Restructured Model of the Project Management Body of Knowledge According to Construction Project Life Cycle

Arash Nourbakhsh

Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the Degree of

Master of Science
in
Civil Engineering

Eastern Mediterranean University
July 2014
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Prof. Dr. Elvan Yılmaz
Director

I certify that this thesis satisfies the requirements as a thesis for the degree of Master of Science in Civil Engineering.

Prof. Dr. Özgür Eren
Chair, Department of Civil Engineering

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Civil Engineering.

Asst. Prof. Dr. Alireza Rezaei
Supervisor

Examining Committee

1. Prof. Dr. Özgür Eren
2. Asst. Prof. Dr. Mürüde Çelikag
3. Asst. Prof. Dr. Alireza Rezaei

ABSTRACT

The Project Management Institute (PMI) has published the Project Management Body of Knowledge (PMBOK) in 1996 and has been revising it ever since. This book is a guideline contributing to the management field by defining ten knowledge areas and several processes; later on, an extension has been published to fill the gap of knowledge areas regarding the construction industry's unique characteristic. Although both of the books are useful, but the sequence of the processes has not been clarified and was left to the project team. In this study, a new model was developed for construction projects using the processes identified by PMBOK with a construction project lifecycle approach. The model includes flowcharts that have the characteristics of the guideline with construction perspective. Hence, the restructured model can be used more effectively in the industry due to it's characteristics. This model facilitates the use of PMBOK for all the managers in the construction industry by providing a sequential and step by step procedure throughout the whole project lifecycle; clarifying each process inputs origins and outputs destination.

Keywords: Construction, Management, PMBOK, restructured model, project lifecycle

ÖZ

Proje Yönetimi Enstitüsü, 1996'da Proje Yönetimi Bilgi Kütle'sini yayınlamıştır ve o tarihten bu yana sürekli gözden geçirmekte, düzeltme ve ekleme yapmaktadır. Bu kitap, on bilgi alanını ve çeşitli süreçleri tanımlayarak yönetim alanına katkı koyan, ana ilkeleri esas alan bir rehber kaynaktır. İlerleyen zamanlarda bu kitaba yapım ile ilgili bir kitab eklenmiştir. Bu ilavenin amacı yapım sektöründe, proje yönetiminde eksik görünen yapı endüstrisinin benzersiz özellikleri ile ilgili boşluğun doldurulması içindir. İki kitap da çok yararlı kaynaklar olmalarına rağmen, yapım süreçlerinin sıralaması yeterince açık değildir ve bu sıralamayı yapmasorumluluğu proje takımına bırakılmıştır. Bu araştırma kapsamında PMBOK tarafından tanımlanan süreçler ve inşaat projelerinin yaşam döngüsü yaklaşımı kullanılarak, yapı projeleri için yeni bir model geliştirilmiştir. Bu modelde, yapı perspektifi olan ve kılavuzun özelliklerini barındıran akım grafikleri de bulunmaktadır. Buna bağlı olarak, bu model endüstride çok daha etkili bir biçimde kullanılabilecektir. Bu model, tüm proje yaşam döngüsü boyunca ardışık ve adım adım yöntem sağlayarak ve her işlem girişinin kökenini ve çıkış hedeflerini netleştirerek inşaat endüstrisinin tüm yöneticileri için PMBOK kullanımını kolaylaştırır.

Anahtar Kelimeler: Yapı, Yönetim, PMBOK (Proje Yönetimi Bilgi Birikimi Kılavuzu), yeniden modeli, proje yaşam döngüsü

This is dedicated to my parents Omran and Nasrin, their novelty and patience as well as their restless efforts to support me all my life.

ACKNOWLEDGMENT

I would like to thank Asst. Prof. Dr. Alireza Rezaei for his time and all he has done, I cannot imagine how hard it is to help out all these students with different problems, without your priceless helps and guidance this thesis would not have existed.

Friends, former teachers and many others have contributed to the creation of this thesis, naming everyone is almost impossible. I am forever indebted to all of you and thankful for all your cooperation. The Eastern Mediterranean University and the Department of Civil Engineering deserve the gratitude of all the students, including me for all they have done.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ABBREVIATIONS

ClM	Claim management
CM	Construction management
ComM	Communications management
CoM	Cost management
EM	Environmental management
FM	Financial management
HRM	Human resource management
ItM	Integration management
OPM	Organizational project management
PrM	Procurement management
PLC	Project life cycle
PM	Project management
PMBOK	Project management body of knowledge
PMI	Project management institute
PMO	Project management office
PPM	Project portfolio management
PT	Project team
QM	Quality management
RM	Risk management
ScM	Scope management
TM	Time management
SM	Safety management

Chapter 1

INTRODUCTION

1.1 Introduction

The Project Management Institute (PMI) has been publishing a guideline by the name of Project Management Body of Knowledge (PMBOK) since 1996. This guideline introduces six process groups and ten knowledge areas to help increase the management team performance. Later on a construction extension was published due to the unique industry characteristics that introduced four more knowledge areas to aid the construction projects. The PMBOK scatters 47 processes within the process groups it has defined and 13 more in the extension.

Projects, programs and portfolio managements have been defined by PMI (2013). The understanding of a project is mentioned and described as a unique work with specific characteristics that creates a single deliverable which might outlive the project itself. Portfolios are considered the largest part of managerial system that might consist of programs and projects. Programs are considered smaller; however they also are consisting of programs and projects, but the difference is that they must be related and cannot be in different fields (PMI, 2013).

Project life cycle (PLC) has been introduced as where the project initiates and matures and grows old to the conclusion (Sinha, 2014). PLC is reviewed and different stages have been identified by many studies. PMI (2013) defines that any PLC structure is of four stages; starting, organizing, carrying out and closing the

project. An alternative phase has been given in the literature reviews in such the LC is of four steps which are recognition, construction, operation and ending. (Ghaffari, Sheikhahmadi, & Safakish, 2014)

The construction management (CM) approaches toward the PMBOK has been investigated in literature. The identified steps, knowledge areas and processes for CM have been reviewed.

For large projects which are difficult for one manager to take care of the business, the high level manager will hire other Construction Managers to help the project management in different phases and aspects (Bureau Of Labor Statistics, 2014). Although the definitions given are up to date, but it is still based on the old trend toward the CM and has not been accompanied with any new characteristics such as PMBOK or PMO or etc.

Bennett (2003) introduced a construction PLC that consists of six stages that covers all of the activities form initiation to completion. The stages are: pre-project, planning and design, contract selection, mobilization, operation and project closeout and termination. This approach will be considered as the main source of construction PLC information in this study.

The vitality of the PMBOK as a resource is unquestionable yet all its processes, tools and techniques may not be appropriate for every industry, the effectiveness of the PMBOK is yet to be examined in construction industry. However, the knowledge areas of PMBOK are considered essential and facilitating management (Chou & Yang, 2013).

The knowledge explained in the PMBOK should not be used uniformly to all projects and the team is responsible for choosing the appropriate way regarding the project characteristics (PMI, 2013).

This research will focus on the creation of a singular model concentrated on the PMBOK processes but with a PLC approach regarding the construction industry principles. Flowcharts based on PMBOK and Bennett (2003) has been created. The flowcharts were created with E-DRAW software to maximize the effects and ease the reading. The main source of this study data is the PMBOK and vast research information that has been gathered through the literature of this topic.

The collaboration of these two flowcharts will develop a model that can form the PMBOK processes based on their priorities and their occurrences in the PLC. This model can help a Construction Manager sort all the processes defined by the PMBOK with a construction view just by simply doing each activity step by step to the end.

1.2 Research Question

As it has been declared before, the PMBOK may not be used uniformly and the processes may be altered based on project characteristics. Therefor the PMBOK cannot be used as a method to complete a project, just by doing every activity step by step. Thus, the research question of this study is “How this guideline can be used in a construction project and how does PMBOK’s terms correlate with the construction PLC”, and “What is the method of relating these processes according to construction industry?”

1.3 Objectives of This Study

Through studying the literature about the construction PLC and the PMBOK, this thesis focuses on the following objectives:

- Introducing what is considered being the best PLC in the construction history.
- Improving the construction PLC application in the industry.
- Implementing the PMBOK guideline in the construction PLC.

1.4 Works Carried Out

To achieve the goals set in this study, a large investigation has been undertaken through the collected works and models have been created. The following works were carried out:

- Investigating the literature for different construction PLC approaches and reviewing what different studies have considered the best practice.
- Creating flowcharts through selected methods and approaches to increase the understanding of a PLC.
- Combining the flowcharts to model the coexistence of both approaches of PMBOK and Bennett (2003).

1.5 Achievements

Through all the work, investigations, reviews and modeling processes undertook by this study, following objects have been achieved:

- A collection of best PLC approaches and processes including the PMBOK and etc.
- Flowcharts to assist a project manager with his job, by preparing a step by step model to follow.
- A collaborative model based on processes introduced by PMBOK with a construction PLC approach was the main achievement of this study.

1.6 Thesis Outline

This thesis consists of six chapters.

In chapter two a side by side research were conducted on definitions introduced by PMBOK and other studies understanding of the issue, as well as an in-depth study over the definition of PLC in different industries in comparison to construction industry.

In chapter three, explanation of the methods and approaches toward creating the flowcharts and frameworks, how they have been selected and how they have been created will be provided.

Processes of the PMBOK and construction PLC will be described and a flowchart according to each method is created, the in-depth material of each process will be explained in chapter four to clarify each flowchart characteristics.

Chapter five focuses on using the previous studies that have introduced the construction PLC. A simple model has been developed that unites both construction and managerial issues and can be used as a methodology in construction industry.

Chapter six concludes main achievements and goals, gives a general understanding of what has been done and what has been gained through each phase also suggests what can be done furthermore and states cases that have been out of this study scope.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

PMI is a non-profit institute that has been contributing to the management field ever since 1969. This institute has matured project management through its standards which are globally recognized (PMI, 2014).

In this chapter a side by side research were conducted on definitions introduced by PMBOK and other studies understanding of the issue, as well as an in-depth study over the definition of PLC in different industries in comparison to construction industry.

2.2 Project Management Body of Knowledge (PMBOK)

PMBOK is a guideline to managing individual projects and illustrates the project management (PM) and the PLC. This standard has been created by the use of well-known practices of project managers who have contributed to improve this standard. The knowledge that has been gathered in this standard is generally recognized which means that they are practicable in most cases but yet the PMBOK clarifies that the knowledge described in this guideline should not be continuously applied uniformly to each project and it depends on PM group to determine the appropriate method to manage a project. This guide also provides a fundamental vocabulary which may be used by all project stakeholders ranging from portfolio manager (PFMR) to the smallest stakeholders involved (PMI, 2013).

PMBOK constantly defines that this standard is just a guideline rather than being a tool or methodology like agile, PRINCE2 or etc. (PMI, 2013).

2.2.1 PMBOK understandings of a project, program or portfolio and management

Based on PMBOK, a project will create a unique deliverable which might be tangible or not, be repetitive or last for centuries and outlive the projects themselves but neither way it will not change the essential and unique characteristics of the work. A project stays unique with different place, stakeholders, design or situation and etc. (PMI, 2013).

This standard characterizes a project as a temporary activity which has a definite start and end, in which the end of a project is when the goal has been achieved or the project has been dismissed due to several reasons like the client wishes to cancel the project or the need for the project does not exist or the goal cannot or will not be met. In this case, temporary does not refer to the duration of the project nor it applies to the deliverables and products, it just pertains to project's engagement and permanency (PMI, 2013).

PMBOK introduces projects as listed below:

- A product might be a section of an item or the final product itself.
- A service or the ability to execute a service.
- Development of an existing item or service line.
- A result for instance an outcome or a paper.

