therefore, the detailed analysis of the applicability of value engineering process for creating an efficient construction project is required to be evaluated in this research. Furthermore, frameworks like CRAVE framework is tested on infrastructure and transportation projects. Hence, this process of integration will be investigated on other type of projects like commercial building projects.

Research aim

This research project focuses on predicting the risk associated with the construction business and application of value engineering for the management of the risk within the business. The research determines the mechanism of value engineering to increase the value of product and services offered by the construction industry in terms of cost and time. Hence, the aim of this research study is to identify the relationship between value engineering process and the performance of a construction project and to optimise this relationship.

Research objectives

The following objectives were set for this research:

- Evaluate the application of value engineering process within the construction industry
- Utilizing the CRAVE framework in construction projects within the UAE.
- Establish a relationship between the value engineering process and risk management for a construction project
- Formulate recommendation on the application of value engineering application on the risk management

Research questions

The research question is formulated based on the above-mentioned research objectives of the study, which are as follows-

- How is the value engineering process applied on a construction project?
- How can value engineering be integrated in the processes of risk management?
- Is there any relationship between the value engineering process and risk mitigation of a construction project?
- What are the issues faced by the construction industry to mitigate the risk by value engineering mechanism?

LITERATURE REVIEW

Introduction

This section presents a literature review study for the research topic of this paper. A detailed investigation is performed to gather information on the previous research frameworks of risk and value management and how the integration of these two tools can be implemented on an industrial construction project. This literature review will help in understanding the value engineering concepts and the risk management analysis that can be used for this research. Additionally, this information will be used to evaluate the impacts of value engineering and the advantage of using value engineering in construction project.

Each of the two disciplines will have its own framework and will be discussed in this section. Furthermore, the framework of the integration between these two disciplines will be discussed. The aim of the literature review is to identify all existing theoretical models and framework that are related to value engineering and risk management and their implementation on construction projects. The target is to test the theories and the framework on an industrial project and quantify the benefits. These theories, as well as the models, will improve the development of the idea about the research that is to be performed in order to form a relationship among the value engineering and risk management of a construction project.

Risk Management

Risk Definition

There are several definitions of risk. The Association of Project Management stated that risk is any outcome on the

progress of the project's goals due to an uncertain incident thatcan help in providing an increasing information based on could take place and affect the planned outcome and targetquantitative data. Nieto-Morote and Ruz-Vila (2011) also or risk people lives and wellbeing. Thus, risk and uncertaintyargued that there is a continuous process of risk management are two wide perceptions used in the literature that is coveredmainly the risk identifications, all contractual parties are in the risk management field. There is a limitless amount ofcontinuously adopting the several learning approaches as all risks that a project can experience in both the planning andthese past projects are placing the real-life scenarios such the execution stages. Every project manager deals with risksthat it can help over gathering experience that is placing all on a daily basis, continuously and throughout the life cycleparties in a good state.

of the project there will be some degree of certainty (Siraj & Fayek, 2019).

Concepts of Risk Management in Construction Projects

Risk Management is the most important area of discussion among professionals working in the field of construction. Increasingly, professionals are engaged in risk management even before the project contract is signed off. It is difficult to imagine project management without formal or informal risk management plan. According to Kuo and Lu (2013), it can be stated that before identifying and discussing the term and management, it is important to identify the existence of risks within the managerial skills of the construction project. Taroun (2014) explained that proper management of all assets are very much prone to several damage issues and are huge risk factors in order to form a proper management of the construction business project. Taylan et al. (2014) also opined that there are mainly two types of assets namely the primary assets (for example: information, activities, and processes) as well as supporting assets (for example: networks, personnel, equipment, software, organizational support, and premises). These are the two main assets of a construction project that are related to a potential damage from activities of a high risk. The main risks of all these assets are that they are very much prone to damages.

The literature showed that within the last four decades, there are many risk management research and adaptation within the construction industry (Zavadskas et al., 2010). Construction projects are exposed to several risks that is caused due to the involvement of many contracting parties namely the designers, contractors, and owners. Winch (2009) stated that all contractors have traditionally used the high markups in order to cover all risks but this traditional method is no longer an effective approach as all margins has become smaller.

Walker (2015) stated that the systems that are used for the risk management are solely focusing on the quantitative analysis as these techniques allow the lessons learned, remedial measures, problems and risks from previous other projects are to be reused or captured while developing new projects. Abdelgawad and Fayek (2010) also indicated that the successful instalment of risk management in the projects

Processes of Risk Management

According to Curran (2006), risk can be divided into three main stages:

- Risk Identification
- Risk Assessment / Analysis
- Risk Response

Risk Identification

Risk Identification can be performed by different technique and that there are no specific guidelines to follow or utilize, and that before identifying and discussing the term and management, it is important to identify the existence of risks all of these techniques depend mainly on experience (Hiley & Paliokostas, 2001). According to PMI (2013), identifying risk is a process of identifying the threats that might affect the project and then register them along with their appearances and features. According to various literature, the risk identification process can be placed together as shown in Table 1 (Ovidiu et al 2011, PMI 2013) (Rory, 1996).

TABLE 1- RISK IDENTIFICATION TECHNIQUES

Information gathering techniques	Workshops
	Brainstorming
	Interviews
	Benchmarking
	Expert Judgement
	SWOT Analysis
	Delphi technique
Diagramming techniques	Cause and effect diagrams
	System or process flow charts
	Templates
Analysis techniques	Study project documentation (plan, files etc.)
	Study specialist literature
	Checklists analysis
	Root cause analysis

Fig. 1, illustrates that risk in the construction can be divided into three main groups (Zavadskas et al., 2010); namely: External, Project and Internal risks.

External Risks are beyond the governance of the project management team and include political, economic, social, weather, etc.

Project Risks concentrates on the triple constraints of the project that is time, cost and quality

Internal Risks which are related to the resources, project members, the construction site or the contradiction in the documents and information available.

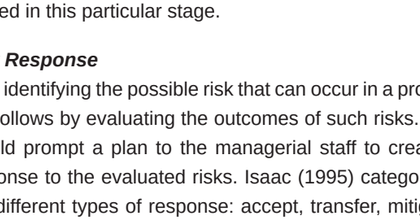

FIG. 1- RISK IDENTIFICATION GROUPS (Zavadskas et al., 2010)

Risk Assessment / Analysis

The second stage in the risk management process is the risk assessment. In this stage, the gathered information about the possible risk will be analysed and assessed. It is used to quantify the degree of the risks identified. Heinz (2010) stated that risk assessment includes the observance of the threat cause, the outcome, and the probability in order to evaluate the imminent risk without setting up controls. Furthermore, it includes the identification of the controls, an evaluation of their leverage and the subsequent level of risk along with setting up controls in place. Dallas (2008) supported this by stating that risk assessment is done in two stages qualitative assessment and quantitative assessment. The qualitative assessment is when risk is registered on an illustrative scale of high to low level, while in quantitative assessment, the risk is identified by its probability and impact based on the numeric evaluation. Curran (2006) however, stated that huge resources are wasted in this particular stage.

Risk Response

After identifying the possible risk that can occur in a project, this follows by evaluating the outcomes of such risks. This should prompt a plan to the managerial staff to create a response to the evaluated risks. Isaac (1995) categorized five different types of response: accept, transfer, mitigate, avoid and contingency. He also concluded that choosing the timing of the response is more important than choosing the type of response.

