

An Overview of the Roles of Project Managers in Monitoring and Controlling Engineering Projects

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ABSTRACT

The roles of engineers as project managers in the planning, designing, and monitoring of engineering projects are very important. These key roles impact factors such as quality, reliability, maintainability, availability of constructed projects, and costs. The combination of these key activities on business is measured ultimately in financial terms and the attributes of quality, reliability, and maintainability can claim no exception. In fact, these factors contribute largely to the project cost, from the project initiation stage through the life cycle of the project. In other words, cost influences occur from the planning, design, implementation, and commissioning stages to the maintenance and operation cycle up to the end of the useful life of the project. Project managers, therefore, must be cost conscious. The realistic approach of ensuring good cost consciousness is the commitment of engineers to their active roles in proper planning, design, monitoring, and controlling of engineering projects at all stages of project development and during its operation from the date of commissioning to the end of the useful life of the project.

(Key words: engineering quality, cost management, project lifecycle, planning).

INTRODUCTION

Managing [1] means structuring social processes in order to achieve a pre-determined objective. Management can be broken down into separate functions in order to describe the full range of structuring tasks involved. The main functions are agreeing to objectives, planning, decision making, motivation, organizing, steering, monitoring, and the organization of information. These functions and their resultant tasks must be performed regularly throughout the processes of project management (construction and maintenance), from the outset

to the very end or through the life cycle of the project.

A project [2] can be described as the process of providing inputs over a given period, using given resources, activities, and outputs (results) generated in order to achieve a defined impact (the project purpose). We talk of programs or scheduling when more than one project in a sector, sub-sector, or region are linked together by a clearly defined concept. Projects and programs are sustainable if the impact continues to have an effect.

The "life cycle" [3] of a project commonly found in business theory stretches from the start of planning to the conclusion of project activities. This can be taken as an orientation aid for managerial action. According to this concept, a project goes through the phases of identification, concept, implementation, and maintenance. During this life cycle, project managers must regularly perform the tasks involved in the functions listed above. Thus, a project or program which is a social process, is not just subjected to a one-off planning and subsequent implementation.

REVIEW OF LITERATURE

Since the eighteenth century when the British first came to Nigeria, the country has undergone a development process; hence, Nigeria is classified as a developing nation. One of the major reasons that Nigeria continues as a developing country is the lack of efficient and effective project management process even when sufficient money is available for development projects. The development and management of projects in Nigeria poses a difficult problem now and in future. This difficulty is a direct consequence of inadequate conceptualization in planning [4], execution, monitoring, scheduling, control, and maintenance of engineering projects in the country and especially in the maintenance of the

technology used. For this reason, the existing infrastructures in the country perform poorly and do not justify the huge capital investments committed to key projects throughout the nation.

The issue of the poor state of infrastructure in the country is a major concern to both the public and private sectors of the Nigerian economy. Some glaring examples of this are the Nigerian airways, railway, telecommunications, and electric power systems. Services provided by these systems are grossly inefficient, inadequate, and frequently unavailable over a long periods. Other utilities like the water system, roads, and transportation systems follow the same pattern of inefficiency. The country, to date, cannot credit itself with any reasonable infrastructure development.

As a nation, we are quick to allocate money to gigantic projects, but fail frequently to execute these projects professionally and officially. Even for completed projects, we often overlook adequate maintenance requirements, simply because we lack a good maintenance culture. This often results in the breakdown of our major infrastructures to a level from which they cannot be recovered. This paper has therefore attempted to address the roles of engineers in effective and efficient project management. It has tried to provide guidelines used by developed countries that have already undergone different stages of process refinement (just as Nigeria is currently facing) for proper project management.

METHODOLOGY

1. Planning

Planning [5] is an ongoing process throughout the implementation of the project (the so-called "rolling-plan"). It is also to be remembered that maintenance operations require planning. Planning should therefore include the real project plan and a maintenance plan indicating how the constructed system should be implemented. The stages which a project progress through its life cycle are:

- Information
- Planning
- Motivation
- Steering

The transition between phases or the discussion of a specific phase are termed as "objectives clarified" (conceptual phrase) and "project purpose achieved" (implemented phrase). The individual project planning steps are geared to this logical system. The entire process is not linear but has many feedback loops [6] in which to review the analyses, planning, and decisions made or to re-examine the process in a more detailed fashion with the experience gained during each step.

