Process Performance Improvement for an Elevator Construction Company

Edi Lynne L. Cruz
School of Industrial Engineering and Engineering Management
Mapua University
Manila, Philippines
edilynnecruz@gmail.com

Grace Lorraine Intal
School of Information Technology
School of Industrial Engineering and Engineering Management
Mapua University
Manila, Philippines
gldintal@mapua.edu.ph

Abstract
The success of an organization is measured by accomplished project deliverables and growth in market competition. However, hindrances can be an impediment in project successes. These hindrances are mostly attributed to project delays. This study aims to outline project delays in construction projects, particularly in elevator constructions. Furthermore, the paper addresses the issue of these delays and proposes a process performance improvement through the identification and mitigation of delays in elevator construction – by presentation of project research criteria and identification of appropriate project management tools and techniques. To achieve this goal, a multi-mode descriptive study is adapted by using quantitative and qualitative approaches by means of interviews, root-cause analysis, decision analyses, and potential problem analysis. Based on the analyses conducted, risk assessment, supply chain forecasting,Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), Make to Stock (MTS), and schedule compression are necessary to avoid the three most significant delays: lack of project management tools, poorrisk management plan, and delay in delivery of materials by supplier, respectively.

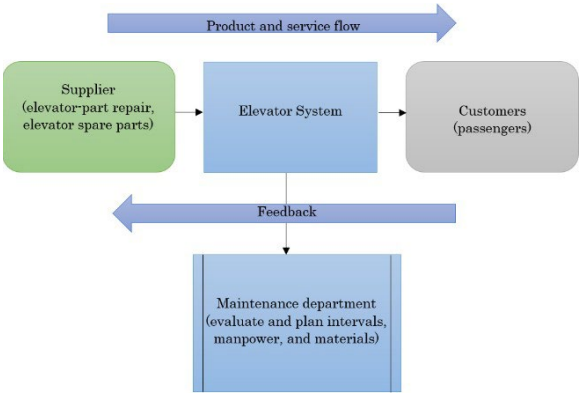
Keywords
Project management, Decision Analysis, Delay Factors, Weighted Scoring, FMEA.

1. Introduction
Company A is an elevator company engaged in the supply of parts, installation, sales, and maintenance of elevators and escalators. The company's primary location is in Manila, Philippines. It is the sole distributor of A brand in the country. The McKinsey's 7s Framework of the company is represented in Table 1, as shown below:

Table 1. McKinsey's 7s Framework

McKinsey 7s Framework	
Strategy	Short term: **Market penetration** Medium term: **Strengthen after-sales service** Long term: **Brand expansion in South East Asia**
Structure	**Team-based Organization** A system in which the company are made of teams working towards a common goal while working on their individual tasks. It is made up of people with complementary skills, achieving a common goal. The managers establish goals, milestones, and performance standards, but are less hierarchical
System	**Company Rules and Regulations** **Occupational Safety and Health standards by Department of Labor and Employment** - DO 198-118 Formal Systems: **Personnel Management System** **Quality Assurance System** **Client support** **Strategic Planning in Operations Management**
Skill	**Development and trainings**: - Assessment of training need - Designing training programs - Evaluating training program effectiveness **Performance Appraisals** **Career Development**
Staff	The organization is divided into groups, namely: **Group 1:** upper-level employees who are responsible for making company policies, procedures, and practices. **Group 2:** managerial-level employees which has a responsibility in handling its subordinates and directly reporting to the executive in accordance to his division. **Group 3:** employee level supervisors and staff, which are concerned in administration and execution of physical work. **Group 4**: employees' level of personnel, where at this level in the execution of work more concerned with physical work or the working agent.
Style	**Transformational leadership** Individualized consideration and emphasis in developing mutual interests of managers and employees Employees are involved in every process of the company, promoting positive relationships within groups
Shared Values	**Company's Mission and Vision**

The process flow of the system is illustrated in Figure 1. The materials and services are supplied by the company to the client; the system will then be used by individuals inside the establishment. Feedbacks will be given to the supplier / contractor. In order to maintain good feedback and the good working condition of the system, an effectiveand efficient maintenance must be conducted. This yields to inspection, service, and repair procedures in several intervals within the month.