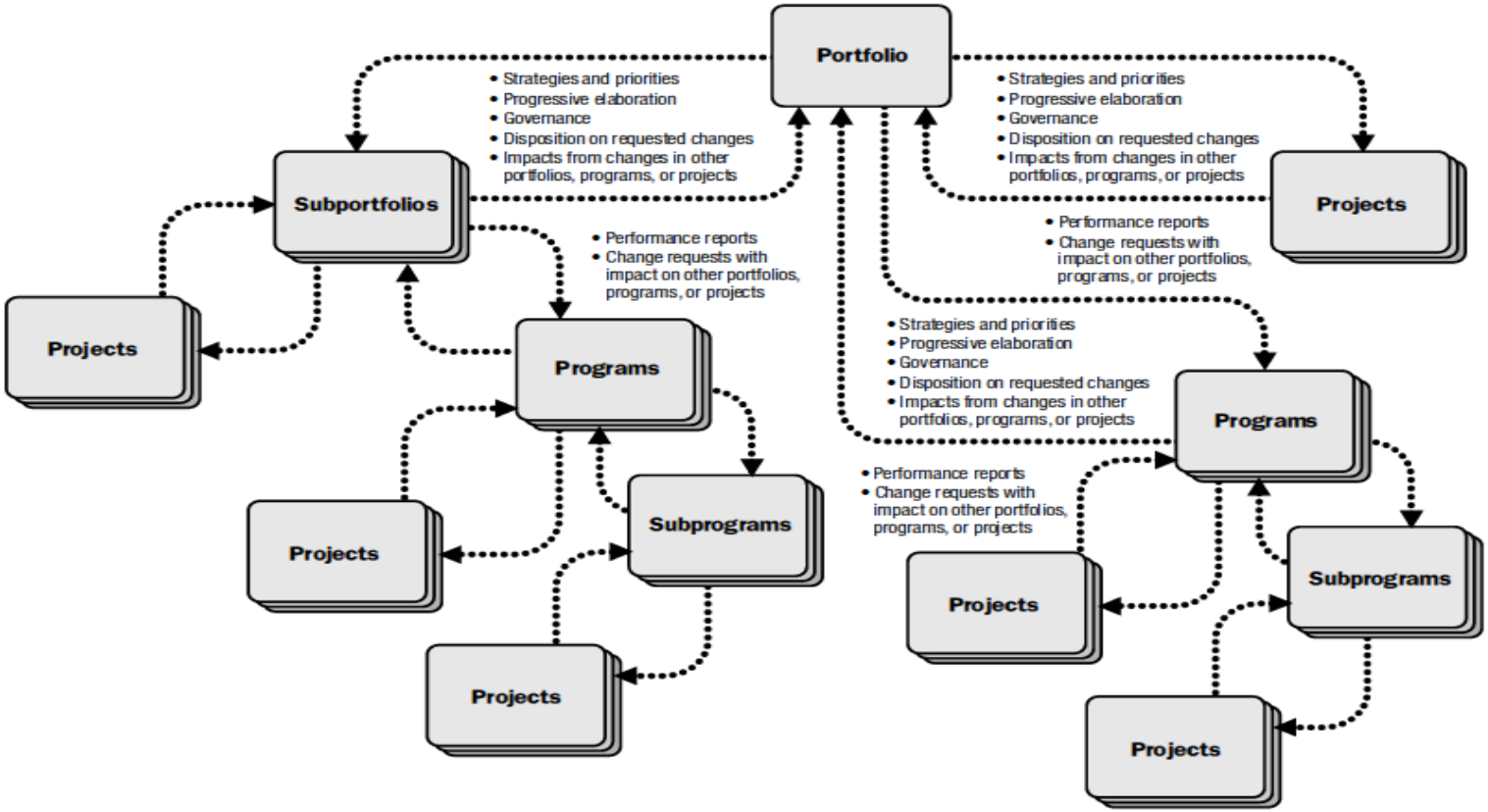

Figure 1: Portfolio, program and project management interactions (PMI, 2013)

PMBOK describes the relationships between portfolio, program and project as shown in Figure 1.

In other words, project is the smallest part of management system and portfolio is the largest of them; a portfolio may contain several programs, projects and sub portfolios which might not even be related but are linked to the organization's plan. For better understanding of these three, organizational project management (OPM) may be helpful. OPM is a strategic framework that utilizes project, program and portfolio management enabling them to consistently generating better performance, results and etc. regarding the organization interests. The main difference which is illustrated in this guide is that portfolio may include non-related portfolios, programs and projects to reach strategic purposes. But programs' sub-divisions should be in a same area of expertise (PMI, 2013). Portfolio is described as selections of projects with scarce resources, which are carried out by an organization as the sponsor and/or manager (Arthur & Ghasemzade, 1999). In other words, Blichfeldt & Eskerod (2008) described project portfolio management (PPM) as "managerial activities that relate to the initial screening, selection and prioritizing of project proposals, the concurrent reprioritization of projects in the portfolio, and the allocation and reallocation of resources to projects according to priority". Managerial activities are organized in three core phases; "portfolio structuring, resource management, and portfolio steering" as Beringer, Kock, & Jonas (2013) showed in their study and they defined that the process model can provide a complete understanding on the scope of activities and other researches that relate to PPM.

2.2.2 Project management office (PMO)

PMBOK (2013) describes a PMO as "a management structure that standardizes the project-related governance processes and facilitates the sharing of resources, methodologies, tools, and techniques." It also characterizes PMO in three types:

- Supportive: This type of PMOs offer a consultative role in the project but the level of control is low.
- Controlling: This type is both supportive and controlling which gives it a higher level of control authority.
- Directive: This model has the highest degree of controlling and it of course handles the projects directly.

PMO's primary purpose is supporting the project managers in different ways ranging from managing shared resources and developing methodologies, coaching and mentoring the team to synchronize communications across the projects (PMI, 2013).

A PMO as Dai and Wells (2004) described as "a center of excellence or center of expertise" is an organizational unit developed to help project managers and the management team in different managerial levels on strategic difficulties and functional entities all over the project to applying PM tools and techniques. A study over the large functional organizations supports the need for developing PMOs and their profits (Tony & Powers, 1997). Many organizations are establishing PMOs or have established it, which illustrates the confidence that management have in this method. It is also noteworthy to know that PMOs may not fully illustrate what it finally exposes (Dai & Wells, 2004).

2.2.3 Project life cycle and phases

The characteristic of the project life cycle is discussed in the PMBOK and described as of sequential phases that a project deals with from the beginning to the end. A life cycle can be shaped or defined by the unique features of the organization. It provides the basic structure to manage any project regardless of the work involved. Based on this guide, any PLC structure is of four stages; starting, organizing, carrying out and closing the project (PMI, 2013). PMI (2013) addressed this map as a "common frame of reference for comparing projects-even if they are dissimilar in nature."

Sinha (2014) described life cycle (LC) as "a series of identifiable phases, wherein it is 'born' it matures, it carries through to old age and it 'expires'". An alternative phase has been given in the literature reviews in such the LC is of four steps which are recognition, construction, operation and ending. The steps are described as the beginning of the project as identification, evaluation and business market analysis, the next is project team (PT) selection and the project designs including structure, information and communications and the third step is to monitor project processes and analyzing risk management and so on, and the last step is to disengage PT and termination of the processes (Ghaffari et al., 2014)

2.2.4 Project management (PM) processes

To create a predefined product or to reach any project goal, a collection of interconnected actions must be performed which is called a process that has its own unique characteristics based on its inputs, tools and technics and the output of the process. As it is emphasized in PMBOK, to reach the project deliverables, the PT should choose processes appropriately. Two main categories has been predefined by the PMI (2013); "PM processes and product-oriented processes". But only the PM

processes are described and discussed in both the PMBOK and in this study (PMI, 2013).

Initiating, planning, executing, monitoring and closing process group are the fundamentals of the PMBOK processes, these processes range from defining a new project to finalizing every activity in each process group.

Figure 2 illustrates the activity peaks in each group and the time those actions are to be made.

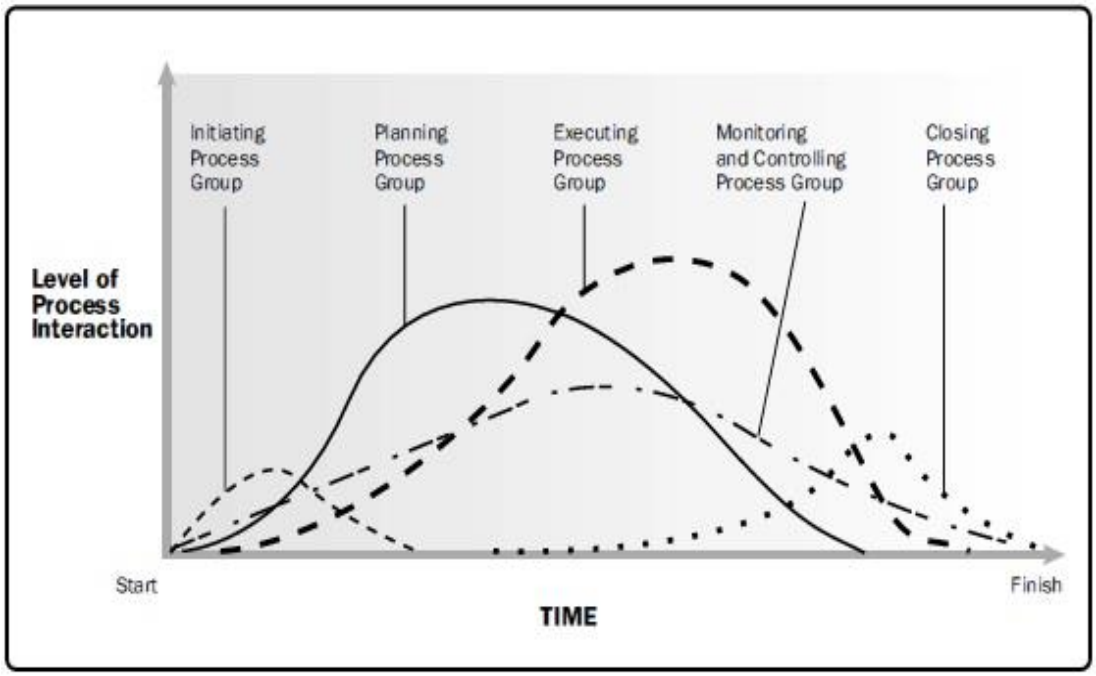

Figure 2: Process group interaction in a project (PMI, 2013).

2.2.5 Knowledge areas

PMI (2013) defined the knowledge areas to categorize the 47 processes that take place in a project. There are ten knowledge areas; each with a whole set of activities that characterize them into a management field. Figure 3 shows the relation between the process groups and the knowledge areas. The PMBOK explains vital aspects of

the knowledge areas and how they should interact and integrate in different process groups.

Although PMBOK is successful in defining the areas of knowledge within a wide range of industries, it ignores some of the essential issues in the construction industry (Loosemore, 2004).

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring and Controlling Process Group	Closing Process Group
4. Project Integration Management	4.1 Develop Project Charter	4.2 Develop Project Management Plan	4.3 Direct and Manage Project Work	4.4 Monitor and Control Project Work 4.5 Perform Integrated Change Control	4.6 Close Project or Phase
5. Project Scope Management		5.1 Plan Scope Management 5.2 Collect Requirements 5.3 Define Scope 5.4 Create WBS		5.5 Validate Scope 5.6 Control Scope	
6. Project Time Management		6.1 Plan Schedule Management 6.2 Define Activities 6.3 Sequence Activities 6.4 Estimate Activity Resources 6.5 Estimate Activity Durations 6.6 Develop Schedule		6.7 Control Schedule	

Figure 3: Process group and knowledge area mapping (PMI, 2013)

7. Project Cost Management		7.1 Plan Cost Management 7.2 Estimate Costs 7.3 Determine Budget		7.4 Control Costs	
8. Project Quality Management		8.1 Plan Quality Management	8.2 Perform Quality Assurance	8.3 Control Quality	
9. Project Human Resource Management		9.1 Plan Human Resource Management	9.2 Acquire Project Team 9.3 Develop Project Team 9.4 Manage Project Team		
10. Project Communications Management		10.1 Plan Communications Management	10.2 Manage Communications	10.3 Control Communications	
11. Project Risk Management		11.1 Plan Risk Management 11.2 Identify Risks 11.3 Perform Qualitative Risk Analysis 11.4 Perform Quantitative Risk Analysis 11.5 Plan Risk Responses		11.6 Control Risks	
12. Project Procurement Management		12.1 Plan Procurement Management	12.2 Conduct Procurements	12.3 Control Procurements	12.4 Close Procurements
13. Project Stakeholder Management	13.1 Identify Stakeholders	13.2 Plan Stakeholder Management	13.3 Manage Stakeholder Engagement	13.4 Control Stakeholder Engagement	

Figure 4: Process group and knowledge area mapping (PMI, 2013)

A summary of explanation given by PMI about each area will be provided in the following sections:

2.2.5.1 Integration management (ItM)

ItM is the area that has the most effects during the PLC through all process groups. Its main intention as is obvious by the name is to integrate the project activities. It includes definitions of integration, communication, consolidation and unification of the project activities to successfully managing the stakeholders and achieving the job goal. The processes of this area are illustrated in Figure 3.

2.2.5.2 Scope management (ScM)

This area basically aims to define what the project is and what it is not which includes ensuring the activities that must be done are accomplished and only those actions are taken place by defining and controlling what is not the job requirement.

2.2.5.3 Time management (TM)

This area focuses on timely managing a project in order to complete the job within the time limits of the project, providing the schedule and controlling it, by taking the necessary processes discussed in the guide as the focal objective of TM.

2.2.5.4 Cost management (CoM)

Based on the approved budget given to complete a project, creating a CoM plan is necessary to plan, estimate, budget, finance, fund, manage and control costs as the main purposes of this area of expertise.

2.2.5.5 Quality management (QM)

The aim of this knowledge area is to identify the quality requirements of the project and its outputs, auditing the quality requirements, measuring the quality control evaluations, and monitoring project outcomes to inform the team for necessary changes.

2.2.5.6 Human resource management (HRM)

As name of this knowledge area clarifies, its main purpose is to manage, organize and lead the PT, gathering, developing and managing the PT are the processes that took place in this area.

2.2.5.7 Communications management (ComM)

Bridging between various stakeholders in a project is the PM job in project by managing the communications in a project, through developing an effective plan of communication, creating and collecting, distributing the information amongst the project participants, and controlling the information flow to meet the stakeholder's requirements.

2.2.5.8 Risk management (RM)

This area includes deciding how to do the RM, the risks threatening the project, performing risk analysis both quantitative and qualitative and the best available responses to each risk, and to monitor and track the risks, finding new risks threatening the project and defining the responses to be made.

2.2.5.9 Procurement management (PrM)

PrM includes all the necessary processes to acquire or purchase anything from outside the PT which includes the contract administration or purchase orders, issued by the PT. Planning, process of procuring, controlling the procurements and completing each task is the activities in this knowledge area.

2.2.5.10 Stakeholder management

This knowledge area focuses on identifying the stakeholders, their relations and managing them to get the best results regarding the project deliverables, and controlling the stakeholders associations and adjusting plan for interlocking them.

Figure 4 demonstrates some of the knowledge areas sensitivities to risk factors during different stages of economy fluctuation, which emphasizes the effects of PM methods in different economy statuses as many developing countries are experimenting.