Risk Management Frameworks

Growing concept of project risk management has facilitated a number of new software for risk analysis and risk management frameworks. A traditional risk management framework inside a work environment facilitates identification of risks and their types, their degree of impact and formulation of a proper risk mitigating strategy (Siraj & Fayek, 2019). The construction industry is regarded as a high-risk industry; numbers of the risk management frameworks have been developed. A particular framework adopted by Kerzner (2013) showed that techniques of risk analysis and decision analysis via multi-attribute value theory are most important for mitigating risks. Mootanah (1998) stated that while developing a framework of risk, it is most important to build up techniques for perceiving the risk, which implicates a greater requirement for knowledge in risk perception. Knowledge of stakeholders in risk perception is also important, which means if stakeholders have no great knowledge of the undergoing projects, it can lead towards unidentified threats in the construction. However, that might not be physical every time but the risk in managing and allocating the resources is also creating a hindrance for the project. K. L. Smith (2012) mentioned that risk management is costly and time consuming specially on a small project with a small overhead margin. Cretu et al. (2011) stated that formal risk management techniques are not used by engineers and their managers in the construction field. Therefore, risk management framework must be improved and modified by integrating with other management disciplines like value management and create a model that focus on cost modelling and value engineering. Therefore, risk management and value engineering are integrated process for which both approaches in the management of value are becoming important (Berawi, 2010).

Value Engineering Background

Value engineering was introduced by Lawrence Miles from General Electric in the 1940's and it was a response to the shortage of skilled labour, raw materials, and component parts that they faced during the second world war (Taher, 2010). There are two terminologies which are sometimes used to refer to the same application; value engineering (VE) and value analysis (VA). Value analysis is a technique applied to improve existing process, service or project with the main objective is a cost reduction. However, it may be used as a tool to improve performance or quality. While VE is an organized process that has been effectively used by a wide range of companies and establishments to achieve continuous goals (Al-Yousefi, 2008). It is a technique applied to identify optimum value solutions during new product development, process or projects activities.

Berawi (2010) described value engineering as a process that has been developed to give the best value for projects, products, services, or processes. It Essentially focuses on the concept of functions of a product or service and follows the thought based on the functions, that is what something does rather than what it is. Hence, instead of looking at the problem that is presented which may be an existing building or product, the problem is being defined in term of functions. For instance, if one is considering the main function of a multimedia projector, then the answer is that it projects an image, but the projector actually does some other secondary functions, so, for example, the fan inside the project is used to rejects heat from the projector. That secondary function is something not required by the customer, the customer wants to project an image. Therefore, the secondary functions are supporting how the basic function is being delivered. Hence, finding ways that eliminate or minimizes those supporting functions to deliver the basic function could achieve greater opportunity. Value engineering is sometimes interchanged with the terminology of Value Management or Value Analysis (Ranesh et al., 2012). However, some researchers argue that and considered that value engineering is a part of the Value Management. The value can be expressed as a ratio between the function and cost as shown in the following formula (Leviäkangas & Hietajärvi, 2010):

This formula is a transfer function ratio of the output over the input. The “Value” relate to benefits, which could include quality, reliability, and appeal to an input of resources such as cost, time, and energy. Therefore, the increase of the “Value” can be achieved by either increasing the output or reduce the input. A competitive advantage of a project, product or a service can be achieved by a better value and better quality at lower cost.

Concept of Value Engineering in Construction Projects

Kerzner (2013), opined that the basic methodology for the usage of value engineering is done in order to solve problems that are related to the identification, solving as well as the elimination of the problems related to unwanted costs while they were improving the quality and function. Sears et al. (2015) also stated that the main aim of value engineering is to increase the value of the products as well as satisfying the performance requirements of the products at a low possible price. Walker (2015) also argued that within the construction project it involves the considering of the materials, transportation issues, construction methods, profits, costs and so on.

Value engineering should be started at the inception of the project where there is a need to gain large benefits (Fellows & Liu, 2012). Here the contractor has some input in order to make a significant contribution to the changes required of the contract and is not affecting the completion dates, timescales and also, no incarnation of the additional costs that can easily outweigh savings over offer (Hwang & Ng, 2013).

Hwang et al. (2014) stated there are several procedures that are involved in the value engineering processes of a construction project. They are:

- **Identification of main elements** of the services as well as products of the construction projects
- **Analysis of the functions** of all these elements of construction project
- **Development of all alternative solutions** helps over delivering all functions of the construction project
- **Assessment of all alternative solutions** of a construction project
- **Allocation of the costs** for all alternative solutions of the construction project
- **Development of alternatives** having alternatives with the highest success likelihood in a construction project

Most reviewed literature indicate that Value Engineering is usually adopted by organisations and teams to improve quality, increase reliability and availability of product or process, and therefore increase customer satisfaction. It is highlighted that value engineering would improve the performance of an organisation by using resources more effectively and efficiently, identifying problems, and recommend calculated and measured solutions. The VE method integrates cost, schedule, and scope and can be used to predict the planning and the outcome of future activities. However, there are some weaknesses which should be noted. Firstly, successful VE results are very much dependent on the quality of information brought to the VE team for evaluation. Secondly, VE is a product oriented, and time is not function of the VE parameters, hence it improves the product or process rather than shorten the process time. There are many misunderstandings and biases against VE that have been built up over time due to misuse of the methodology. This have resulted in the perception that VE as mainly a cost saving exercise and hence reduce the quality of the product or process.

Process of Value Engineering in Construction Projects

In the previous section, it was noted that with effective use of value engineering, the function of a product or service can be improved. It should also be mentioned that there must not be any compromise with the service quality or its reliability by using VE (Zetha et al., 2009). The VE process needs professional from various sectors with expertise related to the concerned projects, and are able to work as a team. Value engineering relies on functional team building principles and therefore there should be more focus on listening, observing and creating solutions along with efficient decision-making ideas (Alaqad et al., 2015). The various steps that are included in the Value engineering process include selection, investigation, specialisation followed by evaluation, development, presentation, implementation, and audit (Dallas, 2008). Other researchers summarised the principle of VE by six phases (Information, creativity, evaluation, planning, reporting, and implementation).

Selection

This holds the responsibility of selecting the project for value engineering analysis; it is usually controlled by the team. There are some requirements to conduct a study, there are some criteria that are used to select projects, but it is not limited to high cost and high priority projects, it is important but there are a lower priority of projects and fails to meet the transformation agency’s budgetary cutoff. The sustainability exceeds the initial cost and its estimation. There must not be involvement of multiple stakeholders in the project, but there must be sensitive solution workshop, risk-based cost, and scheduled estimation (Dallas, 2008).

Investigation

At the investigation phase the study team determines what is important from the gathered information at the selection phase. It must include the phase of availability of information and how the problems can be solved. The investigation phase determines the availability of the concepts, in terms of VE such as function, cost, and worth. The information that is required to initialize the phase should be readily available. The length of the project can be identified and determined. The VE team must investigate the further information and it is necessary to complete the investigation phase. The functions of the projects and its elements need to be analysed in the next stage of production. The function that denotes the specific accomplishment needs to be achieved by the elements or combination of the elements (Dallas, 2008). Selection and Investigation phase (Information Phase) brings all team members to a common, basic level of understanding of the project. It identifies the specifics and the operational side of subject (Al-Yousefi, 2008).

Creative

Creative refers to the phase that is followed by the investigation and the benefits of the VE techniques are manifested in this process. The techniques are delivered in this to the projects are designed in that systematic way. The VE study group utilizes to conceptualize and to create a huge rundown of potential answers for the issue that is portrayed by the two-word capacity, which prepare the group to enter the following stage (Dallas, 2008). The outcome of this phase provides a wide choice of ideas with a variety of possible alternatives to perform the functions (Al-Yousefi, 2008).