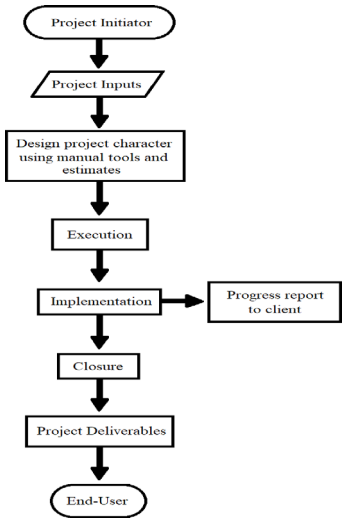


Figure 1. System Process Flow

Figure 2. Existing System Flowchart of Company A

The existing construction project management process of the company utilizes manual tools and estimates as its methodology as shown in Figure 2. The current system of the company does not employ project management softwareand

data analytics to forecast possible scenarios that may come up as the project progresses.

1.3 Environmental Scanning and Problem Analysis

1.3.1 SWOT Analysis

Table 2. SWOT Analysis of Company A

Strengths	**Weaknesses**
Skillful work team After-sales service Inexpensive but quality products Good relationship with material suppliers Availability of parts	New player in elevator and escalator industry Number of manpower
Opportunities	**Threats**
Elevator and escalator industry market isincreasing exponentially Technological advances Expanding project scale Elevator modernization	Increased competition Country's economy Lack of timely payments from clients Rising material prices Hazards in the workplace

Strengths

- Skillful Work Team: The technicians and skilled workers had undergone a series of trainings in relation with elevators and escalators. Moreover, the workers selected are already experienced - from both the country andabroad – and competent. This is to make sure that effectual project delivery and competitive services are maintained.
- After-sales service: The company gives importance to the after-sales service as much as the pre-sales experience. Preventive maintenance is conducted every month in every project to ensure good working condition of equipment. This prevents errors and defects in the system.
- Inexpensive but quality products: The products of Company A adhere to the international standards while providing inexpensive prices for consumers. This gives a competitive edge from the major players in elevatorindustry.
- Good relationship with materials supplier: The supplier and the company has established a good relationshipthroughout the years. This can be seen in fair contracts, requirements, pricing, etc. The amount of trust givenby the materials suppliers to the company and vice versa is also evident.
- Availability of parts: Despite the fact that the materials are from outside the country, the company has provided warehouses and inventory of parts in case of demand. This ensures that the parts are always available; resulting to faster repairs and deliveries.

Weaknesses:

- New player in elevator and escalator industry: The company's brand is a new player in the industry and is still in the process of introducing the products to clients. This can be disadvantageous if the client prefers themajor brands. Moreover, because the company is a new player in the industry, not enough tools in project management have been demonstrated yet.
- Number of manpower: Due to the expanding project scale of the company as evident in the recent years, theneed for a greater manpower is required.

Opportunities:

- Elevator and escalator industry market is increasing exponentially: The global elevator and escalator marketis projected to grow from USD 83.86 billion to USD 132.08 billion by 2029.
- Technological advances: Adaptation of data analytics, Internet of Things (IoT) and AI in the implementationof the system provides a significant opportunity towards innovation.
- Expanding project scale: The rising investment in commercial and residential infrastructure projects increases the construction works and is expected to result in the growth of the market
- Elevator modernization: Upgrading of elevators from existing units can result on more project opportunities.

Threats:

- Increased competition: Due to a numerous number of elevator brands and companies in the country, there isa stiff competition present resulting to tougher market penetration.
- Country's economy: Oil price hikes, impending wars, COVID-19, and political decisions of leaders can affect the economic status of a country; resulting to the decrease of projects and construction works.
- Lack of timely payments from clients: The current COVID-19 pandemic and unstable economy made a negative impact

on the numerous sectors throughout the country. These can yield to delayed payments fromclients.

- Rising material prices: Expensive construction materials can contribute to higher equipment pricing and labor costs.
- Hazards in the workplace: Elevator industry is a high-risk sector due to the hazardous environment. It can compromise the health and lives of the workers due to injuries and fatal accidents.