The definition given to an objective during the identification phase is not a definite one [7], but must be repeatedly re-examined over the course of implementation and can be modified, if necessary, if other decisions are to be regularly reviewed and modified. All-in-all, hard and fast decisions should be taken expeditiously for a given situation and results held as valid until final decisions are reached.

Re-planning is the result of systematic observation, analysis, and an assessment of implementation (i.e. monitoring and evaluation [8]). Focus does not center exclusively on the planning targets or objectives, but also on pertinent conditions and circumstances in the project environment. Any unintended impacts and other consequences must be identified at an early stage.

2. Setting Objectives and Specifications

Monitoring is an important role in project management. Monitoring is an observation to ensure that the project/system can continue to operate to the specified standards. Setting objectives and specifications are therefore necessary as the bases of comparison for determining any deviation from the objectives and specifications. Therefore, realistic reliability and maintainability objectives [9] need to be set with due regard to user's design and operating requirements and cost constraints.

Some joint discussion and joint study with the customers/users may be required to establish economic reliability values which sensibly meet their requirements and are achievable with the proposed technology at the allowed costs. Over specifying the requirements may delay the project, when the tests eventually show that the objectives cannot be met and it is realized that the budget will be exceeded.

When specifying objectives and specifications, it is a common mistake to include confidence levels; in fact requirements should stand alone. The addition of confidence levels implies that a single demonstration at the stated confidence level is sufficient to validate specifications. On the contrary, a design objective is a target and must be stated without statistical limitations.

Consideration of the equipment type and the use to which it is employed will influence the chosen parameters including failure rate, availability, and mean time to repair the system.

A major contribution to the problems of cost and quality comes from the lack of, or inadequate engineering design specifications [10]. Design specifications should detail the product requirements, in full, including reliability and performance parameters. The factors should include:

- Function Description – speed, functions, human interfaces and operating periods.
- Environment – temperature, humidity etc.
- Design Life – related to wear and replacement policies.
- Standards – standard for materials components and testing.
- Finishes – appearances and materials.
- Ergonomics – human limitations and safety considerations.
- Physical Parameters – size and weight restriction, power safety limits.
- Reliability and Maintainability – module reliability and objectives.
- Manufacturing – projected manufacturing levels, batch flow, quantity guarantees for continuity of manufacture.
- Maintenance – type and frequency of preventive philosophy and 2nd line repair including maintenance, repair levels, and methods of diagnosis.

3. Design and Quality Assurance

The design and quality assurance of a project will simply not occur in practice unless a

reliability and maintainability program is developed and specific resources are allocated. Responsibilities have to be placed on individuals for each of the activities and a reliability program manager appointed with sufficient authority and the absence of conflicting priorities [11] (that is program dates) to control the project objectives. Milestones with specific dates will be required against which progress can be measured; for example:

- Completion of feasibility study (including repair and maintenance calculations).
- Reliability objectives for sub systems, modules etc.
- Test specification prepared and agreed upon.
- Prototype tests completed.
- Modifications arising from completed tests.
- Demonstration of reliability and maintenance (burn-in period of 21 days without system consequent failure).
- Established design reviewed dates.
- As-built drawings and documentation.

The purpose of a feasibility study is to establish if the performance specifications can be met within the constraints of costs, technology, time, and so on. This involves a brief reliability and quality prediction. Reliability and maintainability contribute ultimately in financial terms to a project, therefore project managers must have as an important role, a realistic approach to cost consciousness. They should focus on quality engineering in order to pay greater attention to preparation of quality plans, workmanship standards, monitoring, and to enforce adherence to standards.

4. Scheduling or Programming Project Activities

The extent of reliability and maintainability activities in a project will depend upon the following factors:

- Severity of requirements.
- Complexity of the products.

- Time and cost constraints.
- Safety considerations.
- The number of items to be produced, fixed, or assembled

These activities include [12]:

- ❖ **Setting Objectives:** as we have discussed earlier with allocation and feasibility for project managers or operational engineers.
- ❖ **Training:** design engineers should be trained to a level where they can work with project specialists, repair, and maintenance specialists. Customer/user training for maintenance staff is another aspect that may arise.
- ❖ **Quality Assurance:** this involves manufacturing controls to ensure correct materials, tolerances, and suitability to environment (temperature, moisture, humidity etc). This involves all activities of quality engineering, test planning, test and inspection, reliability engineering, etc.
- ❖ **Design Review:** is intended to provide an evaluation of the design at different milestones. The design review board should be comprised of a variety of skills and be chaired by a person independent of the design team. The following check list [13] is a guide to the factors which might be considered:
 - (a) Electrical factors involving critical features, component standard, circuit trade-offs, etc.
 - (b) Software reliability involving configuration control, flow charts, user documentation, etc.
 - (c) Mechanical features such as materials and finish, industrial design, ergonomics, equipment practice, and so on.
 - (d) Quality and reliability, covering environmental testing, predictions and demonstrations, test equipment, and procedures.
 - (e) Maintenance philosophy including repair policy, operational predictions, maintenance resource forecasts, customer training, and operating / maintenance manuals.