Evaluation

In the evaluation phase, the benefits and challenges of the alternatives are listed. The advantages and the disadvantages of the process are explained in general terms. The terms help in the conceptualization of the alternatives and highlight the best alternative for the project. To conduct the analysis, the VE objectives are satisfied and a blend of performance is measured (Dallas, 2008).

Development

When the team selects the best alternatives that are fully developed through the cost estimation, the test data validation and other technical areas of the assumption in between the development of the process. The study team designs and formulate an implementation that describes the process of the agency that must be followed for implementation of any recommendation (Dallas, 2008).

Presentation

The final product of the study is the formal VE report and the presentation of that is recommended by the VE team members (Nieto-Morote & Ruz-Vila, 2011). The VE report serves a step by step implementation of the project and the work that is accomplished in between the team’s recommendation. The teams’ deliberation is tracked along with the consideration; it aids in implementing the recommendations. It serves as a tool for the future project development. The final phase of the VE includes the determination of the actual amount of saving that is generated by the VE analysis, based on that several implementations are being made. The outcomes of the recommendation are achieved through focusing on the VE analysis record (Dallas, 2008).

Value Management Frameworks

After the evolution of the project management in the American manufacturing industry, there have been serious

developments in the field. The society of American Value Engineers has been established in 1959. AVE body has standardised the value management framework to include value analysis and value engineering whereby the VE can be recognized as techniques and systems set in a procedural way, where those VE functions can meet with performance and justify the overall required cost. Under value management frameworks, the notion of value methodology is assessed through the integration of a multi-disciplinary team, who is responsible for making up a job plan with a prerequisite of function analysis (Abd Karim et al., 2007). As illustrated in Fig. 2, it is concluded that there are three techniques in conducting the value management process. The framework intends to identify potentials and competence in a broader range of skills. In the construction industry, value management is important because the experts are seeking for most value against the expenditure. However, development of SMART value management framework during the 90s emerged as an important one because of its ability in managing multiple numbers of stakeholders' interest (Hamid et al., 2011). The global value management framework was composed of two particular elements job planning technique and life cycle costing. This job planning is scientifically approved as well facilitating style and devices of value management make this approach a hard and pragmatist one.

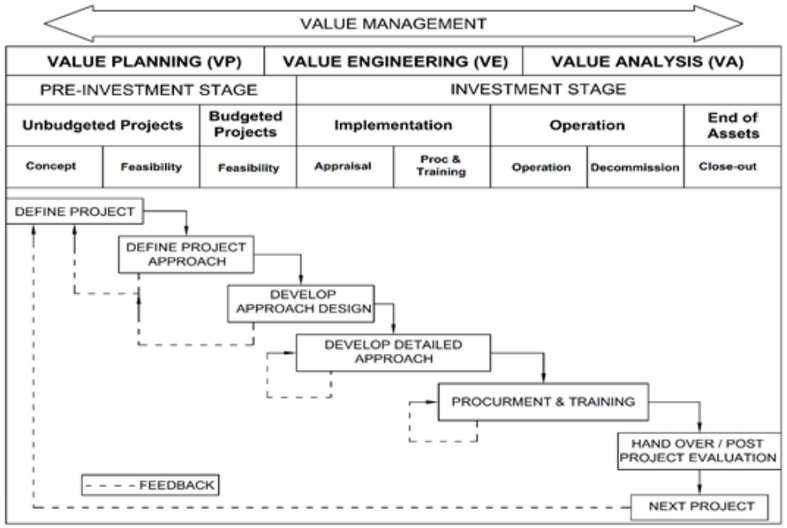

FIG. 2 TECHNIQUES IN CONDUCTING VALUE MANAGEMENT (Abd Karim et al., 2007)

Value engineering proved its effectiveness in increasing project value, but on the other hand, it is still developing stage and hence it has some shortcoming and weaknesses. Out of these weaknesses is the difficulty to choose the team members with suitable skills. Beside that the unavailability of a standard definition of value engineering makes it difficult to widespread its application (Green, 1999). Also, some literature stated that this methodology can also be considered as time-consuming and can come at high cost.

Integration of Value and Risk Management

The risk is always there, but that should not prevent the company from making calculated moves (Dallas, 2008). A new approach to thinking about risk new ways to communicate risk is required. Some Executive Management teams are obsessed today about operational data not really directly associated with the achievements of the desired business outcomes. They lost sight of the true goal and this disconnect means wasted effort with little value perpetuating the idea that risk management is a wastage of time (Curran, 2006). Putting risk management in a business context is the foundation of risk-adjusted of value management (Sondergaard, 2011). This research is designed to address the broad disconnect between strategy setting and strategy execution. In a similar way of using the key performance indicators to help the manager succeed, it is required to have a measurable key risk indicator to help managing the risk. Companies that integrate value engineering with risk management could outperform their competitors.

Construction industry faces huge challenges and they need to manage their risk better and identify the value at an early stage of their projects (Dikun & Rahman, 2010). Best industry outcomes in terms of value optimisation cannot be delivered unless there is a joint effort by the industry. Until now individual firms have been working on their own on what become a box ticking exercise and more often all have been dealing with and catering for the same risks, without working together to identify value opportunity (Kirk, 1995). This is not a good use of time or an efficient way to work. Curran (2006) suggested that firms are looking towards a collaborative industry work environment where all can sit together looking at a project and identify what are the threats and opportunities. Then appropriate responses can be initiated and identify whether a value can be created. This will lead to a greater transparency and result in a more effective industry where all players are working together in the interest of what is best for the construction industry. To help achieve this vision, there is a need to create an industry-wide collaborative approach to risk and value management. Fig. 3 illustrates a generic model for the integration of value and risk management.

Project Stage	Value Study Type	Issues addressed	Outputs	Risk Study Type
Inception	**VM0** Need Verification	Strategic Fit Need for project	Recommendation to sponsors	**RM0** Strategic Risk Study
Strategy & Feasibility	**VM1** Project Definition	Linking design consideration to project objectives	Value & Risk Profiles Project Brief Risk Allocation Management Plan	**RM1** Initial Project Reviews
	VM2 Brief Development	Selecting options Procurement Strategy Project organization	Brief Risk Register Management Plan	**RM2** Project Risk Reviews
Pre-Construction	**VM3** Value Engineering	Optimising cost, time and quality	Inform design development and tender documentation Risk Register and Management Plan	**RM3** Detailed Project Reviews
Build	**VM4** Design Cost Review	Review cost effectiveness Optimise components	Refine detailed design and construction Construction Risk Management Plan	**RM4** Construction Risk Management
Use	**VM5** Project Review	Project review	Lessons learned for future projects Identifying future project needs	**RM5** Operation Risk Reviews
	Arrows indicates potential re-iterations which may be necessary if circumstances require strategic changes to the project			

FIG. 3. INTEGRATION OF VALUE AND RISK MANAGEMENT GENERIC MODEL (Dallas, 2008)

Terminologies of the Integration of Value Engineering and Risk Management

a) Cost Risk Assessment and Value Engineering (CRAVE)

The word CRAVE came from the combination of the initials of cost risk assessment (CRA) and Value Engineering (VA). It is a process of combining two different techniques, the cost risk assessment and value engineering. It is an integrated process that helps in evaluating the alternatives and the recommended delivery methods in order to deliver project in time and within budget (Berends & Long, 2007).

K. Smith et al. (2011) stated that all project managers seek CRAVE for the proper combination of the costs of the risk assessments with the help of the proven tools as well as the processes of the value engineering. The Cost Risk Assessment and Value Engineering (CRAVE) can be developed over a proper explanation of an example that can help to properly understanding of these factors.