1.3.2 Problem Statement and Objectives

Over the last six months, Company A assessed that 10% of the projects had been marred with project delays, causingthe organization to look for solutions to overcome them. However, with the application of current available tools in the company, decrease of productivity and revenue are unprecedented.

The study aims to improve process effectiveness in the reduction of project delays of the company through decision analysis and system improvement. Furthermore, the aim of this paper is to evaluate the delay risks and conduct assessments to identify the appropriate response for such circumstances.

2. Literature Review

One of the most pivotal factors of project success is time performance. Project management involved planning, monitoring and control, and organizing of all aspects of project, as well as coordination of all project participants to achieve the project objectives in a safe manner, within agreed budget, schedule, and performance criteria. Olawale and Sun (2010) mentioned that a project is considered successful if the following are attained: accomplished technical performance, remained within budgetary costs, and maintained project schedule. In the increasing competition in elevator industry, the success of projects is the conclusive factor in the business performance of an organization. However, a good business performance and project success can be obstructed by project failure – which are commonlycaused by extensive delays. Extensively delays can lead to the postponement of initial schedule, stated in the contract, and thereby result to exceed the estimated budget cost. As defined by Zarei et al. (2017), project delays are the difference in time between project completion as stated in the contract and the time the project is handed over to the client. Construction project delays are a worldwide occurrence (Sambasivan and Soon, 2007). Time delays and cost overrunsare two of the most typical construction issues (Koushki et al., 2005). A number of studies have been conducted to investigate the reasons why construction projects are delayed – examining both researched locally and globally. Doloi et al (2012) developed a study that tackles the causes of delay in Indian construction, and categorized the causes into:

(1) site related, (2) project related, (3) process related, (4) human related, and (5) technical issues related.

The use of scientific methods and tools has been used in a number of studies to identify risks and prevent failure of the project. Generally, issues in project implementation may occur due to inefficient management of project risks. One of the most frequent mention methods in project delay mitigation is Root Cause Analysis (RCA). Mpanza (2016) studied that Root Cause Analysis (RCA) is a tool used to address a problem to identify the root cause of the problem.RCA involves the identification and management of processes, procedure, activities, behaviors or conditions. K. Ishikawa (1976) developed one of the methods used for RCA - the Fishbone diagram, also known as Ishikawa diagram. Ishikawa diagram is used as a brainstorming tool for identifying root causes. The identification of root causes yields to the planning of corrective actions in order to possibly alleviate the causes of delay. Many researchers have used the tool of weight scoring in identifying risk treatment actions. Weighted scoring model is a project management technique utilized for prioritizing project actions and weighing certain decisions.

The How-How method of Root Cause Analysis requires questioning how the sequential solution to problem can solvea failure event. Furthermore, it is used to determine a root or permanent solution to the root causes of the problem.

In 1963, NASA employed Failure Mode and Effects Analysis (FMEA) for their reliability requirements (Ebeling 2001). Since then, it is widely used as a reliability analysis of products and processes in various industries. According to Ebeling (2001), FMEA is used as a countermeasure for weak points in the early conception phase of products and processes. When applying FMEA, each component is examined to identify possible failures. Three measures are considered: the probability of failure occurrence, the impact or severity of the failure, and the capacity to detect failure before it occurs. The Risk Priority Number (RPN) is generated through the multiplication of these measures.

3. Research Methodology

3.1 Data Collection

The focus of this research is the delay factors on construction projects in the elevator industry and the target areas are the project sites located in the Philippines. The research design adapted is quantitative approach. Interviews were conducted with various project managers of the company; the sample group includes three project managers and operations department executive.

3.1.1 Project Delay Factors Identification

The risks are identified through application of different techniques such as interviews and brainstorming. After the evaluation, the organization reached a numerous number of risks as shown below in Table 3.

Table 3. Delay Factors in Project Construction

Delay Factors Identification	
Scope changed during construction	Client-related Delay Factors
Delay in the approval of plans and materials	
Poor communication and coordination from the client	
Unavailability of support infrastructure, e.g., power supply	
Owner's indefinite stoppage of work	
Difficulties in project financing	
Delay in materials delivery by supplier	Materials-related Delay Factors
Material type changes during construction	
Damage of sorted materials that are needed urgently	
Manpower Shortage	Labor-related Delay Factors
Personal Conflicts between labors	
Lack of sufficient skilled labors	
Improper planning and preparation during construction	Management-related Delay Factors
Delays in mobilization of workers	
Poor communication among teams	
Poor risk management planning	
Lack of scheduling tools, control tools, and PM software	

The items on Table 3 are categorized into four elements, namely: client-related, materials-related, labor-related, and management-related. The items are, then, assessed based on the most significant items in the construction of elevatorin the organization.