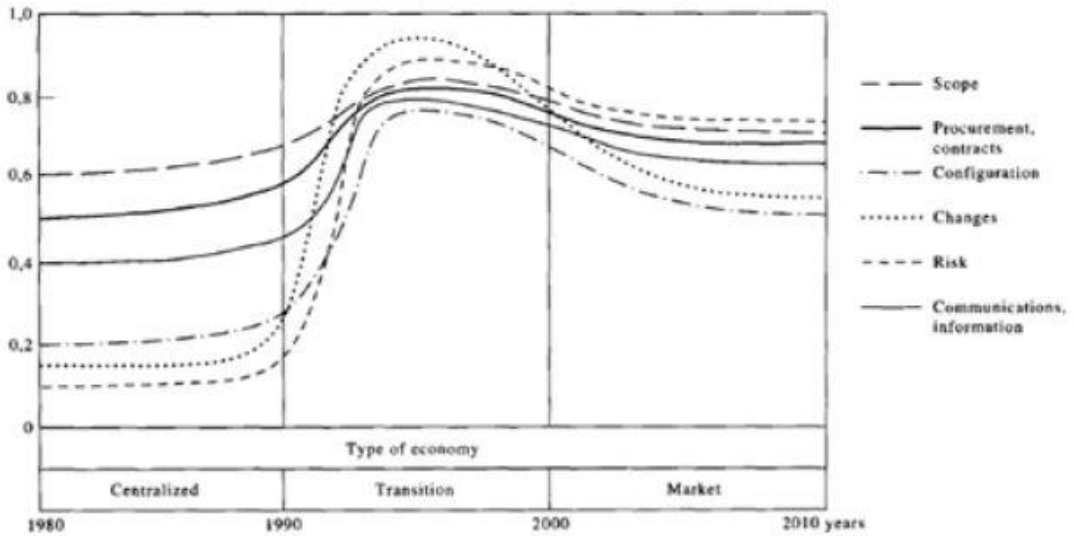

Figure 5: Knowledge area sensitivities to risk factors in different economies (Abadir, 2011)

2.2.6 Construction extension for PMBOK

Even though CM projects were one of the foundation practices that has been used by PMI to create the PMBOK due to escalating recognition of the PM value, it has broaden the concepts of PMs and due to CMs nature, PMBOK does not fully embrace such practices nowadays. So as to improve the CM projects, the extension has been created that contains material applicable to CM (PMI, 2000). The new knowledge areas introduced by the extension have been demonstrated in figure 5 and their occurrence according to the process groups has been illustrated in figure 6.

2.2.6.1 Safety management (SM)

Developing a managing approach toward hazards in a project, carrying the plan and reporting the safety issues is this knowledge area expertise, to assure the project is executed appropriate to prevent and reduce accidents causing losses both directly and indirectly.

2.2.6.2 Environmental management (EM)

This knowledge area focuses on identifying the potential impacts of the construction that might have on the environment surrounding the project place. It also includes planning to conserve the nature and auditing and inspecting conditions of the environment, which mostly collaborate between the project and legal authorities.

2.2.6.3 Financial management (FM)

FM is differen from CoM; CoM is based on the daily costs and payments for labor and material while FM focuses on project expenditure by detecting key financial concerns and solving the issues and controlling the financial plan.

2.2.6.4 Claim management (ClM)

ClM describes processes to prevent or eliminate claims from occurring, and handling the claim if they occurred. ClM has two perspectives; the claim maker and the defender.

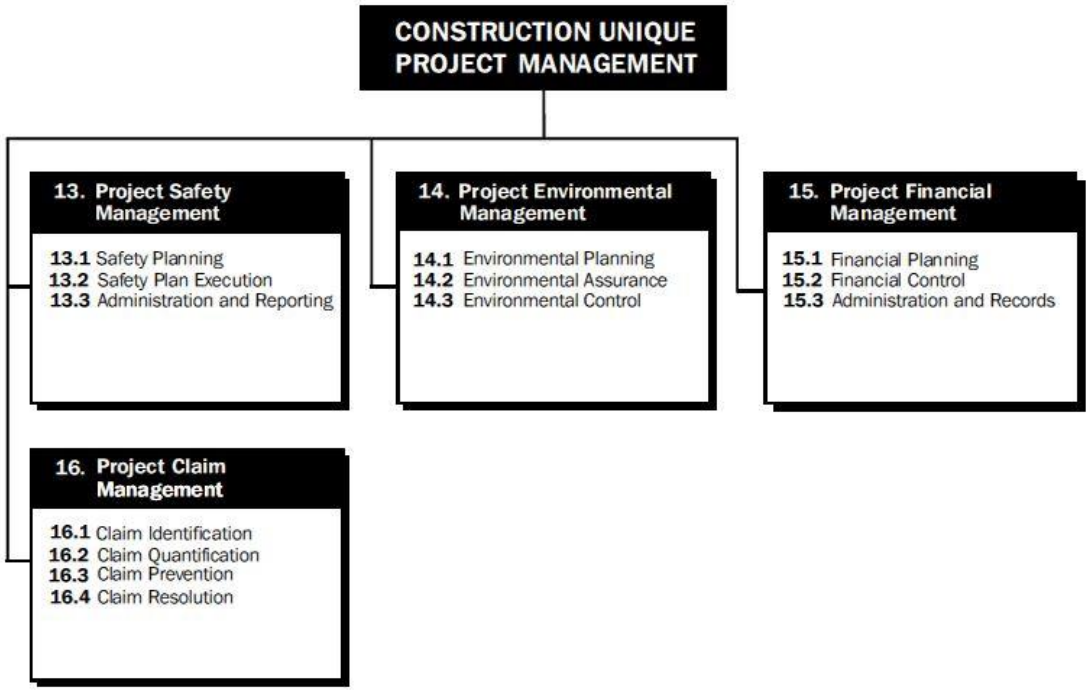

Figure 6: CM unique knowledge areas (PMI, 2000)

Process Groups / Knowledge Area	Initiating	Planning	Executing	Controlling	Closing
13. Project Safety Management		13.1 Safety Planning	13.2 Safety Plan Execution		13.3 Administration & Reporting
14. Project Environmental Management		14.1 Environmental Planning	14.2 Environmental Assurance	14.3 Environmental Control	
15. Project Financial Management		15.1 Financial Planning		15.2 Financial Control	15.3 Administration & Records
16. Project Claim Management		16.1 Claim Indentification 16.2 Claim Quantification		16.3 Claim Prevention	16.3 Claim Resolution

Figure 7: Construction extension knowledge areas and process groups

2.3 Construction management (CM)

CM is known to be a project-oriented industry. Construction industries usually face insecurity due to lack of resources and the projects characteristics; therefore, an effective PM is vital (Isik, Arditi, Dikmen, & Dirgonul, 2009). Companies that usually do construction businesses are called contractors due to their agreement upon a contract with a client.

Munns and Bjeirmi (1996) indicated some factors that may cause a failure in the project:

- "Inadequate basis for project"
- "Wrong person as project manager"
- "Top management unsupportive"
- "Inadequately defined tasks"
- "Lack of project management techniques"
- "Management techniques mis-used"
- "Project closedown not planned"
- "Lack of commitment to project"

The vitality of the PMBOK as a resource is unquestionable yet all its processes, tools and techniques may not be appropriate for every industry; the effectiveness of this guide is yet to be examined in construction industry. Knowledge areas of PMBOK are considered to be essential and facilitating the management (Chou & Yang, 2013). United States department of labor statistics (BLS, 2014) described that a Construction Manager role is from development to completion in a construction project which consists of planning, coordination, budgeting and executing the project. It is also mentioned that within 2012-2022, employment of Construction

Managers will increase by 16% which is more than any other occupations average. The work of Construction Manager is typically as follows: (a) cost estimations, timetables and budgets preparation; (b) explanation of contracts and other project documents to PT members; (c) inform the client of work progress and financial matters; (d) cooperate with other team members; (e) manage the subcontractors activities; (f) respond to any problem regarding the project work including delays and emergencies; (g) act in accordance with legal obligations of construction and safety issues.

For large projects which are difficult for one manager to take care of the business, the high level manager will hire other Construction Managers to help the project management in different phase and aspects (Bureau Of Labor Statistics, 2014).

Although the definitions given above are up to date, but it is still based on the old trend toward the CM and has not been influenced by new approaches such as PMBOK or PMO or etc.

In a construction project, there are two keys to achieve the project goal which are material and human resources. It is obvious that there are many countries with rich resources yet being challenged due to lack of human resources and managing to handle them, though availability, quality and managing the human resources is the only element in achieving project purposes. CM consists of three phases of planning, scheduling and controlling, the first two phases are done before the project starts and controlling is executed while the project has started (Punmia, 1993).

CM is different from other PM fields and it is all due to its natural characteristics. For instance, CM projects are typically undertaken outside and are exposed to many risks such as traffics or weather fluctuations or site instability due to municipal or other governing authorities; therefore, geography and site conditions must be addressed. Many different specialists and experts in a variety of fields work on a single project to reach its aims. Hence substantial management skills are required. Compared to other industries, construction projects consume materials and physical tools immensely and comparatively have an intensive workforce use (Abadir, 2011).

2.3.1 Project Life Cycle (PLC) (construction approach)

Discussing the PLC through the view of a construction team might be considered different as of other PTs. Construction projects pass stages from initiation to finishing point which may be outlined as follows; (1) concept; (2) design; (3) tendering; (4) preconstruction; (5) construction; (6) commissioning; and (7) asset management. These steps are sequential which means they must be finish successfully in order to move to the next step; but sometimes due to lack of time, fast tracking or overlapping some phases are possible. PT does change during these stages but only the client and the PMR remain the same, the PT is selected based on their expertise and proficiency which is linked to the PLC stages. Members of construction PT may be listed as follows: client, PM, financier, legal adviser, design leader and design advisor, contractor and subcontractors, cost advisor, other consultant's dependent of job requirements and the end user or costumer. However, other members and participants might join the project depending on a variety of reasons like size or methods of delivery (Loosemore, 2004).

Furthermore, the PLC stages are to be discussed in order to illustrate the activities and importance of each one. First stage, the concept stage is to identify the extent of the project to evaluate the effectiveness and success of the project. The main purpose of this stage is to create an outline of necessary decisions to develop and successfully complete a construction management (Loosemore, 2004). Figure 7 illustrates the cost of decisions and changes during the PLC.

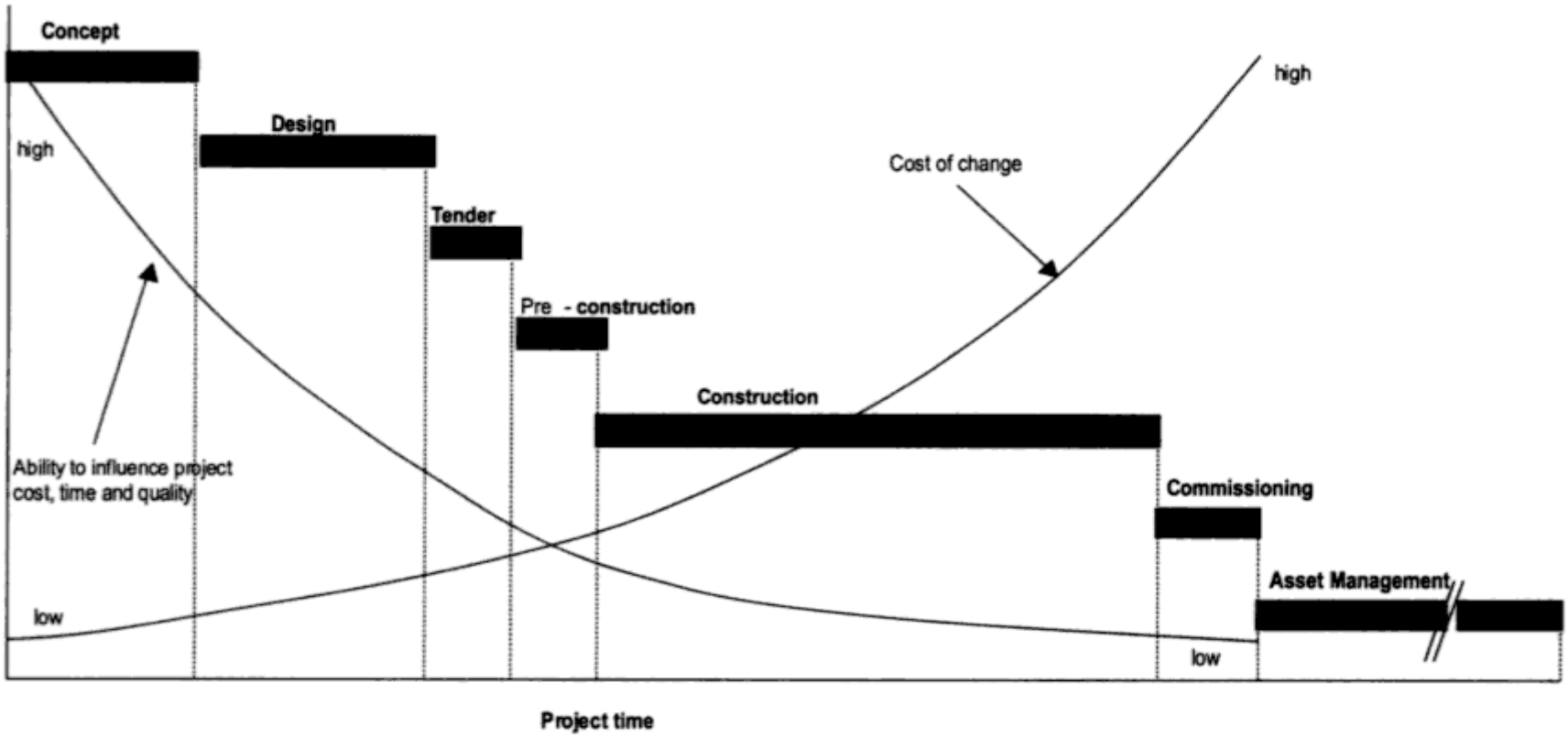

Figure 8: The impact of decisions during the PLC and their costs (Loosemore, 2004)

Another categorization for the PLC stages described by The Chartered Institute of Building which varies in some aspects with the others mentioned before is:

(1) Inception, (2) feasibility, (3) strategy, (4) preconstruction, (5) construction, (6) engineering services commissioning, (7) completion and handover and occupation, (8) post-completion review (The Chartered Institute Of Buildings, 2002).