Washington State Department of Transportation WSDOT claims that they are committed to a constant evaluation of the costs that would help the better management of the projects as well as properly respond to the public concerns and scepticism that can provide the actual costs and project estimations. According to Abdelgawad and Fayek (2010), also stated that WSDOT is also tackling the issues since 2002 when the Cost Estimate Validation Process or CEVP at the groundbreaking efforts that help over the quantification and identification of all potential risks that is creating an impact on the schedule and budget of the project. Zavadskas et al. (2010) stated that the CEVP is a workshop where a team of top risk managers and engineers from the national and local public agencies or private firms examine the transportation projects and also review their details with WSDOT engineers.

On the contrary, Winch (2009) stated that Cost Risk Assessment or CRA is a common term used in order to describe the broad program of the risk-based assessment that is conducted with the WSDOT and is also stated as the workshop process that is similar to that of the Cost Estimate Validation Process (CEVP).The primary goal of the risk management process is to vendor the performance among the companies. Effective risk management helps in cost saving as it deals with precautions without any financial cost in between the process. It also ensures that time is saved in any project. K. Smith et al. (2011) explains how the How CRAVE process works. A summary of his steps is shown in Fig. 4.

The process consists of the following four steps:

Step 1: Baseline Risk Assessment. Firstly, the baseline cost along with the schedule should be first reviewed. The risks with respect to the baseline are then identified. After the risks being identified, they should be assessed and quantified in terms of project's cost and schedule.

Step 2: Value Engineering & Risk Response. In this step the value engineering recommendations is developed in order to mitigate or avoid high risk elements. Also, the value recommendations that add value to the project either by modifying project scope and/or schedule is developed in this stage.

Step 3: Risk Analysis on Response Strategies. In this step the risk related to the response of the strategies is being identified. Also, the threats and the opportunities are then identified in terms of project's cost and schedule.

Step 4: Tracking, Monitoring, and Control. Finally, the risk owners are identified and the risk management plan will be updated continuously. Also, the cost and the schedule are updated at key milestones.

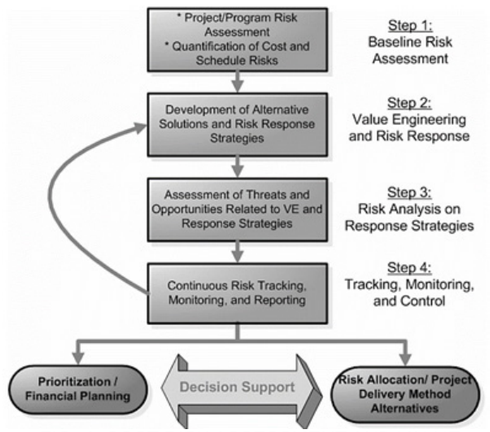

FIG. 4. COST RISK ASSESSMENT AND VALUE ENGINEERING (K. SMITH ET AL., 2011)

a) Value Based Risk Management (VBRM)

Most of the traditional risk management approaches suffer an inevitable imbalance within various phases of the risk management process (Curran, 2006). It has been observed in various studies that the first two phases of risk management, which are identification, as well as analysing the issues are favoured by a greater proportionate of risk managers and engineers. On the other hand, the last two phases of the risk management, which are mitigating and controlling the problems suffers from a lack of resources. In order to correct this particular imbalance within the traditional risk management the benchmarking along with grading scope are initiated, which is most effective for producing higher quality results within a short time period as well as resources. This modified risk management approach is considered as value-based risk management approach in the contemporary practices (Curran, 2006).

According to Walker (2015), the value based risk management is gaining a serious amount of popularity within the various organizations in the contemporary market. However, on the contrary, Abdelgawad and Fayek (2010) argued that the risk management consists of some critical annoying issues. The issues are mainly focusing on the first two phases of the risk management, which is quite inappropriate for the proper outcome. In addition, it has been also revealed that the value-based risk management includes some significant amount of disparities within the actual outcomes as well as predictions. In addition to that, various studies on the value risk management disclosed that the major dilemma in this particular approach it has less understanding and support within senior management.

As stated by Nieto-Morote and Ruz-Vila (2011), the effectiveness of the last two phases of the value-based risk management approach can be greatly disrupted due to the overemphasis on the first two phases of the risk management approach. On the other hand, the most important benefit of the value-based risk management is the impressive reduction of the human as well as financial resources in the first two phases, which is proved most effective for the last two phases of the value-based risk management approach. The value-based risk assessment most imperatively provides the assurance of the better quality of the analysis result in several important areas such as risk-opportunity rankings and contingency.

Apart from the above positive points, Curran (2006) identified some crucial attributes of this particular risk management approach. These advantages are a proper examination as well as optimization of the mitigation phase in the risk management. Moreover, it is quite remarkable in terms of enhancing the risk management skills of the overall team. In addition to that, the frequent analysis in a regular fashion is another crucial aspect of the value-based risk management approach which is essential for ensuring the control of the persistent risks and opportunities.

Benefits of Integration Risk Management and Value Management

The integration of risk and value management in construction project makes the projects flexible and dynamic by allowing a space for changes during the design phase (Mootanah, 1998). Therefore, the stakeholders associated with the entire projects can gain enough amount of value against the spent money as well as the amount of risk. Economically, the approach is viable because an industry can go for higher profit margin by increasing the reputation as a low-cost provider in the market (K. Smith et al., 2011). Therefore, it has to do something with the intangible ideas about the company such as reputation, corporate identity, and brand name. However, the integration is important for both the client and service providers because all information will be available to the client for assessing the risks and identifying any potential risks. As procurement procedures are continuously evolving in the construction industry, clients are thereby exposed to greater risk areas. However, the problem is that not all contractors have an adequate level of expertise and knowledge in managing risks, which means the process outcome might be negative and resource scarcity would be inevitable. Therefore, after the adoption of an integrated value management system, the contractors can identify potential risks their likely impact on the project in terms of cost and time. A concept is an important tool for the contractors for increasing the awareness and critically evaluating the factors of cost performance and their impact. However, other than identifying the risks, the contractors are able to take adequate measures so that risk are having less impact on the project performance. The integration in the framework asks for developing a trust-based framework that means there is adequate availability of information among the stakeholder over important decision-making processes. The conflicts and distrusts could be avoided, which can add more value to the project as well time and cost could be saved. As client's' consent is inevitable during a design change, the adequate measures on cost estimation are necessary to obtain and an integrative approach would help in affirming the client prior to any conflict and overall success of the project can be assured.

Summary

The literature has shown that Value Engineering is an important methodology to use and apply for both quick fixes or as an integrated part of organisations desire to encourage innovation and improve overall quality. Value Engineering is one part of the general total quality tools that can improve process and ensure a high-quality outcome. It enables the management of the team's thinking so that the best use of the knowledge and experience they have can generate new ideas to perform functions and propose alternatives (Al-Yousefi, 2008).

The literature review has identified some insight into the adoption of both risk management and value engineering within the construction industry. Details of how organization can benefit from their integration were presented in this section. Some executive managers around the world still considers risk management as a waste of funding as it allocates very high resources from cost and time perspective, Although, risk management got several advantages from controlling the risk and trying to eliminate uncertainties in the projects, however, in terms of cost wise it is not efficient for all projects. Therefore, the overhead margins increase substantially allowing them to lose their bid for projects. Moreover, companies find it expensive to implement this kind of management tools.

It was described how Value Engineering can help in the deficiencies of the risk management analysis. Companies can use techniques like value engineering to cut down the costs and reduce the allocated resources and integrate

those techniques into the risk management to gain the advantages of both types of management tools.