3.1.2 Data Processing and Analysis

The data gathered are evaluated using weighted scoring and have the following criteria:

Table 4. Criteria Weighting

Criteria	1	2	3	4	5	Criteria Weighting
Frequency (F)	Very Low 0-20%	Low 21-41%	Medium 42-62%	High 63-83%	Very High 84-100%	40%
Severity (S)	Negligible 0-20%	Minor 21-41%	Moderate 42-62%	Major 63-83%	Catastrophic 84-100%	40%
Detectability (D)	Very easy to detect	Easy	Moderate	Difficult	Almost impossible	20%

As shown in Table 4, the study focuses on the weight scoring based on frequency (F), severity (S), and detectability (D). The respondents in Company A were asked with rating the frequency of occurrence and the impact on the schedule as seen on the table. This quantitative approach yields to the weighted scoring tool in classifying the first three significant factors in project delays. The results are accomplished by computing the weighted score using the identified criteria weighting.

Once the three most significant factors are identified, the proponents used the 'How-How Diagram' tool to generate solutions to the recognized problems. After the formulations of solutions to the problem, FMEA is applied to the solution to determine the potential problem that may occur in the implementation.

The qualitative factors for FMEA that influence risk deterioration is based on a scale of 1 to 10. The ranking of severity and occurrences are by priority order, 1 being the lowest and 10 the highest. The proponents, then, established the information and processes; and potential risks are considered. Brainstorming method is used utilized to gain a better understanding of performance and risks in the planning stage. Business rules, standards, and regulations affecting theworkplace and working conditions are assessed in order to properly analyze risks.

4. Results and Discussion

In order to overcome the shortcomings of the company in risk management, interviews with technical personnel in the company was conducted. Weight scoring and ranking approach are the techniques applied in order to identify andassessed risks. In this way, solutions are adapted in correlation with the identified and assessed risks. This can yield to mitigation of the main problems in the company, particularly concerning in project management process.

Table 5. Weighted Scoring of Client-related Delay Factors

Criteria	Score			Weighted Score			TOTAL
Client-related Delay Factors	Frequency	Severity	Detectabilty	Frequency	Severity	Detectabilty	
C1 Scope changes during construction	2	4	3	0.8	1.6	0.6	3
C2 Delay in the approval of sample materials	2	3	2	0.8	1.2	0.4	2.4
C3 Poor communication and coordination with contracting parties	2	2	2	0.8	0.8	0.4	2
C4 Unavailability of support infrastructure, e.g. power	4	3	2	1.6	1.2	0.4	3.2
C5 Indefinite suspension of work by owner	1	5	4	0.4	2	0.8	3.2
C6 Difficulties in project financing	1	5	4	0.4	2	0.8	3.2

According to Table 5, the three most influential factors agreed upon by the respondents as the major causes of project delays related to clients are unavailability of support infrastructures (particularly power supply), indefinite suspension of work by the owner, and difficulties in project financing. The key factors received a 3.2 rating. Furthermore, underthe client-related category, the issue with the least significant cause of delay is poor communication and coordination with contractual parties, which scored 2 for frequency, severity, and detectability.

Table 6. Weighted Scoring of Material-related Delay Factors

Criteria	Score			Weighted Score			TOTAL
Materials-related Delay Factors	Frequency	Severity	Detectabilty	Frequency	Severity	Detectabilty	
C7 Delay in delivery of materials by supplier	2	5	3	0.8	2	0.6	3.4
C8 Changes in material type during construction	1	4	4	0.4	1.6	0.8	2.8
C9 Damage of sorted materials that are needed urgently	2	4	1	0.8	1.6	0.2	2.6

It is shown in Table 6 that the delay in delivery of materials by supplier (total score = 3.4) is the most significant delay related to materials, based on the weight scoring of the respondents. It also has the highest severity in all factors under this category. Similarly, the two factors with the least significant causes of delay have high severity rating; although,low in occurrences.