Inception is where the client decides how a potential project indicates how to reach a specified goal. This may include selecting the PMR and finding the investor and what the risks are.

The next phase is the feasibility which focuses on the objectives of the job, defining probable options through value and risk valuation. The plan to carry out the project in its best way is the core output of this stage.

The strategy stage is where the project scope and change is most related, the main purpose of this step is to establish the procurement and commissioning by understanding project aims and establishing the plan by risk management (The Chartered Institute Of Buildings, 2002). Figure 8 demonstrates the relation amongst scope and change.

Relationship amongst scope, change and cost has been demonstrated in many shapes in this study, trying to expose diverse views over the PLC issue; and while it is out of this chapter's scope, yet it will be illustrated and discussed furthermore in the next chapter.

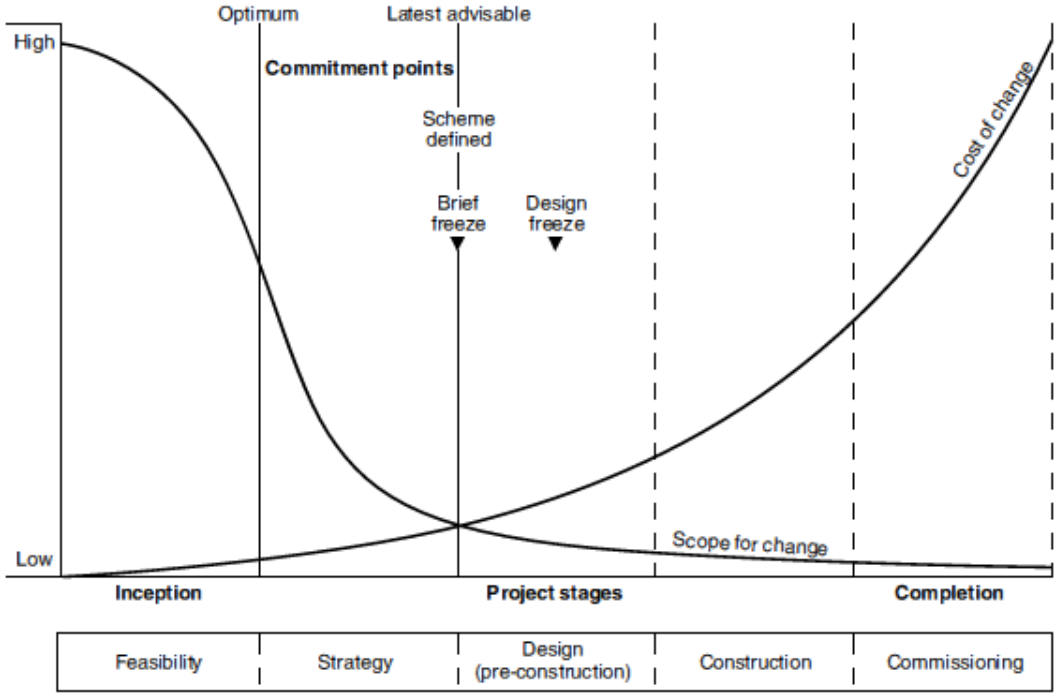

Figure 9: Relation of changing scope and cost (The Chartered Institute Of Buildings, 2002)

Although, it has been stated that feasibility and strategy steps distinction is not always distinguished, they are more or less related and in order to reach an effective result, they must be executed simultaneously. The strategic stage consists of organizational control method, project, cost planning and controlling and even the procurement methods and strategies, and PT appointment (The Chartered Institute Of Buildings, 2002).

The pre-construction stage's main goals are to finalize and identify the best solutions, confirm a detailed design that is deliverable within a specified time and decided cost, and acceptable quality. In this stage, the team prepares tender documents and processes.

Construction stage's main goal is to safely conclude a project within the limitations provided in the previous stages.

Engineering services and commissioning steps goals are checking that engineering installation were correct and safe, and perform as planned, commissioning in between different systems are appropriately scheduled and the handover is successful without any delay.

The last phase, the post completion review, aims to determine the performance of all facets of the project and to carry forward the knowledge gained to the forthcoming projects and undertake preliminary valuation of the newfound facility (The Chartered Institute Of Buildings, 2002).

Celik (2010) defines the construction PLC in five stages. The first stage is briefing which begins with planning the job and appointing designers and other experts, defining client requirements and needs and creating initial sketches and cost estimation. The second stage is the designing stage which starts with starts by creating a comprehensive brief of the project and getting the client approval and developing the schematic designs and accordingly and a reliable cost estimation and an initial schedule. The third stage of this approach is tendering which focuses on selecting and awarding contractors. Obtaining tenders from eligible contractors and the pre-qualification activities and issuing a contract which is most suitable for the job. The next and forth stage of this lifecycle approach is the construction stage which has been defined as "to construct the structure within the agreed limits of cost and time and the specified quality". The last stage is commissioning which has three main purposes; ensuring that the building is constructed as specified, providing an

operating catalogue and training the personnel to use the facility. In this stage the as built documents are prepared as well.

Bennett (2003) introduced another PLC approach for the construction project and characterized six unique stages. This approach starts with the owner responsibilities and decisions in the pre-project stage, plan and design stage comes after the contract selection and related processes. Site preparation and resource allocations and project mobilization is coordinated by the contractor. Now the construction phase is ready, the contractor should simply focus on controlling and monitoring, resource allocation and communication and documenting the work progress. QM and SM and EM are sub stages of this phase which is called the project operation. The project close-up is the last stage of a PLC and activities like site cleaning up, various inspections, releasing the staff, making the as-built plans and etc. must be taken place in this phase. (Bennett, 2003)

Chapter 3

METHODOLOGY

3.1 Introduction

This study focuses on establishing a framework for the PMBOK guide, through developing a flowchart with a comprehensive awareness of all process groups and activities with a construction PLC approach.

An explanation of the methods and approaches toward creating the flowcharts and frameworks, how they have been selected and how they have been created will be given in this chapter.

3.2 Life Cycle Approach

PMBOK establishes a guideline in which it presents a series of activities that believed to be the best practices in each industry; but later on a construction extension was created to accompany the basic guidelines due to construction unique characteristics. The process groups have been introduced and clarified that they are not based on a PLC (PMI, 2013).

Many studies have tried to create different PLC for a construction project that has many differences in the naming and numbering of the phases, but the further these studies get investigated, their similarities become more clear. Therefore, the processes that have been applied and defined in construction PLC will be considered. These steps which have been defined by some of the most respected institutes in the world are considered the best practices until now. A combination of these studies

will be used to create the most useful and efficient framework for construction regarding the PMBOK guide.

3.3 Flowcharts, Frameworks

The first step of this study focuses on finding a pattern between the PMBOK process groups and a construction PLC including all the phases, activities and every aspect of the PM and defining their differences and similarities.

The second part focuses on creating flow charts. Three flowcharts will be developed in this study. First one will be the PMBOK flowchart of activities, since there is not a comprehensive flowchart in the guide which covers all of the activities at once. Using the given information in the guide, this step will finalize a general flowchart. Second flowchart is a combination of activities that have been defined and introduced in the first section of the framework chapter. This can be considered as the state of the art, regarding the best practices done in CM field. Finalizing this flow sheet requires combining many different approaches toward the construction PLC.

With two main flow sheets created, the main goal of this study which is to create a construction framework for the PMBOK guide, a methodology to use the guide as a source in a construction project is at hand. Creating a final flow diagram, founded on the two proposed flowcharts, considering the first one the main chart and implementing and developing it, the second chart introduced, a comprehensive flow diagram is established which can be used in construction project as a main source of activities that has been known to have the most effects in increasing the PM performances and its efficiency.

Chapter 4

FRAMEWORK PREPARATION

4.1 Introduction

The PMBOK and PM were described in chapter two and their perspective toward construction management has been clarified. CM methods have been introduced to illustrate that due to CM's unique characteristics, it differentiates from other industries; therefore PMBOK extension has been presented to feel the gap in the PMBOK guide. However, it has been mentioned and illuminated over and over that PMBOK is just a guide, not a methodology. As PMI (2013) stated the same facts and explained that the extension is not going to be any different, the methods and processes may be changed, altered and not even used according to the PT decision. Fifty steps have been presented by PMBOK and PMBOK extension within five phases of a PLC. Along with the knowledge areas that have been presented by the PMBOK, the process groups categorize them.

Processes of the PMBOK and construction PLC will be described and a flowchart according to each method will be created, each process will be explained in depth in this chapter to clarify each flowchart characteristics.

4.2 Introducing Activities of Each Phase or Process Group and the Flowcharts

4.2.1 Initiating phase

Within this phase, initial scope is defined and preliminary financial assets are committed, PM should be assigned, stakeholders shall be defined and many other

activities which are undertaken in this phase. Initiating phase consists of two processes and figure 9 depicts the processes;

a. Developing project charter: Producing a document that officially approves the existence of the project. Prior to creating this document, the PMr must be assigned to make the most valuable project charter, the business needs. The project statements and agreements are inputs of this process and by the PT judgment and advice the charter can be created which is used in other steps.
b. Identifying stakeholders: Process of identifying the participants of a project whether they could affect the project or it is the other way around. Using project charter, and if the project is procured, the procurement documents and the methods like stakeholder analysis and the PT judgment, the stakeholder register is created.

4.2.2 Planning phase

This step's goal is to create plans of how the project should be carried out, the documents needed to undertake each activity; the furthermore the plans being created the possibility of revisiting and changing other processes that have been already performed increases. Planning phase has the most managerial activities (28 processes) based on PMBOK;

a. Developing PM plan: This plan is basically the coordination of all other subsidiary plans, which gives the PM the basis of all works in a project. This comprehensive plan is created by defining and organizing project charter and other plans which will be described.

b. Plan ScM: This step is defining how to manage the scope during the PLC, what the scope is and help to create the WBS. Meetings are essential to interrelate project plan and scope plan

c. Collect requirements: The process of defining and documenting the needs and objectives of the stakeholders, the main benefit of this process is how it helps to manage and define the scope. This step prepares the requirements documents and traceability matrix.

d. Define scope: Using the project charter and scope plan and requirements documents explained before, a comprehensive description of the job is established that helps the scope statement.

e. Create WBS: A process to divide a project into smaller components that can be handled and managed easier. It also defines the scope baseline. WBS is considered to be known by project managers and its characteristics are out of this study range. Figure 9 and 10 shows the processes mentioned.