- (f) Purchased items including lead times, multiple sourcing, supplies evaluation, and make / buy decisions.
- (g) Manufacturing and installation, covering tolerance, burn-in, packaging, transport, costs, etc.
- (h) Other items include patents, value engineering, safety, documentation standards, and product liability.
- (i) Spares provisioning (e.g. "Fire-up" spares and maintenance spares). These affect reliability and maintainability and have to be calculated during design.
- (j) Data collection and failure analysis - Failure data, with the association stress information is essential to reliability growth programs and also for future predictions. A failure reporting scheme should be set up at an early stage so that tests on the earliest prototype modules contribute towards the analysis.
- (k) Demonstrations are also important, since these involve statistical sampling tests plans and have to be calculated at an early stage so that the risk can be evaluated.

5. Process for Project Management and Control

Purpose of the process: The Project Monitoring and Controlling Process is used by project managers and project teams to ensure the team is making satisfactory progress towards the project goals. The purpose is to track all major project variables including cost, time, scope, and quality of deliverables. The overall objectives [14] of the process are to:

- Track and review actual project accomplishments and results against project plans.
- Revise the project plan to reflect accomplishments thus far and to revise the plan for remaining work, if needed.
- Provide visibility into progress as the project proceeds, so that the team and management can take corrective actions early when project performance varies significantly from original plans.

Deliverables [15] from monitoring and controlling activities include:

- Written status reports.
- Updates to the list of action items, risks, problem, and issues.
- Comparisons of actual costs to budgeted costs as well the cost/benefit analysis used at the start of the project.
- Audit and review reports of the activities and work products under development.

Scope of the Process: The monitoring and controlling processes [16] are based on the project plan, thus overall tailoring for monitoring and controlling is much like tailoring for planning. For many medium and large projects, the plan is likely to undergo change to reflect the resolution of items that were unknown or that have changed since the start of the project.

Activities Tailoring: Monitoring and controlling activities vary for different types of projects in the same way that planning the project varies by types of projects.

Activities	Low focus	Medium focus	High focus
Continuously monitoring progress	Use the project summary as the basis for monitoring and control	Project manager uses project plan as basis for monitoring; team members provide weekly progress reports to the manager or team leader	Project manager uses project plan as basis for monitoring; team members provide weekly progress reports to the manager or team leader
Conduct team reviews	May be done with e-mail or informal sessions	Likely to need a weekly coordination meeting to review status of the work, risk, measures, and action items being handled	May have several sub teams which regularly get together to review progress as well as overall regular team meetings and regular reports
Conduct formal progress reviews	May be done with e-mail or informal sessions	Likely to be done on a monthly basis with senior management and key stakeholders	Likely to be done on a monthly basis with senior management and key stakeholders
Manage changes	May involve only one or two people	Likely to include project representatives, customers, management, QA, CM	Likely to include project representatives, customers, management, QA, CM
Revise the plan	May be informal agreement with management	Significant changes need to be reviewed and agreed to by those who originally approved the plan	Significant changes need to be reviewed and agreed to by those who originally approved the plan
Conduct work product reviews	Likely to be informal walkthroughs with two or three people	Some may be walkthroughs, some technical review and inspections	Likely to have both technical reviews and inspections, based on quality goals
Role	Low focus	Medium focus	High focus
Project manager	Person in this role is also likely to be a member of the team doing the work	Person in this role may also do some of the work on the team	Person in this role is dedicated to project management
Configuration management	Role may be performed by project manager or a member of the team	Role may be performed by someone on the project team or someone from an independent group	Role likely to be performed by someone from an independent group
Change control board	Maybe done by project manager and one or two others	Likely to be small group-project manager, senior manager, QA, user representatives	Formerly chartered group composed of representatives from all major stakeholders
Activities deliverable	Low focus	Medium focus	High focus
Project status reports	E-mail or verbal reports	Meeting, e-mail, possibly hard copy at major milestones	Meetings, e-mails, regular hard copies, filled in project notebook
Project performance measurement indicators	Probably confined to schedule and budget	Schedule, budget, size of major deliverables, defect counts	Schedules, budgets, size of major deliverables, defect counts plus projects issues- driven measures
QA non-compliance reports	Informal discussion with project manager	Notes from QA kept in project notebook	Formal reports to standard distribution
CM activities/status reports	Notes from CM	Activity logs kept in project notebook	Formal reports to standard distribution
Revised work products	Notes added as attachment to original documents	Revision made to major deliverables	Revisions tracked through traceability tools