Table 7. Weighted Scoring of Labor-related Delay Factors

Criteria	Score			Weighted Score			TOTAL
Labor-related Delay Factors	Frequency	Severity	Detectabilty	Frequency	Severity	Detectabilty	
C10 Manpower Shortage	2	2	2	0.8	0.8	0.4	2
C12 Personal conflicts between labors	1	2	2	0.4	0.8	0.4	1.6
C13 Lack of sufficient skilled labors	2	3	2	0.8	1.2	0.4	2.4

Overall, labor-related delay factors are the least influential causes of delay in project implementation of the companyas represented in Table 7.

Table 8. Weighted Scoring of Management-related Delay Factors

Criteria	Score			Weighted Score			TOTAL
Management-related Delay Factors	Frequency	Severity	Detectabilty	Frequency	Severity	Detectabilty	
C14 Improper planning and preparation during construction	3	4	2	1.2	1.6	0.4	3.2
C15 Delays in mobilization of workers	2	3	2	0.8	1.2	0.4	2.4
C16 Poor communication among teams	3	3	2	1.2	1.2	0.4	2.8
C17 Poor risk management plan	4	4	2	1.6	1.6	0.4	3.6
C18 Lack of scheduling tools, controlling tools, and PM software	4	5	2	1.6	2	0.4	4

Table 8 presents the results of the survey analysis of delay factors related to management. As shown, the lack of scheduling tools, control tools, and project management software is the major cause in terms of level of contribution to project delay, as perceived by the personnel in the company. Besides that, lack of risk management plan plays a vital role in project delays.

Table 9. Ranking of Top Three Significant Factors in Project Delays

Significant Factors	Total Score	Ranking
Lack of scheduling tools, controlling tools, and PM software	4	1
Poor risk management plan	3.6	2
Delay in delivery of materials by supplier	3.4	3

Based on the ranking of the identified delay factors, the most significant factors that influence elevator construction project delays is presented in Table 9. Lack of scheduling tools, control tools, and PM software and poor risk management plan, rank 1 and 2 respectively, are management-related. Furthermore, delay in delivery of materials bysupplier (rank 3) is under the materials-related category.

As perceived by the respondents, the company lacks the integration of PM software and other tools in order to track activities and see the backdrop of the entire project. This results to the decrease in internal company communication and organization of project scopes. At present, the company uses manual tools for tracking progress and resource management – in which, based on the project managers and technical personnel – are not sufficient. Subsequently, poor risk management plan is also one of the major causes of delay encountered in the organization. Documentation and assessment of key risks are important in managing them. Understanding potential risks on project implementationprocess and finding ways to minimize the impacts can greatly help the organization to recover quickly if an unprecedented situation occurs.

The delay in delivery of materials by supplier is the most uncontrollable factor presented in the top three ranks withinthe organization. However, number of courses of action proposed in this paper can help in reducing this risk for system improvement.