The literature review showed that the framework of integration of value engineering and risk management already exists. However, the framework was applied on transportation-related projects only. In this research the framework is applied for commercial and residential projects type. In this research the CRAVE framework will be investigated further to determine the benefits and the advantages on a construction based project using an actual case study. Several approaches and models will be used in this research to develop a better understanding of the interaction between value engineering and risk management. It is evident that VE and cost risk assessment shares several tasks and might be utilized by the same team, hence several advantages could be acquired in terms of cost and time savings. The literature showed that the CRAVE framework allows a project team to yield information that is crucial to decision makers and ensures proper project prioritization, adequate delivery method selection and efficient risk allocation (Khalid & Smith, 2012). The CRAVE process have been applied to project ranging from $2 million to $4 billion by the US department of transport (WSDOT) and proved to be very successful tool. In this research the CRAVE framework will be applied to a residential construction project to illustrate how this method could be beneficial for these types of project. The CRAVE process involves a continuous improvement to keep up with the needs of the project managers and to assist them in delivering the project in time and within budget.

METHODOLOGY

Introduction

This section describes the methodology which will be used for the study of Risk Management and Value Engineering analysis. Every research starts by a systematic search for information to obtain the relevant data that is related to the research area and hence are used to formulate the research questions. The investigation is an academic activity that involves an organised, logical and methodical approach of the data collection, interpretation and analysis to draw useful conclusions and recommendation.

The methodology of the research is to follow a structured study that helps to provide several useful guidelines in order to conduct the study. The section provides information on the research method chosen to assess both value engineering and risk management. It also describes how value engineering influences risk assessment for a chosen construction project within the UAE.

Methodology Selection

At the start of any research it is very important to understand all the sequential steps that are to be followed in any given research topic. Mackey and Gass (2015) used an analogy based on the "*Research Onion"* concept, as shown in Fig. 5. They found this method to be a useful tool for their research. It helped in a depiction of each of the steps that are required for conducting their research and provided all necessary direction for their research. They have suggested that this method helps researcher to keep track on the purpose of the research and the timely completion of the project.

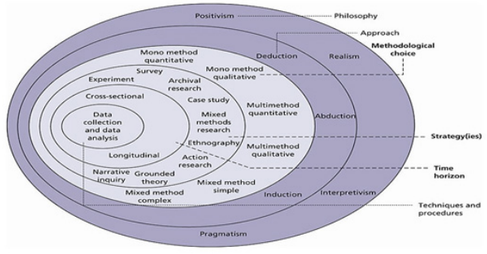

FIG. 5. RESEARCH ONION (Saunders et al., 2013)

Anderson and Shattuck (2012) stated that the research method can be performed over two main types of analyses (quantitative or qualitative). Quantitative analysis is mainly concerned with the generation of statistical and numerical data as well as facts. The aim of all quantitative analysis is to draw conclusions from the sample chosen and hence generalised for the full population using some statistical analysis. The qualitative analysis will help in gaining an in-depth of the subject area under investigation. Recent trends by many researchers is to use the mixed method approach or even the triangulation as described by Gioia et al. (2013) where a combination of both the quantitative as well as qualitative data have been used to generate and hence a comprehensive understanding of the particular topic is achieved.

For the purpose of the research in this study a qualitative method has been adopted to show the benefits of integrating both of the VE and RM techniques.

Case Study

Case study is about studying or observing a phenomenon within its real-life setting. There are some major steps a researcher has to follow when executing a case study as a research strategy. First step is to confirm that this strategy feeds into the research question and all the previous methodological choices. Second step is about selecting a case, there are types of case study; the single case study and the multiple case study. The single case study for instance will examine one company within an industry while the multiple case study will examine several companies within an industry. Third step is selecting a depth of the research within the case. For this type one has to choose between holistic case study and embedded case study. For the holistic case study, one will examine the cases as a whole entity while for the embedded case studies some aspects of the case is examined (Anderson & Shattuck, 2012). The benefit of this research study is that it can work well for all kind of research and would give a depth in the study. The downside of this strategy is that methodological choice and the methodological reasoning is harder to justify and the findings from this research strategy is difficult to generalize (Cameron, 2009).

To observe and recognize the relevance of integrating value engineering in the processes of risk management, the research strategy chosen in this study is a case study. The case study is a strategy where the researcher will examine a current trend in its real-life environment. In this research the case study chosen is construction industry project with 36-month maintenance of high class villas. The Project consists of main villa, guest villa, staff accommodation and substation. The project is planned to finish the construction in 2 years. At the time of implementing the application of value engineering and risk management, the project was in the initial stages. The author vision is to implement both disciplines in the project to show how cost, time and resources could be utilized effectively.

Data Collection

In order to collect the required data for research, interviews were chosen as a research instrument. Interviews with construction industry practitioners often play a vital role during all stages of the research project for identifying the real practices of an organisation in the field. Mackey and Gass (2015) stated that face to face interviews is said to be beneficial for eliciting all information from the respondents. It is said to be compatible in both the qualitative and quantitative research that helps in gathering rich and valuable data. Yin (2009) stated that interviews is a very powerful tool and widely used in many research. There is a negative aspect of interviews which include the respondents are often modifying their answers in front of the interviewer which is adversely affecting all responses. The idea behind the interviews is to purposefully select participants that will help the researcher satisfy the research aims and objectives. The aim of the interview is to focus on perceptions and experience of participants (Fraenkel & Wallen, 1990).

As described in section 4.2.3 construction of high class villas is used as a case study. Thus, in order to apply the CRAVE framework, professional participant from the project team will be interviewed. The professional parties will be divided into two groups, the first group will include: the client representative, consultant project manager, architectural, civil and electrical design engineers from the consultant team. The second group will include: the main contractor project manager, the subcontractor project manager, architectural, civil, electrical engineers from the construction team and three technical engineers from different manufactures of the systems which will be installed in the project. Thus, the total participants are thirteen. The CRAVE process was explained to all the participants prior to commencing with the interviews. The second group will be responsible on generating the different ideas and alternatives, while the first group will be responsible on assessing these ideas.

The interview questions are formulated to contribute to the different steps of the CRAVE process which will be described as follows:

Step 1 – Identifying the project risk, by performing risk register and the respondents will be asked to estimate the likelihood and estimate the impacts of the risks on the project cost, time and quality. The likelihood will have a scale ranges from 0.1 to 0.9, whereas (0.1) will be assigned for the low likelihood and (0.9) for the high likelihood, while the impact will have a scale range from 0.05 to 0.8, whereas (0.05) will be assigned for the low impact and (0.8) for the high impact. These scale ranges are extracted from the PMI book

Step 2 – Identifying the performance attributes, where the team will select four to eight attributes depending on the project. These attributes are comprehensively discussed. Also, the attributes are quantifiable and defined on a scale of 0 to 10, whereas (0) is assigned for an undesirable performance and (10) for the optimum performance. The scale range is adapted from the value engineering handbook for the department of transport of Washington.

Step 3 – Identifying the importance of each attributes, where the group will establish the importance and relative importance of the attributes and the relation between them. Thus, a matrix is formulated and named as a "(PAM)". This

matrix will be used to compare the attributes in pairs. A letter code is entered in the matrix for each pair, by recognizing the level of importance of each. If a pair is considered of equal importance, then both letters are entered (i.e. A/B) in the matrix.

Step 4 – Set up the performance "Baseline" for the original design, where the different ideas of the VE can be compared. Hence, the performance rating matrix is established, then the team rate the different VE ideas from 0 to 10 for each attribute. After that the total performance is calculated by multiplying the attribute's weight by the given rating. Finally, the total performance is obtained by the summation of the scores for all attributes.

Step 5 – Assessing the performance of the different VE ideas. After establishing the Baseline performance, it will be used to assess the concepts and ideas that was developed by the VE team.