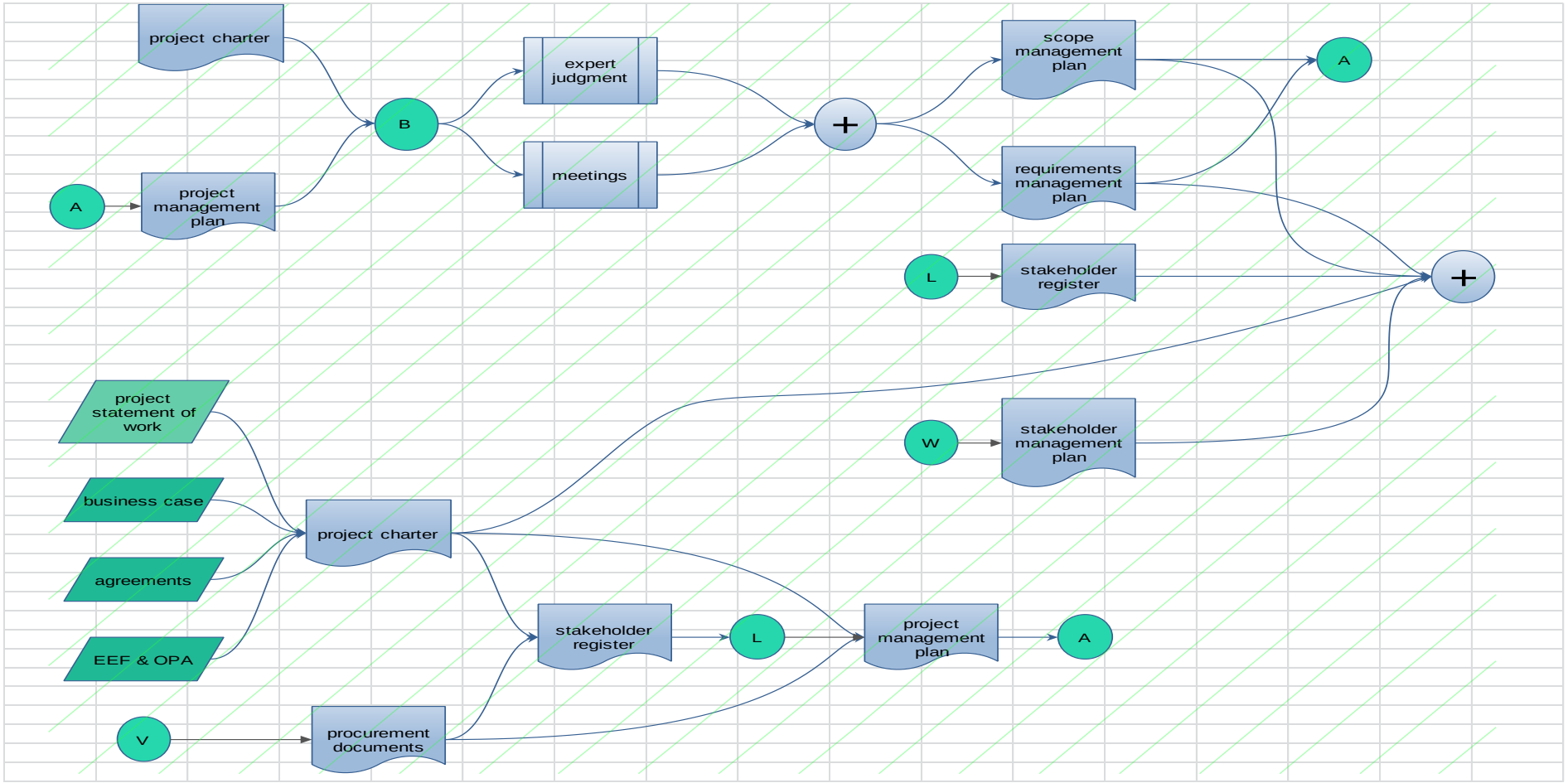

Figure 10: Initial phase and planning phase a, b, c, d, e

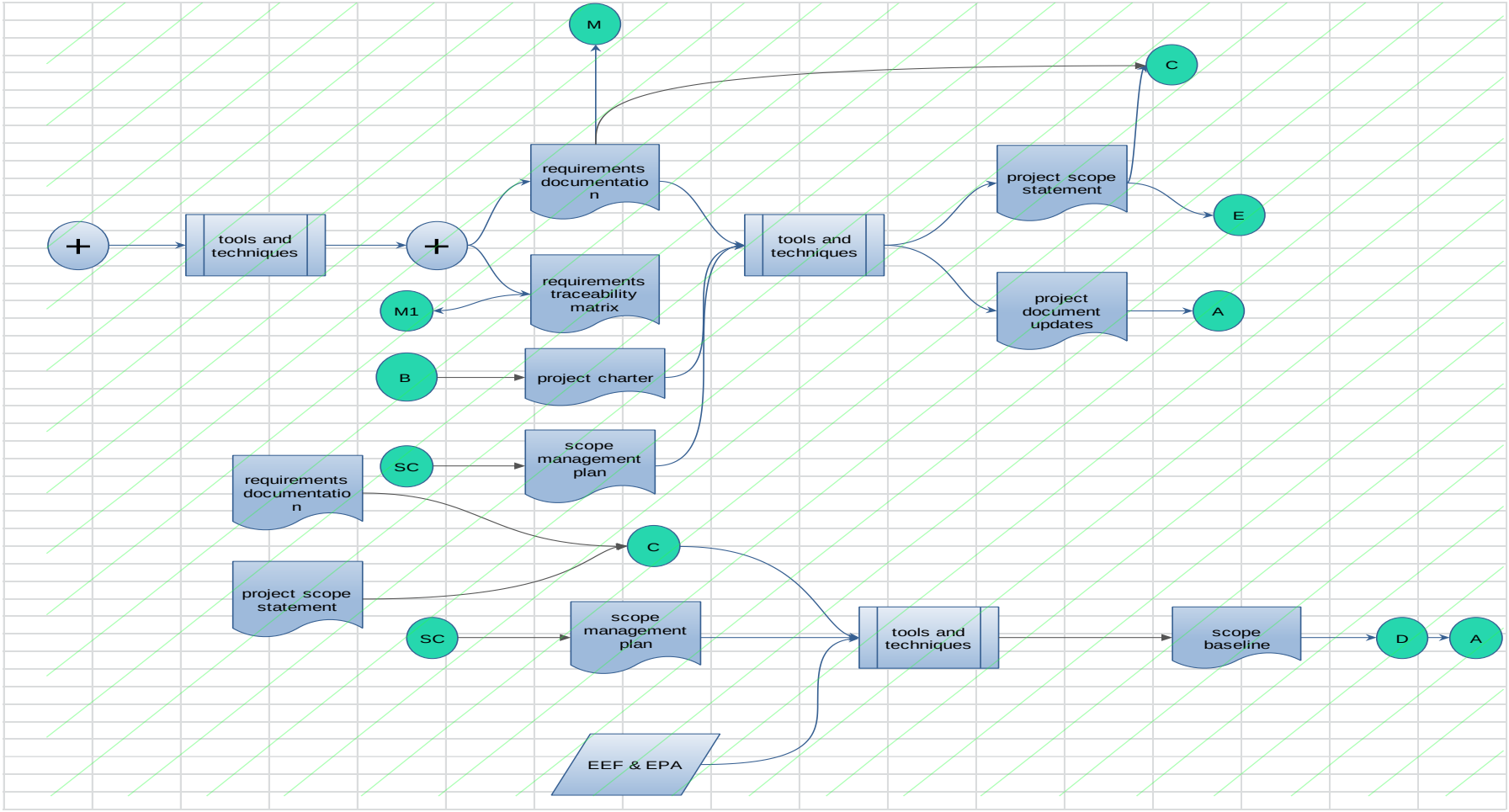

Figure 11: Planning phase a, b, c, d, e

f. Plan schedule: To create a plan, it is necessary to establish the policies, documentation and procedures needed. This will help to understand how the schedule should be managed.

g. Define activities: Activities refer to the actions need to be done to deliver the projects goals. Breaking the work packages into smaller activities, to help produce the foundation of estimating, scheduling and etc. this step provides the list of activities and their attributes and a milestone list.

h. Sequence activities: To gain the efficiency a project needs, all the activities need to be defined and their relation toward one another, regarding all the project constrains, must be in a specified order. This step provides the network diagram.

i. Estimate activity resources: This process provides the resources an activity will need, its type, characteristics and quantity. This process provides the PT with the resources required and their categorization structure.

j. Estimate activity durations: This stage estimates the number of works stages to finish each activity. The main goal of this process is to approximate the time needed for each activity to conclude.

k. Develop schedule: Producing a schedule model with completion dates of activities, regarding their duration, relations, constrains, resources and their availability. This model accuracy is dependent on its input precision. The project schedule is the outcome of this step.