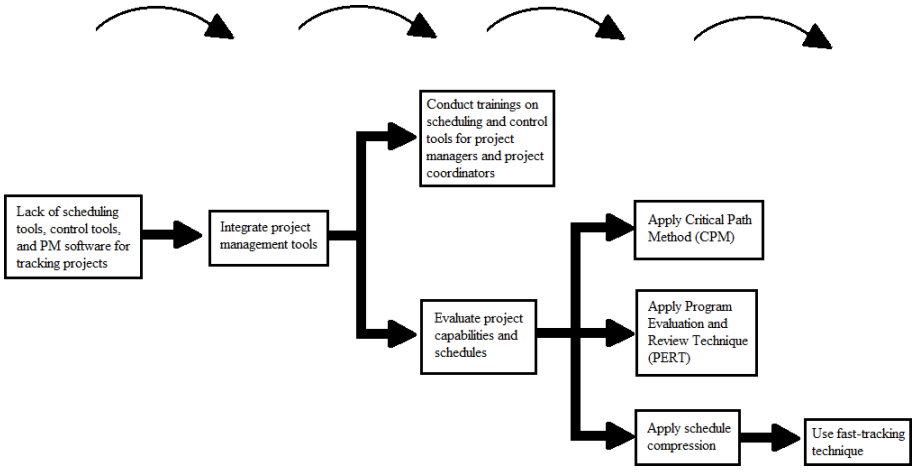


Figure 3. Solution in Lack of Tools through How-how Diagram

Based on the how-how diagram technique for determining solutions, lack of scheduling tools, control tools, and PM software for tracking progress can be resolved through integration of different methods in project management; these are Critical Path Method (CPM), Program Evaluation and Review Technique (PERT), and schedule compression through fast-tracking technique. These methods entail that the company need to invest in these systems in order for proper evaluation in project capabilities and schedules be achieved as shown in Figure 3.

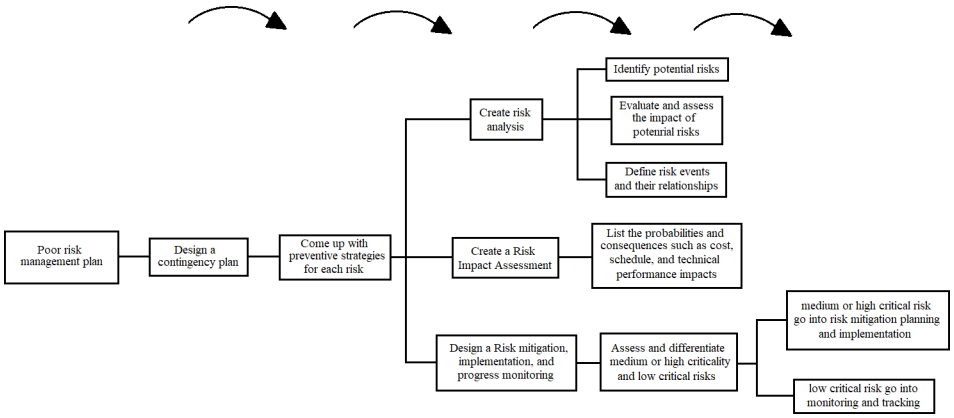


Figure 4. Solution in Poor Risk Management Plan through How-how Diagram

As how-how diagram is incorporated to solve the problem in poor risk management plan, the research identified that the use of risk analysis, risk impact assessment, and risk mitigation, implementation, and progress monitoring assume pivotal roles in the process of anticipating uncertainties in the project. The final measures in the diagram present the elaborated process and procedure in creating suitable risk management plans for the organization.

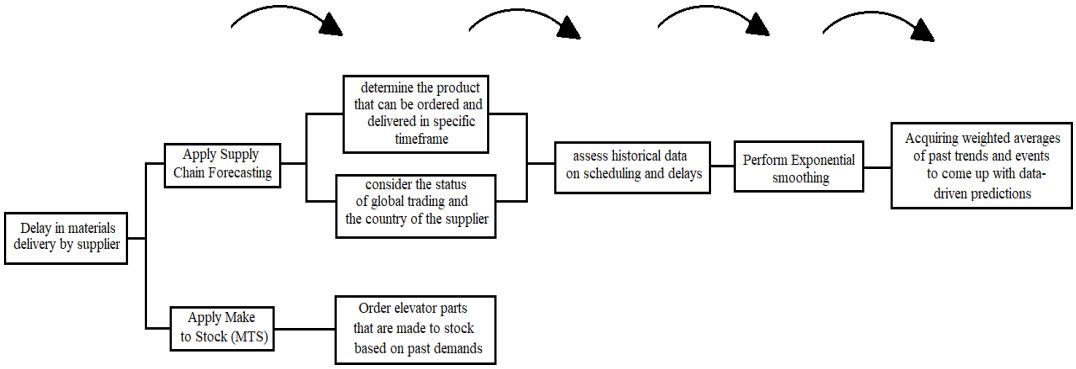


Figure 5. Solution in Delay of Materials Delivery by Supplier through How-how Diagram

Two strategies that the organization can use with their supplier as a solution to reduce delays are presented in Figure 5:

1. Make to Stock (MTS) – the products are made to stock at the company's warehouses based on the past demands. The historical data are analyzed by Company A and the frequent demand for certain parts – such as elevator rollers, buttons, cables, among others – are determined to reduce the number of orders and importation occurrences. The implication of this is that the products are produces in advance by the supplier and are being held in stock by the company in anticipation of orders.
2. Supply Chain Forecasting – entails using data and study to generate forecasts about supply chain aspects. This technique employs quantitative forecasting, in which historical data is used to predict the future, including sales estimates, on the assumption that the future would largely resemble the past.