Step 6 – Comparing the performance rating of the different ideas and the baseline projects. This is the final step in the CRAVE process, where the VE ideas are compared to the original concept. Then a summary of the value matrix is developed where it presents the total changes in cost, performance and value.

Summary

The present section attempted to provide the detailed study of methodology that will be used for conducting this research. All paradigms are elaborated at the beginning of the section. All the selected research approach, design and strategy have been presented in this section. Furthermore, the adopted methodology for this research has been chosen and justified.

The methodology used is a qualitative approach based on case study as the research strategy. The author will be using deductive research approach and exploratory research design. The interviews will be the significant method of collecting data. The methodology of CRAVE framework which will be used in the case study is being highlighted and described in this section. The next section will illustrate the processes of CRAVE for the project used in the case study.

DATA ANALYSIS AND DISCUSSION

Introduction

This section presents the results obtained from the research process with regard to the integrating value and risk management and its impact on the overall value of the project. It presents the answers from the conducted interviews which will be utilized in obtaining the risk register. It will utilize the CRAVE process for the project used in the case study. The description of the project will be followed by different steps of the CRAVE framework.

Project Description

The project used in this case study is the construction of high class villas located in Ras Al-Akhdar area in Abu Dhabi. The project consists of three villas: main villa, guest villa and staff villa. At the time of research, the project was in its initial stage where drawings and material submittals are prepared. Fig. 6 illustrates the construction project process flowchart. Initially, the client gather various information (like feasibility) and determine the project budget and forward this information to the consultant. The consultant is then start designing the project, issuing design drawings and determine the projects specification. The consultant provides the cost estimates to the client for his approval. If the client approves the design, the consultant then finalizes the plans and specification and then award it to the contractor based on a contract between the concerned parties. For the purpose of this research, the author will be studying small trend of the construction process flow chart which is the installation of emergency lighting system in the project. The team assigned for this research was not familiar with the CRAVE processes, but were interested to know more about it and demanded to know about the results of the research.

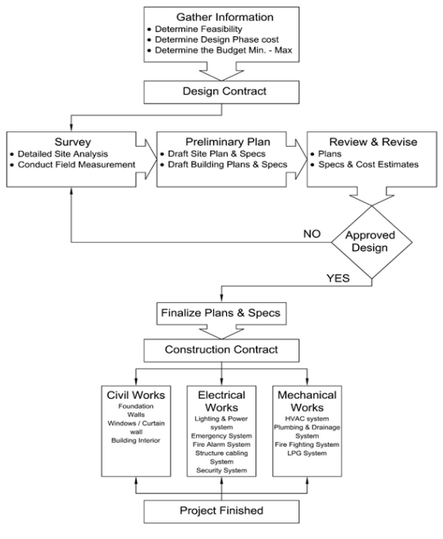

FIG. 6. CONSTRUCTION PROCESS FLOW CHART

Risk Assessment

The experience of the previous project was the main tool by the respondent in identifying the potential risks and uncertainty. The risks identified are presented in the risk register in Table 2. The respondents were asked to estimate the likelihood of the risk incidence and its impact on the project. As mentioned in the previous section the respondent uses a scale from (0.1 to 0.9) to assess the likelihood and (0.05 to 0.8) to assess the impact of the project according to Table 2. Thereafter, ratings to be assigned for each risk based on their likelihood and impact. The rating is calculated by multiplying the likelihood by its impact. The grey determines the level of risk; whereas the dark grey area presents the high-level risk, the medium grey area presents the low-level risk while the light grey area in between presents the medium level risk.

TABLE 2. PROBABILITY & IMPACT MATRIX

LIKELIHOOD (PROBABILITY)						
	0.9	0.05	0.09	0.18	0.36	0.72
	0.7	0.04	0.07	0.14	0.28	0.56
	0.5	0.03	0.05	0.10	0.20	0.40
	0.3	0.02	0.03	0.06	0.12	0.24
	0.1	0.01	0.01	0.02	0.04	0.08
		0.05	0.10	0.20	0.40	0.80
				IMPACT		

Furthermore, for each risk identification, the respondents were asked to suggest an action that should be taken to mitigate or avoid the risk. Finally, all the information is compiled in Table 3. Valuable information can be extracted from the risk assessment process which can be used as potential value engineering ideas. In addition to that the same group of engineers are required for both processes. Thus, in the next step the value engineering process based on the information collected from the risk assessment is applied.

TABLE 3. RISK REGISTER

#	Risk Description	Response		Risk Score		
		Type of Response	Description	Likelihood	Impact	Rating
1	As a consequence of high humidity or high temperature above the ceiling, the batteries in the self-contained emergency light could be damaged and needs to be replaced	Avoid	Use of centralized battery system	0.7	0.8	
2	As a consequence of the short life span of the batteries in the self-contained emergency light, it needs to be replaced regularly.	Avoid	Use of centralized battery system	0.3	0.4	0.12
3	As a consequence of replacing the batteries in the self-contained emergency light, several access panels are required in the ceiling.	Mitigate	Use of an adaptable ceiling design	0.9	0.8	
4	The requirement of several access panel may not be accepted by the Architectural engineer	Mitigate	Getting a new building design	0.9	0.8	
5	Non-Acceptance of the alteration of architectural aesthetics and changing from self-contained luminaires to centralized battery systems will require extra provisions.	Mitigate	Increase in project funding	0.9	0.8	
6	An extra room required to store the centralized battery system	Mitigate	Change the design to incorporate a battery storage room	0.7	0.2	0.14
7	Extra provisions required for the system wiring such as cable conduits, lamp holders, and lamp guards	Mitigate	Provide provisions for the required equipment	0.5	0.2	0.1
8	Change in illuminations levels below the required threshold	Mitigate	Source for lamps with low power consumption and high luminous intensity	0.3	0.1	0.03

Project Analysis

In this section, the project is analysed through the use of value matrix and performance attributes, and project cost.

Performance Attributes

This step is an essential part in the process of value engineering. The performance attributes are the characteristics that are important in achieving the objectives of the project. The first group that consists of the client and the consultant, are the persons who determine these attributes. Thus, were interviewed to define and agree on each attribute.

After that, the group defines the baseline concept that is related to the attributes. The information is compiled in Table 4.

TABLE 4. PROJECT BASELINE ASSESSMENT

Project Baseline Assessment		
Performance attributes	**Attribute Description**	**Baseline Design**
Efficiency	A measurement of the effectiveness of the devices used	Using of self-contained light fittings with LED fittings
Aesthetics	A measurement of the aesthetics of the villas	Using of the decorative ceilings with marbles and gypsum board.
Maintainability	A measurement of the long-term maintainability of devices	Using of self-contained light fittings
Environmental Impacts	A measurement of the permanent effects to the environment.	Usage of recyclable materials as well as usage of LED light fittings for low power consumption.
Project schedule	A measurement of the total project delivery time	March 2016 is starting of the project. Two year is the duration.

Performance Attribute Matrix

This matrix is utilized to clarify the relative significance of a particular performance attribute for the project. It is a method that uses a paired comparison to determine the importance of the performance attributes in meeting the project requirements and needs (Caltrans, 2009). Hence, this technique helped in providing numeric value for each attribute. The score of each attribute is calculated by adding all the compared importance attributes. Then the percentage for each attribute is calculated by dividing that score by the total number of comparison.

Table 5 represents the performance attribute matrix. It was found that aesthetics got the highest level of importance. Further when efficiency and maintainability put into comparison the respondent stated that they are of relative importance to achieve the project importance.