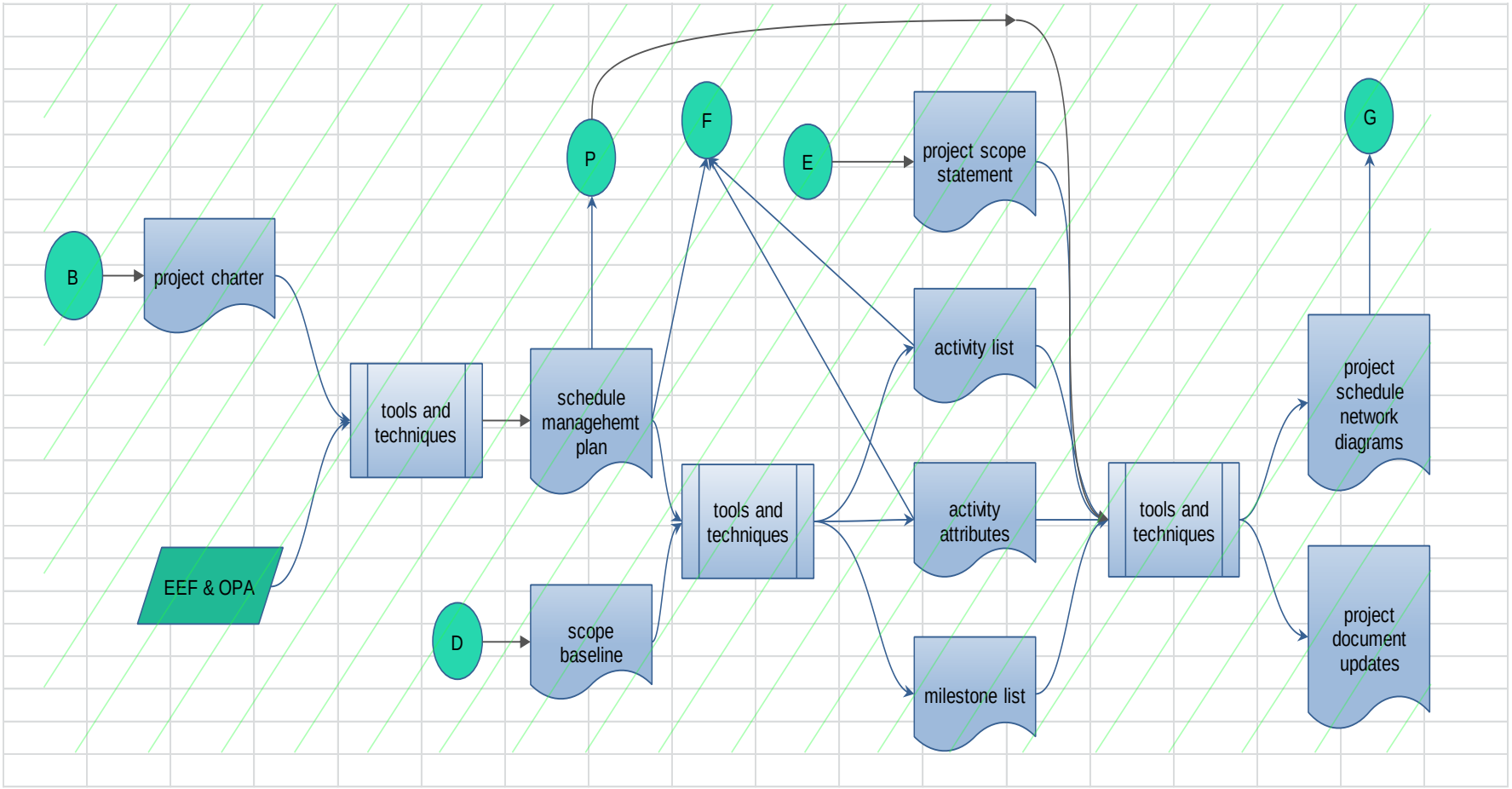

Figure 12: Planning phase f, g, h, i, j, k

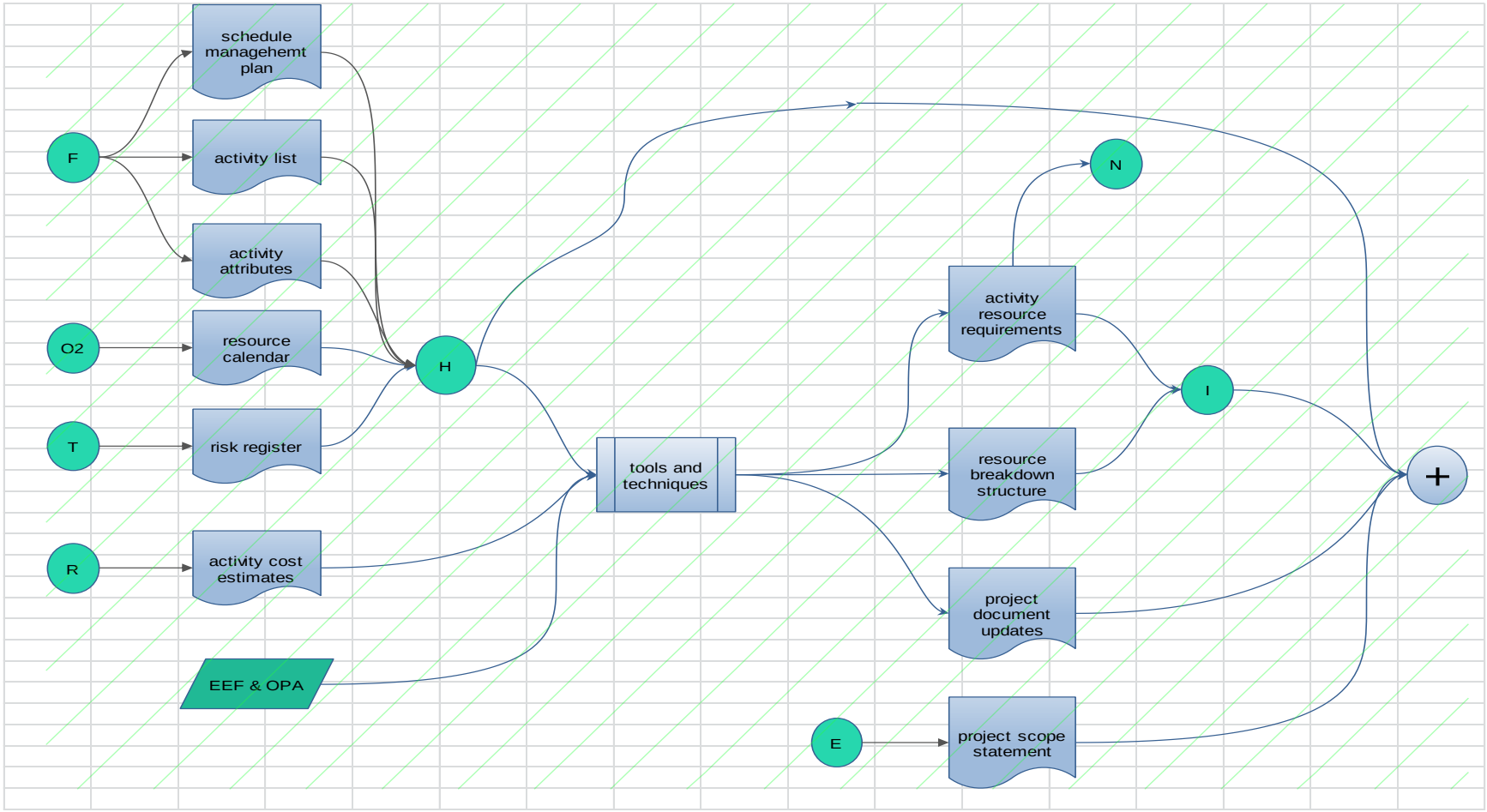

Figure 13: Planning phase f, g, h, i, j, k

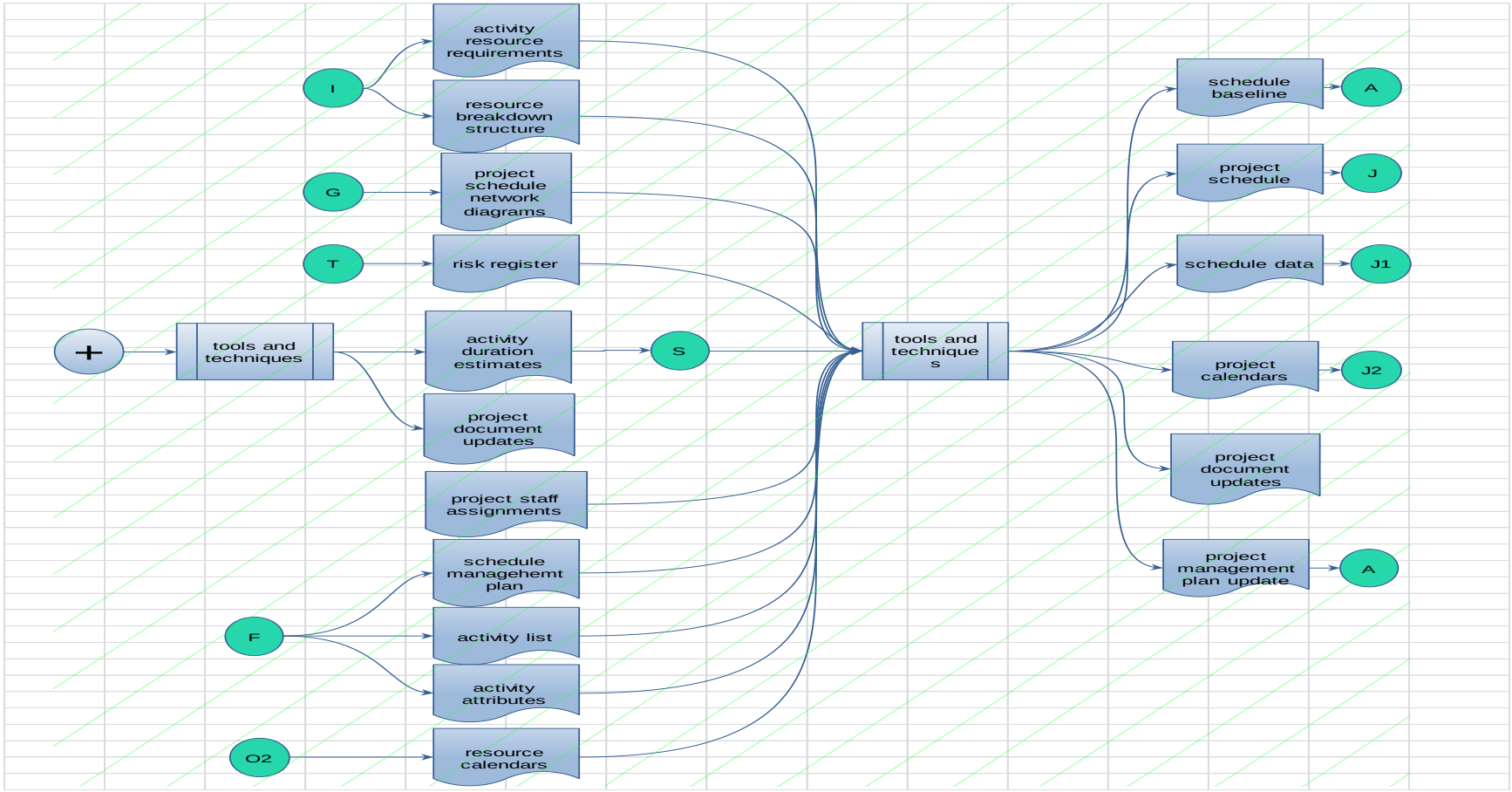

Figure 14: Planning phase f, g, h, i, j, k

Figure 11, 12 and 13 demonstrate f to k processes and the flowcharts.

l. Plan CoM: This process focuses on developing documents needed for cost management procedure and policies. It basically works on how the project cost should be managed.

m. Estimate costs: Estimating the budget needed to finish the project activities, based on the cost plan, scope baseline, and human resource plan, and risk register. Benefit of this step is that it determines the project cost until conclusion. The tools and techniques of cost estimation are out of this study criteria.

n. Determine budget: Creating the cost baseline which helps monitoring and controlling the project performance. Cost baseline is a brief of various activities approved budgets. Cost baseline defines the periodic funding necessities.

Figure 14 and 15 present the flowchart created for the l, m and n processes.

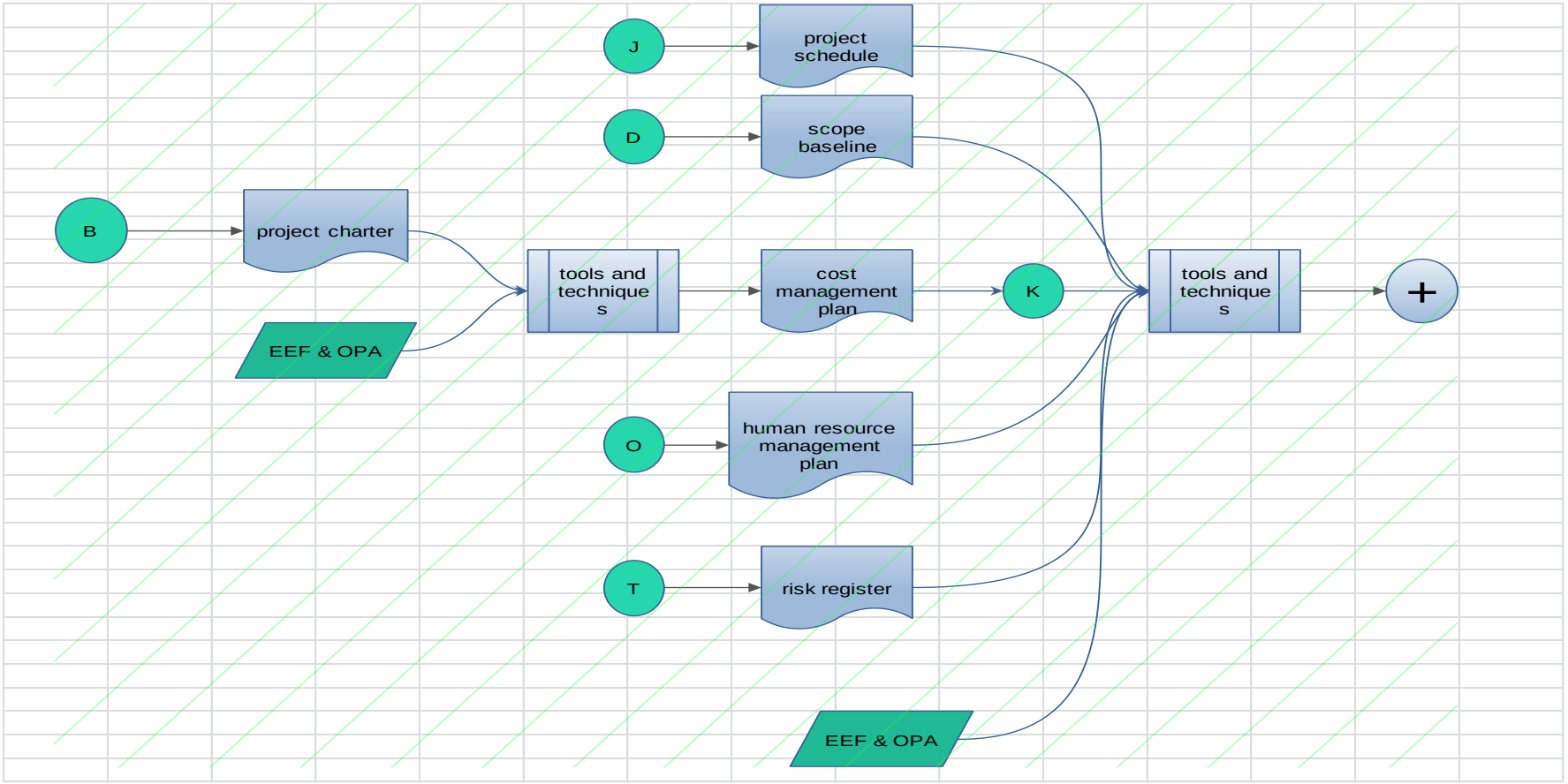

Figure 15: Planning phase l, m, n

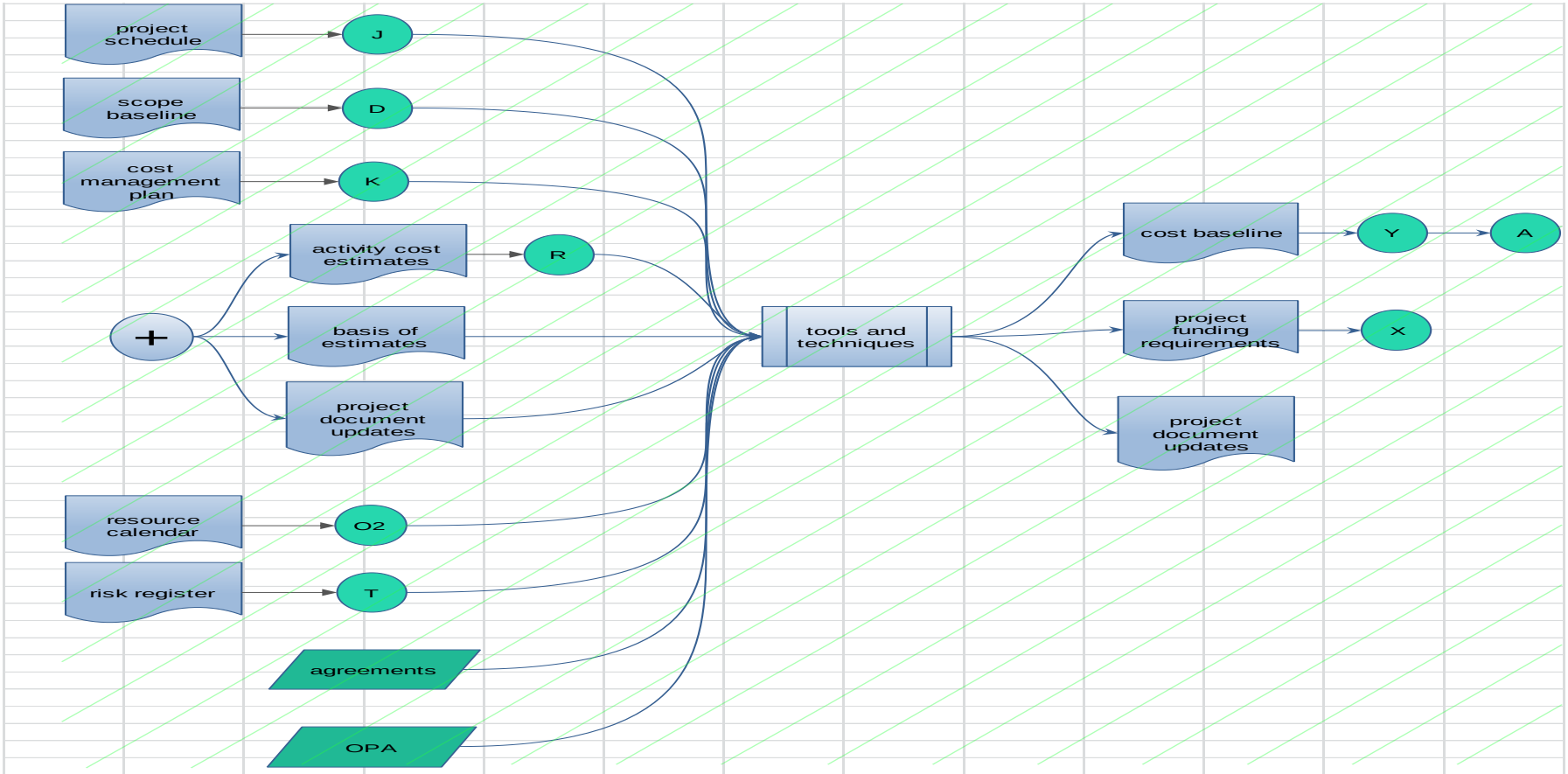

Figure 16: Planning phase l, m, n

o. Plan QM: Defining quality requirements as well as standards needed in some projects, to ensure the deliverables meet the expected quality. This step uses the information gathered in the project plan stakeholder register and risks register and using the tools specified by the PMBOK which are not the purpose of this study and can be discussed furthermore. This stage also provides plan to improve processes, quality metric which defines the attributes of a job and how it should be measured and quality checklists which confirm that the requirements have been met. Figure 16 is the QM flowchart.