Deliverables Tailoring: the roles in the process of deliverables tailoring are illustrated below:

Roles	Roles definitions
Project Manager	<ul style="list-style-type: none"> Responsible for planning and tracking the project, including approved revisions to project plan, estimates, schedules and budgets
Project Team	<ul style="list-style-type: none"> Participates in building and reviewing the plan and project work items; develops or implements the deliverables
Senior Management	<ul style="list-style-type: none"> Authorizes the project and provides personnel and other resources
Steering Committee	<ul style="list-style-type: none"> Reviews progress and approves any change to plan to ensure the project meets organization goals
Quality Assurance	<ul style="list-style-type: none"> Reviews progress [17] used in performing the project, to ensure they comply with the project plan and organization standards and processes Reviews deliverables of the project, to ensure they meet customer requirements, quality requirements, project plans, and organization standards
Configuration Management	<ul style="list-style-type: none"> Identifies (or reviews work done by the team to identify) the configuration items to be handled with configuration management, places the items under control, creates baselines, makes authorized changes to the configurations, provides status reports, and builds releases of the products
Change Control Board	<ul style="list-style-type: none"> Reviews requests for changes to projects baseline (requirements, deliverables completed, work underway), approves or projects change request, ensures approved changes are completed as authorized

ACTIVITY DESCRIPTIONS

The following sections provide details on each activity. A description of the purpose, entry and exit criteria, and the sequence of tasks to be done is provided. Tasks are shown along with the roles generally responsible and/or involved in those tasks and the deliverables produced by the tasks. These activities are not sequential; each is used as needed. Some activities are driven by dates, such as monthly progress reviews, while others are ongoing or they are triggered by events.

Continuously Monitor Progress

To be sure that the project stays on track, the project manager and the project teams continuously monitor their progress to the project development plan.

Purpose: Examine progress on all key dimensions of the project to determine whether or not project goals are likely to be met, as documented in the project development plan. When a variance is detected, take appropriate corrective action.

Entry criteria:

- Project plan is documented and approved; work is underway.
- Explicit assignment of responsibility for work products and activities have been made.
- Project is staffed and other resources are available, particularly the resources and funding required to do project tracking.
- The project manager has been trained to perform the appropriate technical and management responsibilities of the project.
- Other software management personnel have been oriented to the technical aspects of the project

Roles	Roles definitions
Project Manager	<ul style="list-style-type: none"> Monitor, at least weekly, progress to plan on key elements Tasks starting and ending when expected Deliverables with content and quality level required Level of effort as planned Milestones being met when planned Cost as budgeted Critical computer resources as planned Risk management progress Issues and action item resolution Measures to handle key project issues Review and process request for changes to the plan Initiates and monitors corrective actions when necessary

Project Team	<ul style="list-style-type: none"> Review progress on the task assigned and level of effort spent compared to effort planned Report progress weekly to the remainder of the team and the project manager Monitor for and report potential risks to the project Enter data for measures associated with project issues
Quality Assurance	<ul style="list-style-type: none"> Review project work products and activities, identifying any exceptions to the project plan and/or organization processes Review measurement data for accuracy and consistency Discuss deviations with project team and project manager Raised non-compliance items with management, if not resolved in team
Configuration Management	<ul style="list-style-type: none"> Accept items for configuration management as planned, if they meet the conditions set by the project and by organization processes for configuration management Report on status and content of baselines

Exit criteria: Project is complete or terminated (this activity continues throughout the project).

Conduct Team Reviews

For most projects that involve a team, it is useful to have regular reviews of progress and status. Teams might gather for regular meetings, or they might exchange information electronically.

Purpose: Communicate status and plan for next activities of the project.

Entry criteria: Project is staffed and under-way.