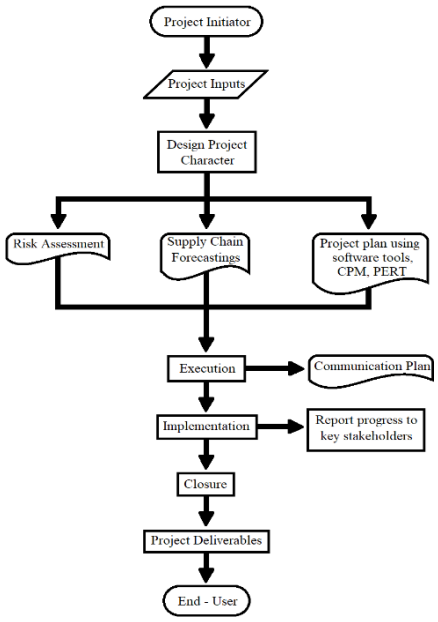


Figure 6. Proposed System Flowchart on Project Management Process

The establishment of new system flowchart allows the usage of different tools and strategies in handling delays and possible mitigation of them. Risk Assessments, Supply Chain Forecasting, and project management methods are conducted before project execution. Application of modern tools and technologies enhance the efficiency and productivity of the processes of the project. Subsequently, communication plan is also designed for the manpower involved. Figure 6 presents the newly added documentation plans for the organization.

Cost Benefit Analysis

Table 10. Cost-Benefit Analysis for Application of Project Management Tools

Cost-Benefit Analysis for Application of Project Management Tools				
Cost				
Category	**Item**	**Quantity**	**Price**	**Total**
Equipment	Specialized software (site license)	1	50,000.00	50,000.00
	User workstation	1	25,000.00	25,000.00
	Printer	1	5,000.00	5,000.00
	Temporary Office	1	70,000.00	70,000.00
Training	Software Training for Project Management Tools	1	20,000.00	20,000.00
	Team Building Activities	1	50,000.00	50,000.00
	Workers' Seminars for Effective Communication	2	20,000.00	40,000.00
TOTAL COST				260,000.00
Benefits				
Effective Project Estimation				750,000.00
Proper Risk Management				500,000.00
Improved Resource Allocation				500,000.00
Comprehensive Project Documentation				300,000.00
Effective Communication Plan among workers involved in the project				250,000.00
TOTAL BENEFITS				2,300,000

The cost-benefit analysis identified by the proponents of this paper is based on a project with a contract cost of PHP 24,000,000.00. After the calculation of the proposed project management software, the total cost yield to a value of 260,000.00. Furthermore, the estimated benefits cost is PHP 2,300,000.00 and is about 9.58% increase in the actual revenue of the company.

Potential Problem Analysis

Based on Table 11, the highest risk priority number obtained is the setting of accurate deadline. Given theaforementioned challenges, authorized individuals in the business should validate the client's needs and implement the technique of documenting, prioritizing, and agreeing on the project scope by both sides in order to generate and set an attainable deadline. The team must also make use of scheduling software and tools.