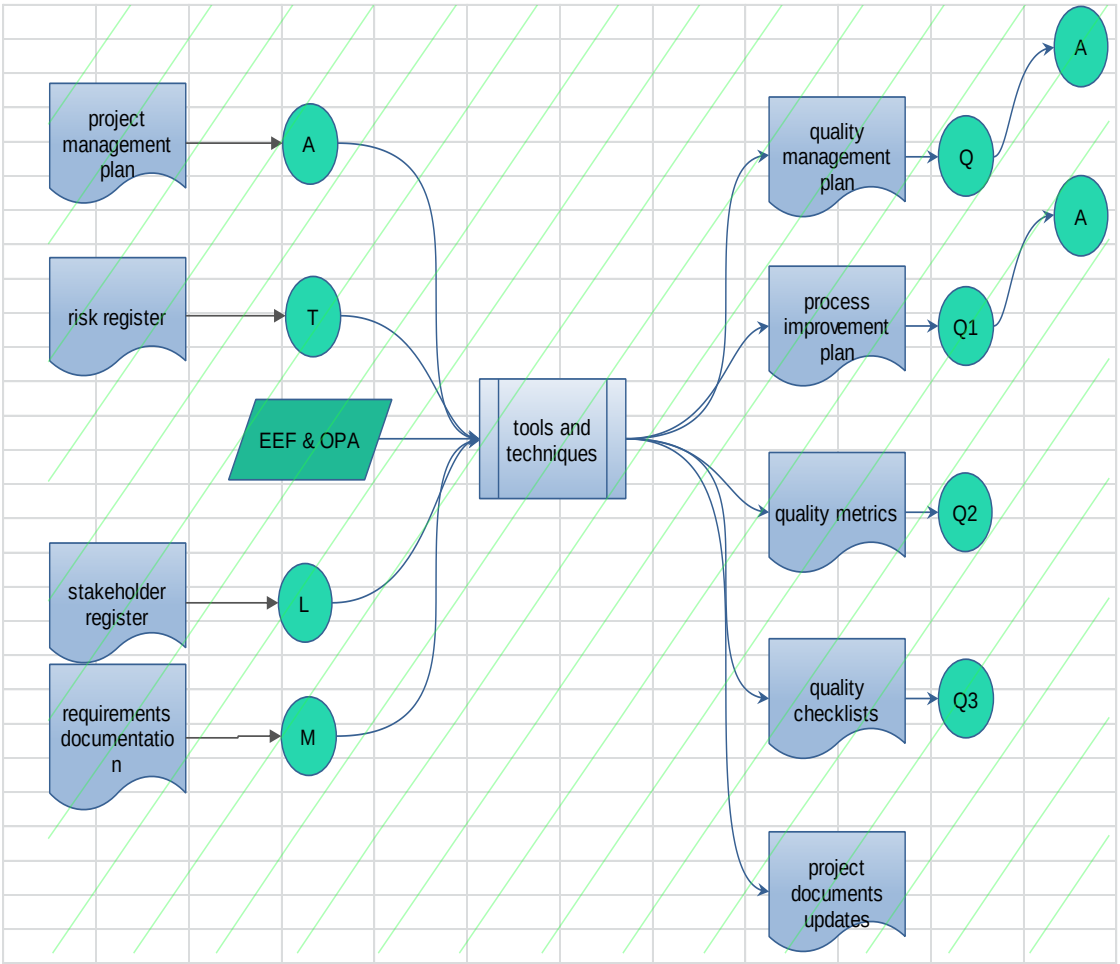

Figure 17: Plan quality management

p. Plan HRM: Recognizing the roles, responsibilities and the skills required for the project, establishing the organizational charts and recruitment management. It simply clarifies what, when, and why a person should be recruited and released.

q. Plan ComM: This step basically focuses on how the stakeholders should interact and how the information must flow within the PT regarding their necessities in the most efficient way by using the communication techniques and models. This includes identifying those in charge of authorizing and those responsible to share the information needed by another party for an identified reason.

Figure 17 demonstrates the ComM and HRM flowcharts

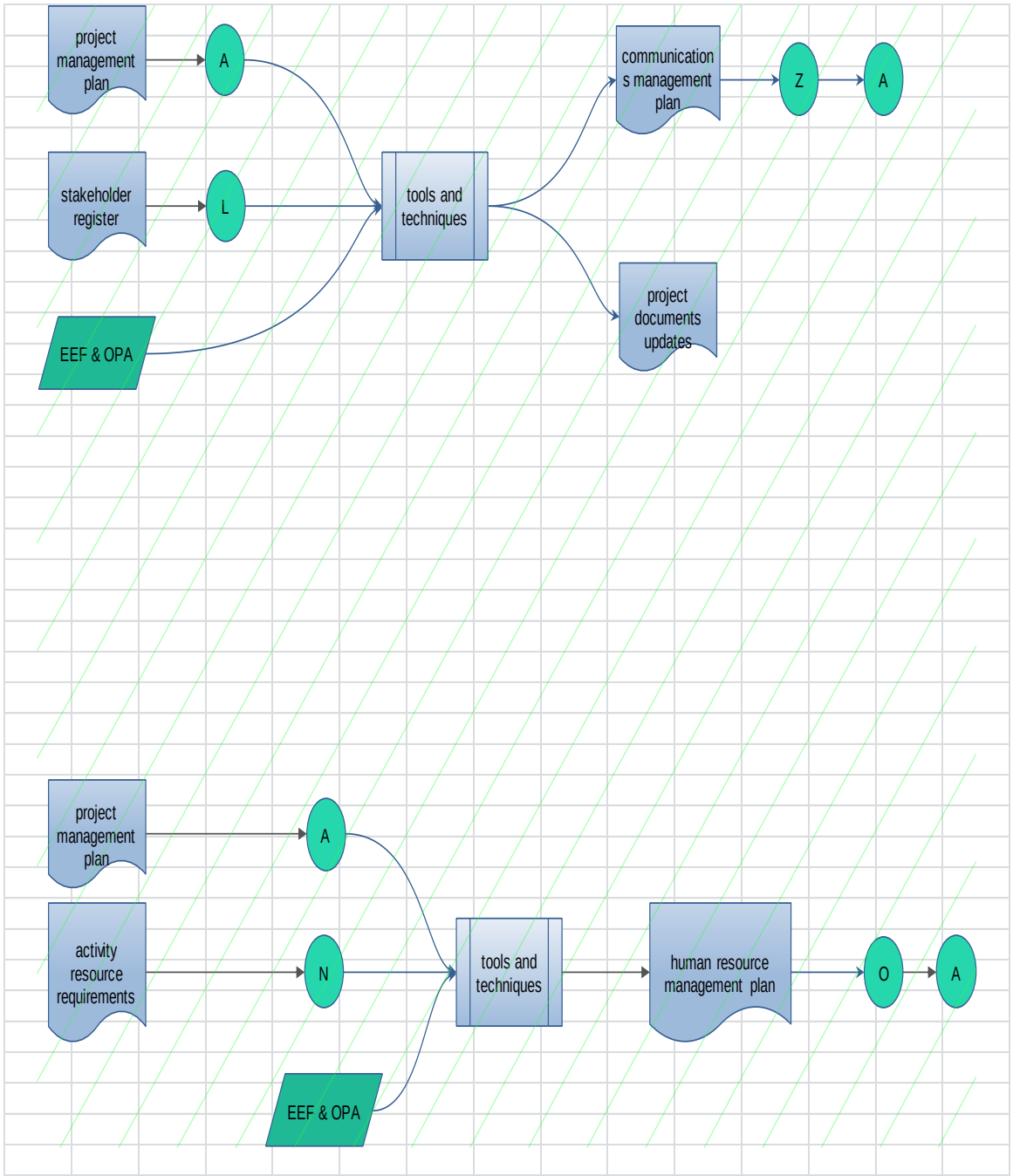

Figure 18: Plan human resource and communication management

r. Plan RM: Outlining how to conduct the RM activities, main purpose of this step is to make sure that the risk degree, visibility and type is adequate with both risk and the significance of a project. To create such plan, it is vital for all the stakeholders of a project to communicate and support it.

s. Identify risk: Clarifying the risks that might affect the job and recording their characteristics, this step aids the team by providing them with occurring risks documentations and enables them to anticipate events. Risk register is the outcome. It is a document which holds the risk analysis and their responses.

Figure 18 illustrates the processes of RM planning and identifying the risks within a flowchart.

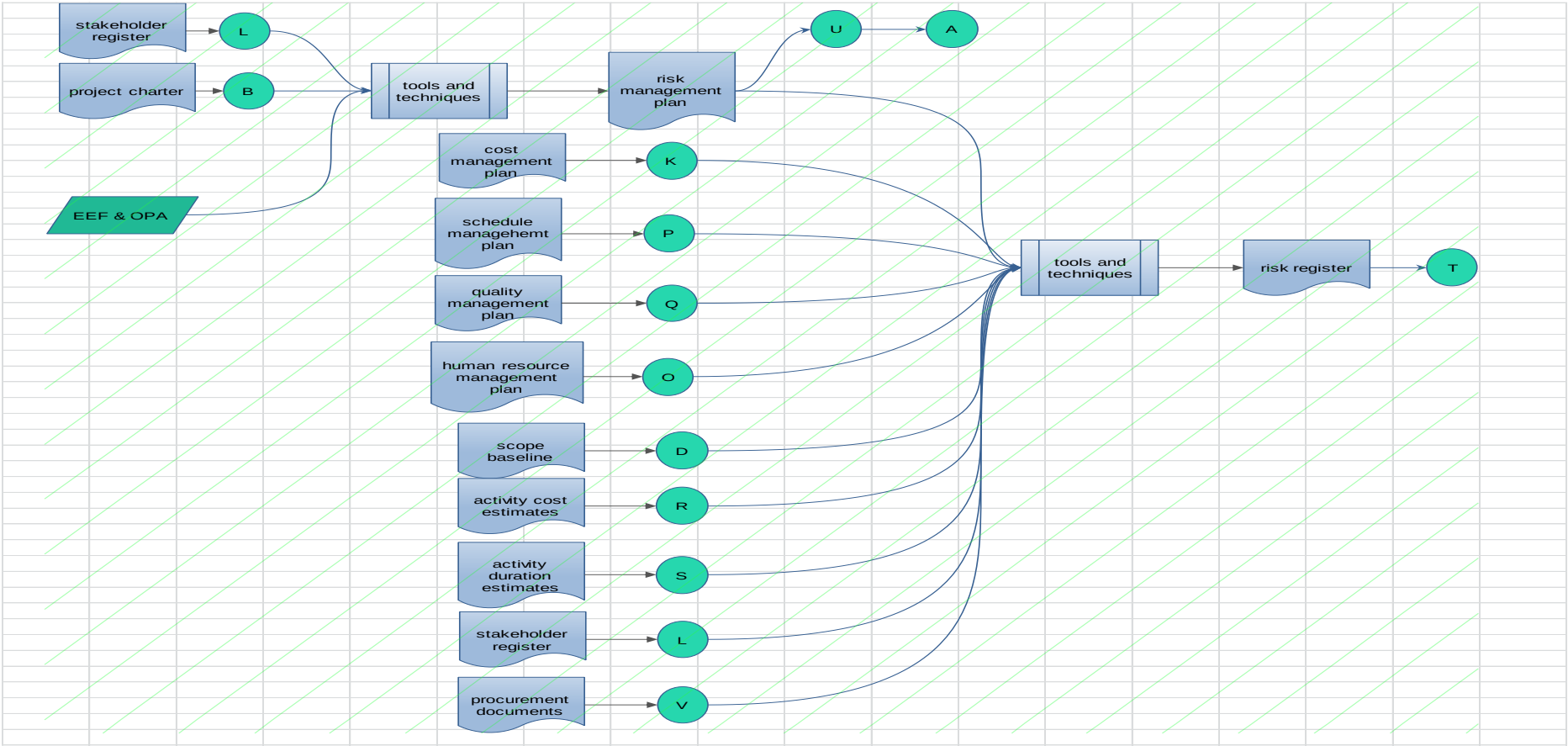

Figure 19: Plan risk management and risk identification

t. Perform qualitative and quantitative risk analysis: This step's aim is to clarify the risk priorities and their manifestation chance and impacts which reduces the level of uncertainty of risks that enables the managers to focus on more important risks

u. Plan risk responses: Developing and establishing activities to diminish threats toward the project, this step focuses the risks based on their importance and supplying the plan and schedule by resources and activities when required.

Figure 19 is the flowchart of performing risk analysis and risk responses.