TABLE 5. PERFORMANCE ATTRIBUTE MATRIX

PERFORMANCE ATTRIBUTE MATRIX								
The attribute that is more vital for the project and need								
							TOTAL	**%**
Aesthetics			A	a	a	a	a	4	40%
	Efficiency			B	b/c	b	b	2.5	25%
		Maintainability			C	c	c	2.5	25%
			Environmental Impacts			D	d/e	0.5	5%
				Project schedule			E	0.5	5%
								10	100%
		a	More Important						
		a/b	Equally Important						

Also, the environmental impacts and project schedule were found of relative importance.

Idea Creativity

This is the phase where ideas are being generated by both groups of respondents based on the information available. Creative Idea List:

- Use of slave luminaires (central battery system).
- Use of multi-panel ceiling.
- Change the design to incorporate a battery storage room or compartment.
- Install lamps with high efficiency, low power consumption and high illumination intensity.
- Provide provisions & cabling for the required equipment.
- Constructing buildings with full length windows.
- Design of open or glass-covered fire escape routes.
- Early Procurement of the centralized emergency system.

Evaluation

This phase will evaluate the ideas that were generated by the brainstorming methods. These ideas will be compared with the baseline concept to determine which ideas are more effective than the others. The two groups will rate the ideas being generated (from 0 to 5). Hence the ideas with high rate will be exploited additionally, and the ideas with low rates will be discontinued. The rating values are described as follows:

- 5 = Major Value Improvement.
- 4 = Good Value Improvement.
- 3 = Equivalent to Baseline.
- 2 = Minor Value Degradation.
- 1 = Significant Value Degradation.
- 0 = Doesn't meet the Purpose & Need of the Project.

Table 6, represented the ideas being generated by the respondents and the rating of the different ideas based on their estimates. The ideas which scores high rating will be considered for the next step, while ideas with low rates will be dismissed from any further consideration.

TABLE 6. EVALUATING THE LIST OF IDEAS

#	Description	Advantages	Disadvantages
1	Use of slave luminaires (central battery system)	• Reduced maintenance costs • high illumination intensity • less disturbance during repairs downtime	• High initial cost
Aesthetics	Efficiency	Maintainability	Environmental Impacts	Project schedule
	C	**C**		
Cost: D / **Rating:** 5	Comments: The Central Battery System has high initial cost. However, the maintenance cost is significantly low when compared to other systems.			
#	**Description**	**Advantages**	**Disadvantages**
2	Use of multi-panel ceiling	• Reduced cost • Easy for above fall ceiling maintenance	• Very bad looking
Aesthetics	Efficiency	Maintainability	Environmental Impacts	Project schedule
D	**C**	**C**		
Cost: C / **Rating:** 1	Comments: In high class villas, cannot install this type of ceiling. Therefore, will be dismissed from further consideration			
#	**Description**	**Advantages**	**Disadvantages**
3	Change the design to incorporate a battery storage room or compartment	The system can be designed with as many batteries as possible since space is not a constraint	The battery storage compartment would take up a large floor space which would reduce the building's utility.
Aesthetics	Efficiency	Maintainability	Environmental Impacts	Project schedule
		C		
Cost: CD / **Rating:** 3	Comments: Moved to further development			
#	**Description**	**Advantages**	**Disadvantages**
4	Install lamps (LED) with high efficiency, low power consumption and high illumination intensity	• Ample illumination would be available to ensure safe evacuation of occupants during emergency situations. Safer for the environment.	High initial cost
Aesthetics	Efficiency	Maintainability	Environmental Impacts	Project schedule
	C		**C**	
Cost: D / **Rating:** 4	Comments: Moved to further development			
#	**Description**	**Advantages**	**Disadvantages**
5	Provide provisions & cabling for the required equipment	The provisions will enable the system to be seamlessly integrated into the building	Extra resources and work required to provide extra provisions, which increases the input and might affect the project schedule. while the project performance remains relatively constant
Aesthetics	Efficiency	Maintainability	Environmental Impacts	Project schedule
				D
Cost: D / **Rating:** 4	Comments: Moved to further development			
#	**Description**	**Advantages**	**Disadvantages**
6	Constructing buildings with full length windows		
Aesthetics	Efficiency	Maintainability	Environmental Impacts	Project schedule
Cost: / **Rating:** 0	Comments: Dismissed from further consideration			
#	**Description**	**Advantages**	**Disadvantages**
7	Design of open or glass-covered fire escape routes		
Aesthetics	Efficiency	Maintainability	Environmental Impacts	Project schedule
Cost: / **Rating:** 0	Comments: Dismissed from further consideration			
#	**Description**	**Advantages**	**Disadvantages**
8	Early Procurement of the centralized emergency system.	Purchasing the material early would mitigate the risk of price increasing	There is a risk of storing the batteries for long time without recharging them
Aesthetics	Efficiency	Maintainability	Environmental Impacts	Project schedule
				C
Cost: / **Rating:** 4	Comments: Moved to further development			

Value Engineering Recommendation

The performance of the high rated recommendation will be evaluated in line with the baseline concept. It is required from the two groups to measures VE alternative to reveal the degree each causes advantageous or unfavourable effects to the performance attributes, i.e. the overall percentage of the change in performance induced by a system change is based on its overall impact on the project. Table 7 represents the value matrix where the qualitative value based method is used to measure the benefits of the attribute on a scale from 1 to 10, where 10 is most beneficial. The scale is adapted from different VE manuals. The recommendation assessment procedure was hinged to a baseline score of 5, which was used as a base for the calculation of the resulting percentage improvement. The value index is calculated for each VE alternative, so from Table 7 the aesthetics has a weighted value of 40 points (40%), the efficiency and maintainability has weighted value of 25 points (25%) while the environmental impacts and project schedule has a weighted value of 5 points (5%).

TABLE 7. VALUE MATRIX

Overall performance		Performance (P)	Performance change (%)	Cost (C) (AED million)	Cost change (%)	Value index (P/C)	Value improvement
#	Baseline	500	-	20	-	25	-
1	Use of slave luminaires (central battery system)	625	25%	19	5%	32.89	31.56%
2	Change the design to incorporate a battery storage room or compartment.	510	0%	20	0%	25	0%
3	Install lamps (LED) with high efficiency, low power consumption and high illumination intensity	695	39%	19.6	2%	35.46	41.84%
4	Provide provisions & cabling for the required equipment	520	4%	19.8	1%	26.26	5%
5	Early Procurement of the centralized emergency system.	505	1%	20	0%	25.25	1%

Then according to respondents' assessment, the value index is calculated by multiplying the performance rating by the weighted value criteria.

The summary of the VE recommendation is presented as follows:

1. Use of slave luminaires (central battery system)
2. Change the design to incorporate a battery storage room or compartment.
3. Install lamps (LED) with high efficiency, low power consumption and high illumination intensity.
4. Provide provisions & cabling for the required equipment
5. Early procurement of the centralized emergency system.

In the final stage, it is important to realize the relationship of the cost, performance and the value of the project baseline in estimating the recommendation of VE. Thus, a comparison between the performance and the cost should be performed to suggest which recommendation to go for. This comparison will be done by the second group of respondents. Table 8 illustrates the comparison of the performance for the different VE alternatives. The performance score column is calculated by adding all the point collected for the performance attributes for each value engineering alternative. Then the second column is the percentage of change from the baseline concept. In the third column, the cost is an estimated value calculated by the second group of respondents, after that the percentage of change of cost from the baseline concept is calculated in the fourth column. The value index score is calculated by dividing the performance score by the cost for each alternative.