Roles	Roles definitions
Project Manager	<ul style="list-style-type: none"> Determine what information needs to be exchanged Decide what best medium for communication Determine frequency of communications
Project Manager / Project Team	<ul style="list-style-type: none"> Exchange status information Communicate current action items, issues, and risks Provide status of technical activities, plans for next activities, and action items Follow up on action items and work on next tasks

Exit criteria: Project is complete or terminated (this activity continues throughout the project).

Conduct Formal Progress Reviews

Formal progress reviews are conducted for large projects and for some medium projects, to ensure that all stakeholders are kept informed of project status and progress. These reviews may be events- or date-driven. Projects often hold monthly or quarterly reviews, in addition to (or instead of) project phase-based milestone reviews.

Purpose: Communicate status of the project to stakeholders and ask for assistance in areas that need management or stakeholder attention.

Entry criteria: Project has reached milestone, event, or date for review.

Roles	Roles definitions
Project Manager	<ul style="list-style-type: none"> Identify information that needs to be prepared and/or presented Identify participants for the review Establish tasks and assignments for the review Establish review logistics Conduct the review Present status information Identify action items that require attention
Project Manager / Project Team	<ul style="list-style-type: none"> Prepare information for the review List of accomplishment in last period List of plans for next period Milestone progress reports (planned to actual) Staffing profile (planned to actual) Cost profile (planned to actual) Size and critical computer resources (if appropriate) Risk management status Action item status Quality assurance status Configuration management status Requirements management status Update cost-benefit analysis
Project Manager / Management / Other Stakeholders	<ul style="list-style-type: none"> Gain agreement on next steps and action items Provide information requested and establish action items

Exit criteria:

- Review was held and any follow-up information communicated.
- Action item list update with items from the review

Manage Change

For most projects, there are multiple changes to one or more project parameters once the project has started. These might include changes to requirements, problems or defects in the deliverables, or changes to resource commitments. Each of these can be handled by a change management process external to this process, or by this activity.

Purpose: Identify, evaluate, prioritize, and control changes to the project.

Entry criteria:

- Project is underway.
- Change request has been submitted by a project member or a stakeholder (requirements change, problem defect, or other).

Roles	Roles definitions
Interested Party	<ul style="list-style-type: none"> ▪ Document the change requested, along with priority of the change, (optional) approaches to handle the change or to work around if the change is not implemented
Project Manager / Change Control Board	<ul style="list-style-type: none"> ▪ Acknowledge the change applies to this project ▪ Enter changes request into tracking system log ▪ Review the change request and determine whether or not it is worth evaluating for action
Project Team	<ul style="list-style-type: none"> ▪ Estimate the impact of the change on the project effort, cost, schedule, resources
Change Control Board	<ul style="list-style-type: none"> ▪ Using the estimate, decide whether or not to authorize the change ▪ If the change is denied, communicate that decision to the requestor and terminate this process
Project Manager	<ul style="list-style-type: none"> ▪ Incorporate the change into the project work plan and adjust resources and schedule as needed to accommodate the change
Project Team	<ul style="list-style-type: none"> ▪ Perform the work needed to address the change and conduct the associated verification activities to ensure correctness ▪ Update the change request records to document the changes made, and communicate completion status to the Change Control Board
Change Control Board	<ul style="list-style-type: none"> ▪ Update the request records to reflect the completion status and inform the requestor of the final status

Exit criteria:

- Change has been addressed and requestor has been informed.
- Change request records have complete information about the request and the work that was done to address it.

Revise the Plan

If there are significant changes in the project deliverables, schedule, budget, or approach, the project plan is revised. This is also usually done at the end of each major life cycle phase. Any signoffs that were needed for the initial project plan are needed for a significant change.

Purpose: To revise the project plan (including estimates and schedule) and to accommodate significant changes, so that the documented plan reflects the plan in use by the project team

Entry criteria: Project team and management have agreed to a significant change in the project.

Roles	Roles definitions
Project Manager	<ul style="list-style-type: none"> ▪ Determines that a significant change in the plan is needed. Examples of such changes include: <ul style="list-style-type: none"> a) life cycle approach has changed from one release cycle to a series of iterations, or the number of releases has changed b) time spent in a given project phase or the overall schedule has been changed more than a percentage determined by established guidance c) requirements have changed in a way that requires additional staffing, more time, or an alternate approach to the work d) tools and method to be used are different from what was initially planned
Project Manager / Project Team	<ul style="list-style-type: none"> ▪ Develop updates to project plan, review with all affected parties ▪ Establish commitments to changes in plan
Senior Management / Stakeholders / Quality Assurance / Project Manger	<ul style="list-style-type: none"> ▪ Review changes to project plan ▪ Approve changes (or negotiate for other changes) ▪ Sign off updated plan ▪ Puts updated plan under configuration management

Exit criteria: Project plan is updated, approved, and under configuration management and all changes to commitments have been communicated to all parties.