Table 11. FMEA of New Solutions for Company

Process Step	Potential Failure Mode	Potential Failure Effect	Potential Causes	Preventive Action	SEV	OCC	DET	RPN
Setting up the Project Management Team	• Conflicts between team members • Insufficient Team Skills	Miscommunication between team members	• Poor management and unclear job roles • Team members are not trained enough for project management	• Establish interpersonal relationships within the team • Conduct trainings and seminars on project management	3	3	2	18
Product Delivery Forecasting	• Unprecedented delay in delivery by supplier • Error in Delivery Forecasting	Equipment delivery delay	• Communication error with the supplier • Failure to review historical data of the supplier delivery	• Maintain constant monitoring and communication with the supplier • Ensure that product forecasting is properly implemented through communicating with team members and use of data analytics	8	5	7	280
Defining Goals and Objectives of the Project	• Poorly defined goals and objectives • Misalignment between goals and core business objectives	Project expectations from Client not attained	Lack of direction and unclear goals between the project managers and the organization	• Establish metrics in the project status • Define the tasks and subtasks with the required information	9	6	4	216
Setting Deadlines	• Scope Changes in the Project • Unrealistic Deadlines	Project delivery exceeds the project deadline	• Lack of formal scope or requirements management • Lack of proper planning and over optimism on project delivery	• Validate the requirements of the client and implement the technique of documenting, prioritizing and agreeing on scope between teams • Utilize scheduling tools and software	9	6	7	378
Designing a Risk Management Plan	Failure to take risks into account Mismeasurement of known risks	Failure in monitoring and managing risks Failure to use appropriate risk metrics	Poor design of risk management plans Improper implementation of risk management tools	Implement strategic planning through research and evaluation of risks Utilize risk management tools	8 7	7 3	2 2	**112** **42**

5. Conclusion

Proactive approach for process improvement is utilized for the prevention of issues that may occur before the projectbegins - through the application of Decision Analyses in the identification of delay factors and implementation of controls on project management. To avoid having delays, the company must focus on the duration of project activities and control the crucial risks that may occur during project development. The study recommends that there is a need to improve in project planning in the current processes of the company; and adaptation and investing in project management tools and software is necessary. Furthermore, the application of weighted scoring in project development can contribute greatly for the prioritization of actions - by means of ranking delays in order to gain adequate insight on risk assessment for project completion. Finally, the study implores that the benefits of integration of PM softwareoutweighs the costs of such tools.

References

Doloi, H., Sawney, A., Iyer, K.C., & Rentala, Samee, Analyzing factors affecting delays in Indian constructionprojects. *International Journal of Project Management,* 30: 479-489, 2012.

Ebeling, C., *An introduction to reliability and maintainability engineering*. Tata McGraw-Hill, New York, NYIshikawa, K. (1976). *Guide to quality control.* Asian Productivity Organization, 1976.

Koushki, P.A., Al-Rashid, K. and Kartam, N., Delays and cost increases in the construction of private residential projects in Kuwait. *Construction Management and Economics*, 23(3): 285-294., 2005.

Mpanza, Z, Identifying the root causes contributing to defects in order to minimize scrap. *Proceedings of the2016 International Conference on Industrial Engineering and Operations Management*, Kuala Lumpur, Malaysia, March 8-10, 2016

Olawale, Y.A. & Sun, M., Cost and time control construction projects: Inhibiting factors and mitigating measures in practice. *Construction Management and Economics*, 509-526, 2010.

Sambasivan, M. and Soon, Y.W,Causes and effects of delays in Malaysian construction industry.*International Journal of Project Management*, 25(5): 517–526.2001.

Semple, C., Hartman, F.T. and Jergeas, G., Construction claims and disputes: Causes and cost/time overruns.*Journal of Construction Engineering and Management*, 120(4): 785-795.1994

Wong, K. and Vimonsatit, V, A study of the factors affecting construction time in Western Australia. *Scientific Research and*

Essays, 7(40): 3390-3398. 2012.

Zarei, , Sharifi H, & Chagouee Y, *Delay Cause Analysis in complex construction project; a semantic Network Analysis Approach*, University of Liverpool , 2017.

Biography

Edi Lynne Cruz, ECE, ECT earned her degree in Electronics Engineering at Technological Institute of the Philippines. She is currently taking up her master's degree in Engineering Management at Mapua University. Presently, she is employed in an elevator company in the Philippines.

Grace Lorraine Intal is a full-time faculty member at Mapua University. She is teaching Information Systems core courses in the School of Information Technology and Information Systems course in the School of Industrial Engineering. She obtained a BS degree in Management and Industrial Engineering from Mapua University, a master's in business administration from Pamantasan ng Lungsod ng Maynila, and a Master's in Information Systems from Asia Pacific College respectively. At present, she is pursuing a Doctorate in Information Technology at the University of the Cordilleras. She is also an independent Management Consultant