TABLE 8. PERFORMANCE COMPARISON OF RECOMMENDATION

VALUE MATRIX												
ATTRIBUTE	WEIGHT	CONCEPT	PERFORMANCE RATING										TOTAL PERFORMANCE
			1	2	3	4	5	6	7	8	9	10	
Aesthetics	40	Baseline					5						200
		1					5						200
		2				4							160
		3							7				280
		4					5						200
		5					5						200
Efficiency	25	Baseline					5						125
		1								8			200
		2					5						125
		3							7				175
		4						6					150
		5					5						125
Maintainability	25	Baseline					5						125
		1							7				175
		2							7				175
		3							7				175
		4					5						125
		5					5						125
Environmental Impacts	5	Baseline					5						25
		1					5						25
		2					5						25
		3							8				40
		4					5						25
		5					5						25
Project schedule	5	Baseline					5						25
		1					5						25
		2					5						25
		3					5						25
		4				4							20
		5						6					30

Hence, Table 8 shows the impacts of the proposed recommendations on the project cost, performance, and value. The percentage change in value is calculated with regard to the baseline performance. The recommendations that are most effective result in the highest change in project value should be implemented while those that add little or no value to the project should be discarded. From Table 8 the installation of the central battery system and LED lamps showed higher value improvement. The value engineering recommendation is passed to the client for their review and approval. Eventually after his approval, the VE alternative will be implemented in the project.

CONCLUSION

Risk in project management is referred to as an outcome that can occur during the project's progress and negatively affect the intended results. If not properly managed, risks can impact negatively on a project's value. Hence, risk management and value engineering are used simultaneously in project management to identify and mitigate major risks that can harm a project's value. This research suggests that there is a need for the integration of risk and value engineering in a systematic process to provide the needed cost and time savings when conducting any construction project. Fig. 7 represents the framework utilized in this research.

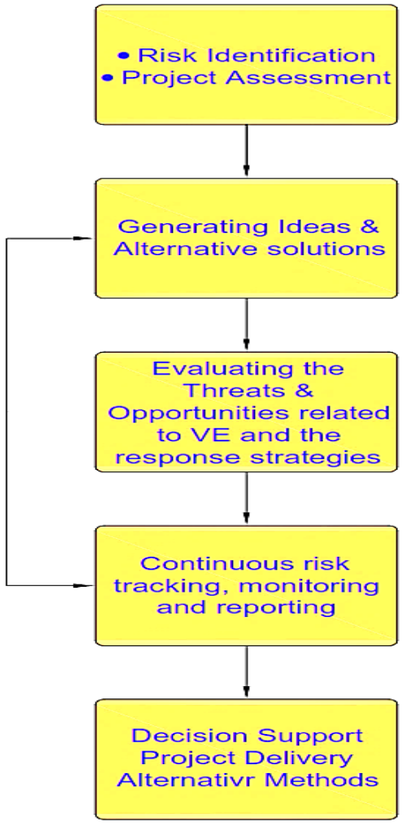

FIG. 7. VALUE ENGINEERING & RISK MANAGEMENT FRAMEWORK

The research reveals that the CRAVE process is a significant tool that can be used by project managers and engineers that will assist them on delivering project on time and within budget. The same team assembled for the VE process, can be utilized for risk assessment process, hence saving both time and cost by using same resource. Furthermore, the combination of both process develops the VE process by an additional value of thorough analysis of the important factors that might affect the project value.

The integration of risk management and value engineering gives several benefits that includes:

- Developing the knowledge of the project's uncertainty and risk
- Better assessment for the VE alternatives.
- Maximizing the opportunities of a project while minimizing their risks.
- Provide an adequate tool to the project team in providing their cost and time estimate.

According to the findings established in section four, centralised or slave emergency luminaires are more beneficial than self-contained luminaires. Centralised luminaires are associated with high initial costs due to the purchase of large battery banks and an elaborate wiring system required for delivering power from the battery to each lamp. However, the required maintenance costs are lower which reduces the lifetime costs of the lighting systems (K. L. Smith, 2012). On the other hand, self-contained lamps cost less to purchase and install. However, the luminaires are associated with high maintenance cost as the battery inbuilt into lamp body has to be changed every three years. Also, slave luminaires are more efficient with regard to illumination levels and hence a wider spacing between lamps can be used (Lester, & Lester, 2007). In addition, the systems can also operate conventional lamps as emergency lights which ensure maximum brightness. The high efficiency and reduced operational costs of centralized luminaires ensures reduced risks to a construction project, which in turn increases its value.

In the long run, the efficient lamps have lower cumulative costs as shown by the Fig. 8. As a result of the high cumulative costs associated with the inefficient emergency lighting systems, they increase project risks, which further lead to low project value Fig. 9. On the other hand, efficient emergency lighting systems lower project risks and raise the project value. Making adjustment to the project design in order to accommodate project specific features increases its appeal and hence its value. Also, undertaking design modifications such as incorporating full length windows and exposed or glass covered escape routes minimises the project risks, which further raises its value.

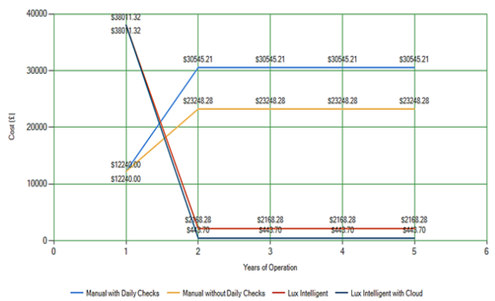

FIG. 8. COMPARISON BETWEEN UPFRONT AND RUNNING COSTS BETWEEN EFFICIENT EMERGENCY LIGHTING SYSTEMS AND INEFFICIENT LIGHTING SYSTEMS. SOURCE: LUX INTELLIGENT, N.D.

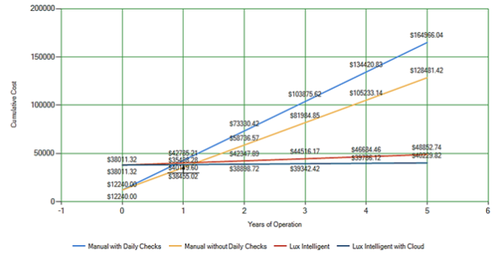

FIG. 9. DIAGRAM SHOWING THE CUMULATIVE COSTS OF INEFFICIENT AND EFFICIENT EMERGENCY LIGHTING SYSTEM. SOURCE: LUX INTELLIGENT, N.D.

RECOMMENDATION

According to the findings established in this study, the following measures are recommended. Firstly, Value engineering should be integrated into risk assessment during the planning of construction projects to enhance the value of projects in the building industry. Secondly, Proper assessment of all possible risks should be done to ensure unforeseen circumstances do not affect the utility of a building.

The research implemented the CRAVE framework on one type of construction project. It is required to evaluate the CRAVE framework on different type of projects like schools, hospitals, hotels etc. in order to confirm the exercisability of the framework on all types of construction projects.

DATA AVAILABILITY STATEMENT

All data, models, and code generated or used during the study appear in the submitted article.

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ABOUT AUTHORS:

Kamal Jaafar - University of Wollongong in Dubai, United Arab Emirates

Dr Kamal Jaafar is an Associate Professor at the Faculty of Engineering and Information Sciences, University of Wollongong in Dubai. He is the Program Director for the Master of Information Technology Management, Master of Engineering Management and the Master of Engineering Asset Management.

He holds BS, MPhil and PhD degrees in Civil Engineering from the University of Cambridge and an MBA from the Ashcroft International Business School in Cambridge.

His research interests focuses on project and construction management. His research has been published in well known engineering journals such as the ACI Journal, Canadian Journal for Civil Engineers, and Magazine of Concrete Research.

Dr Jaafar is a corporate consultant and a trainer in Project Management.

Bilal Maarouf: Project Manager, Heliopolis Contracting, Abu Dhabi, United Arab Emirates

Ahmed Elsayeh: Director of Projects and Quality at Smartworld, United Arab Emirates