Conduct Work Product Reviews

Throughout the project life cycle, the project team conducts team reviews of the work products being built. The types of reviews may vary, according to the plan set by the project team, to ensure best use of time spent on the review.

Purpose: Ensure all involved parties understand the content of a given work product and identify any changes needed in the work product before starting work on other work products that depend on it.

Entry criteria:

- Author agrees work product is ready for review.
- Team is available to review the item.
- Review process is defined and understood by the review team.

<i>Roles</i>	<i>Roles definitions</i>
Project Team Member (author)	<ul style="list-style-type: none"> ▪ Identifies what portion of the work product are to be reviewed ▪ Works with Project Manager to set goals for the review and select type of review. Alternative include: <ul style="list-style-type: none"> a) informal walkthrough by several team members b) technical review by project team members and stakeholders c) inspection by project team members (and perhaps others) ▪ selects a moderator for technical review or inspection
Moderator	<ul style="list-style-type: none"> ▪ Establishes logistics for technical review or inspection ▪ Holds a kick-off meeting if needed, to distribute materials
Review Team	<ul style="list-style-type: none"> ▪ Examines work product before attending the review meeting ▪ Documents questions and defects in the work product
Review Team Moderator (if relevant)	<ul style="list-style-type: none"> ▪ Participates in the review meeting ▪ Informal walkthrough-team examines the work product, giving feedback to author ▪ Technical Review-moderator leads the review team through the key issues of interest identified for the review ▪ Inspection-moderator leads the review team through logging meeting, gathering defects, and questions for the author
Author	<ul style="list-style-type: none"> ▪ Incorporates feedback from the review
Project Manager / Quality Control	<ul style="list-style-type: none"> ▪ Review results of the work product review to ensure goals have been met and organization processes were used (and useful)

Exit criteria: Feedback [18] is properly incorporated into work product.

MEASURES

Measures of the project progress, product quality, and process performance includes the following:

Milestone Attainment – Monitor achievement of milestones to the initial milestones set in the project plan, reporting variance on each; maintain the initial baseline, as well as the most recent update; report achievement and variance to both

Effort Spent – Track the initial estimate for each major element of the work breakdown structure compared to the actual effort spent performing that element (may be a work product or an activity)

Budget/Cost Performance – Track the rate of spending on the project by period (week or month) compared to the planned spending

Requirements Changes – Track requirements change by period (generally month), showing total number of requirements, number added in this period, number deleted in this period, and number changed in this period; also track these dimensions by the amount of effort reflected in each, to understand the impact on the project’s time and cost measures for monitoring the project monitoring and controlling activities.

Handling of Project Tracking – Use items such as schedule attainment (compare progress review dates to the date planned) and effort required (compare the amount of effort used for monitoring and controlling the plan).

VERIFICATION ACTIVITIES

During project monitoring and control, the following verification activities are appropriate for management [19]:

- Review periodic reports of the project team and/or project manager, to ensure that the project continues to meet business needs.
- Provide information as needed by the project, and authorize the work to proceed

if the project is meeting plans and commitments.

- Participate in formal project reviews, reviewing status and handling action items.
- Review the business case (or cost/benefit analysis, as appropriate) on regular basis, to ensure that this project should continue.

The following verification activities are appropriate for Quality Assurance [20]:

- Review activities of the project team on an ongoing basis, to verify that they are following their plan and the relevant processes of organization.
- Review the results of work product reviews and testing, to ensure that the project deliverables meet customer requirements and project quality plans.
- Review change management and configuration management activities to ensure they follow the organization processes and that baseline measures are under control.
- Review document control procedures (including revisions, dates, and descriptions).

CONCLUSIONS

In this paper, we have focused on the roles engineering project managers play in the planning, execution, monitoring, and control of projects whether construction or maintenance. Although there are many ways of managing the execution of projects, we feel that if project managers play their roles properly by effective planning, designing, and implementation of engineering projects in the ways highlighted in this paper, project efficiency and sustainability would improve.

Proper program management supports emerging infrastructures with high availability, lower maintenance efforts, and above all, lower costs in implementation and maintenance.

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