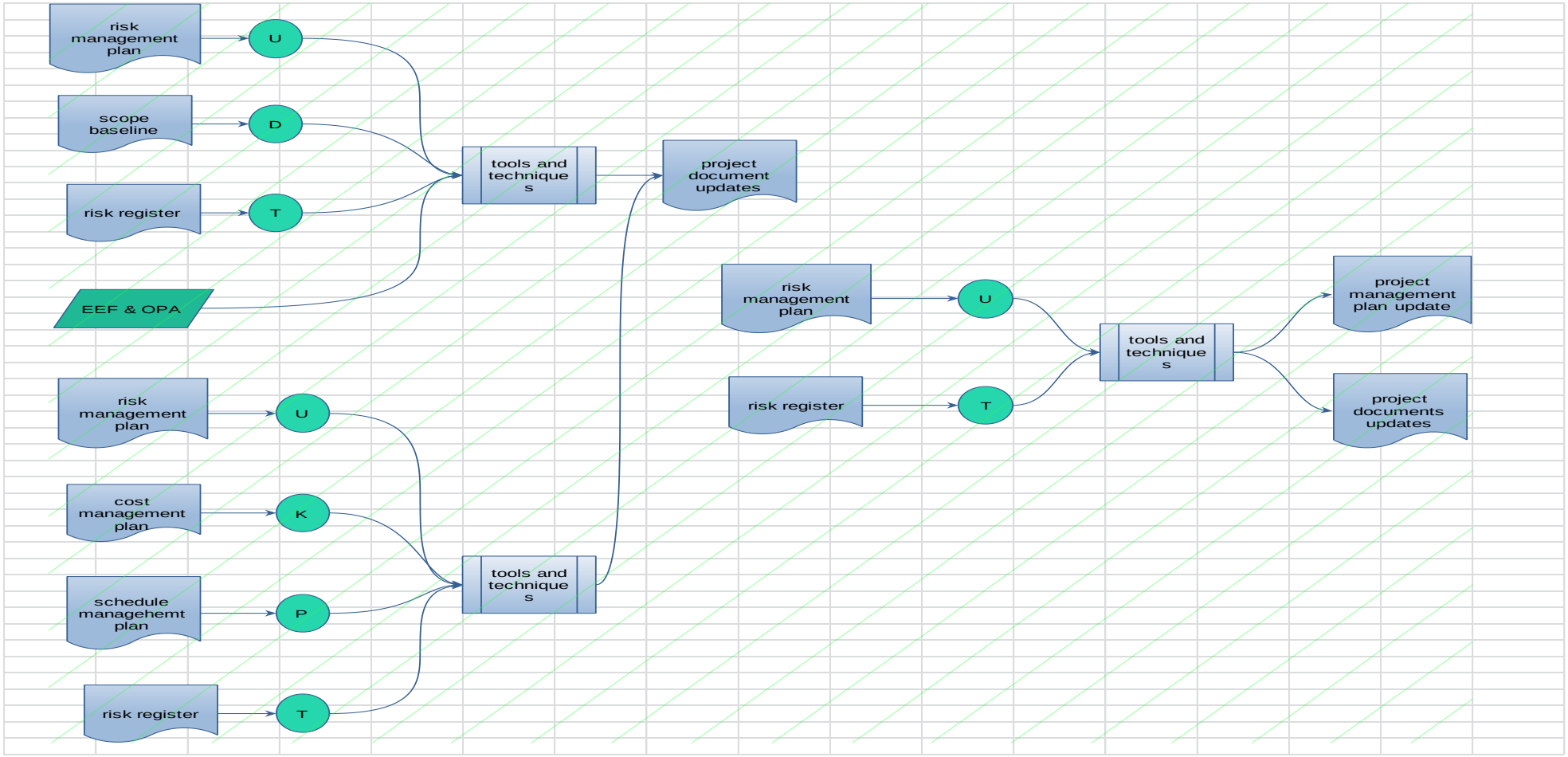

Figure 20: Quantitative and qualitative risk analysis and risk response planning

v. Plan procurement: How to approach and identify the sellers, and recording the procurement results. This step focuses on determining that if the external support should be acquired and if so, the methods and costs of acquiring the external help as well as identifying the contracts types and RM issues and any restrains that could disable the procurement to occur as planned. (figure 21)

w. Plan stakeholder management: How to engage stakeholders in the PLC, regarding their needs, requirements, impacts and interest in order to produce an effective plan to interact amongst them to increase the project management efficiency. (figure 20)

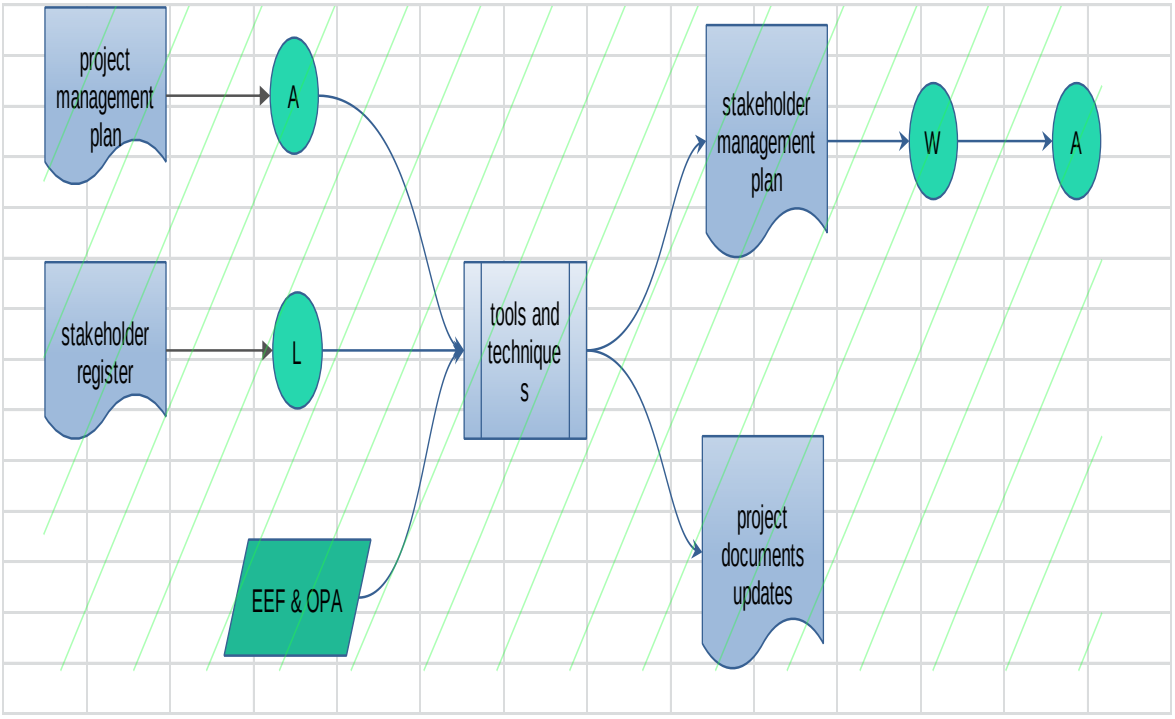

Figure 21: Plan stakeholder management

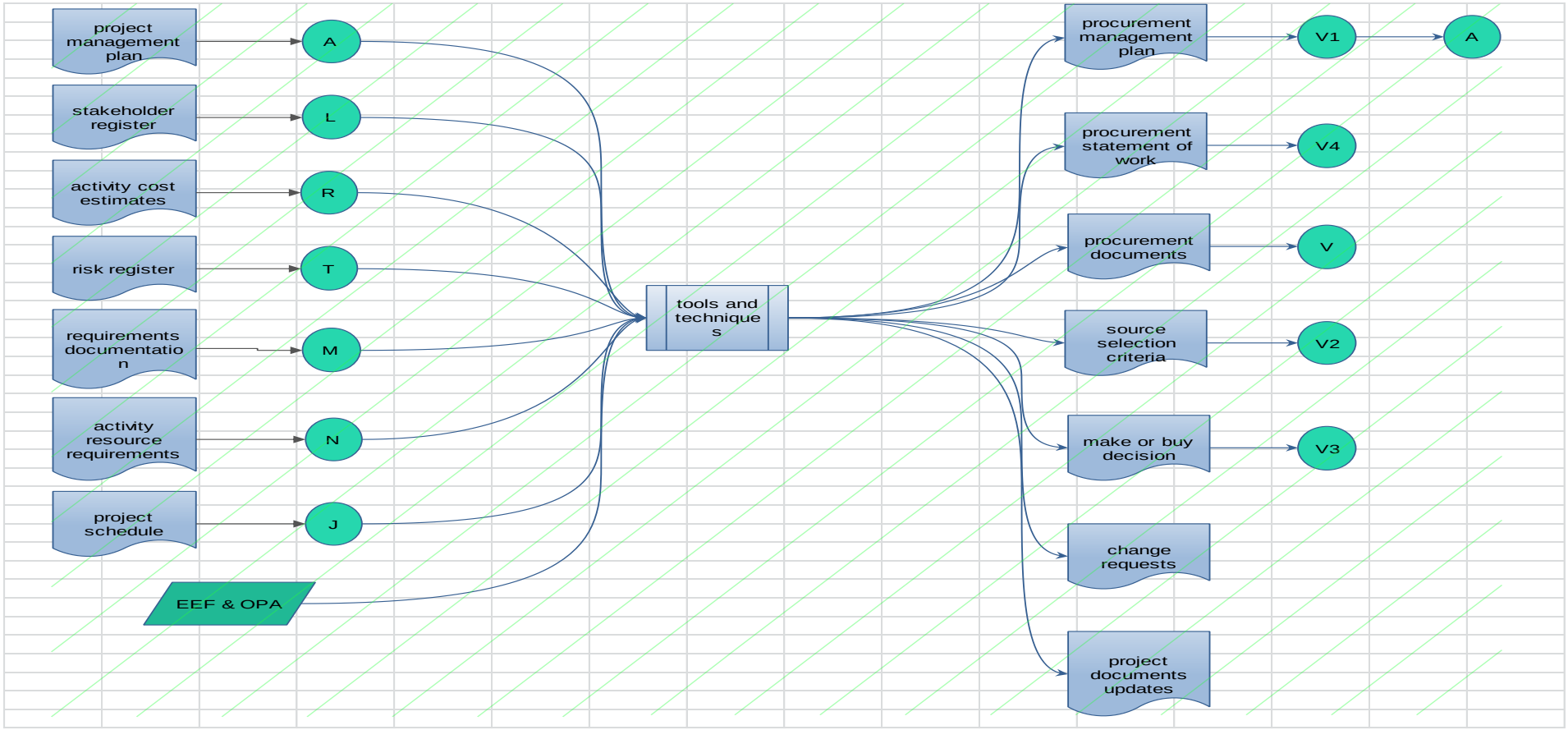

Figure 22: Plan procurement management

x. Safety planning: How to react toward different hazards that compromise the project safety is the main aim of this step, regarding the regulations and safety policies, depending on the contract and site location. Selecting an expert to be the project authority regarding the safety matters. Budget to be assessed to the safety plan will be defined. Figure 22 illustrates the flowchart.

y. Environmental planning: Identifying the project environment, characterizing its standards and the impact of the project on its surroundings and how to satisfy them, the nature of the project and consequences of each activity is on hand to be investigated to introduce the EnM plan. (figure 23)

z. Financial planning: All the financial requirements of the project are recognized and financed. Fund sources and contract requirements, project cost and tax, and the duration will be applied to create plan. (figure 24)

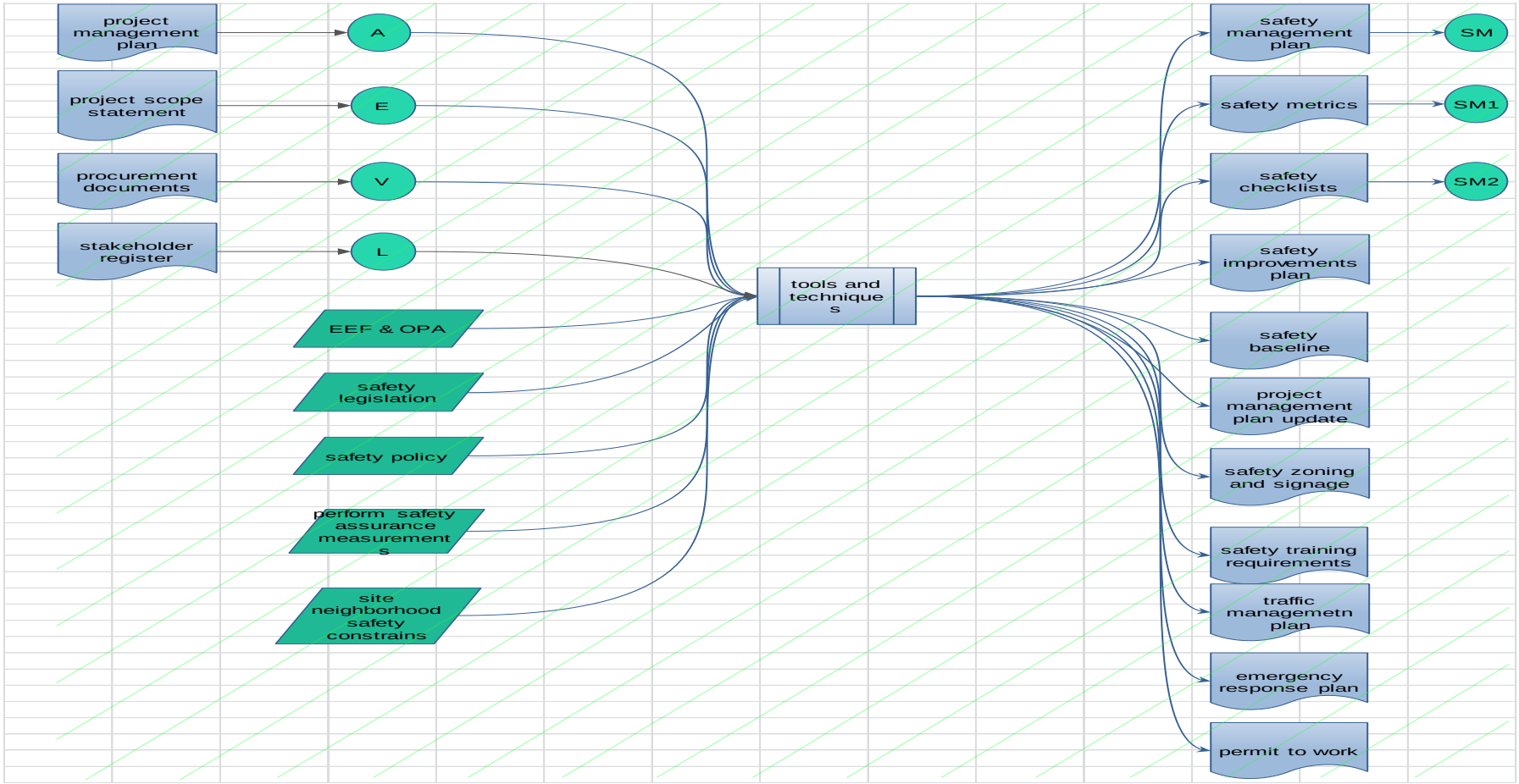

Figure 23: SM plan

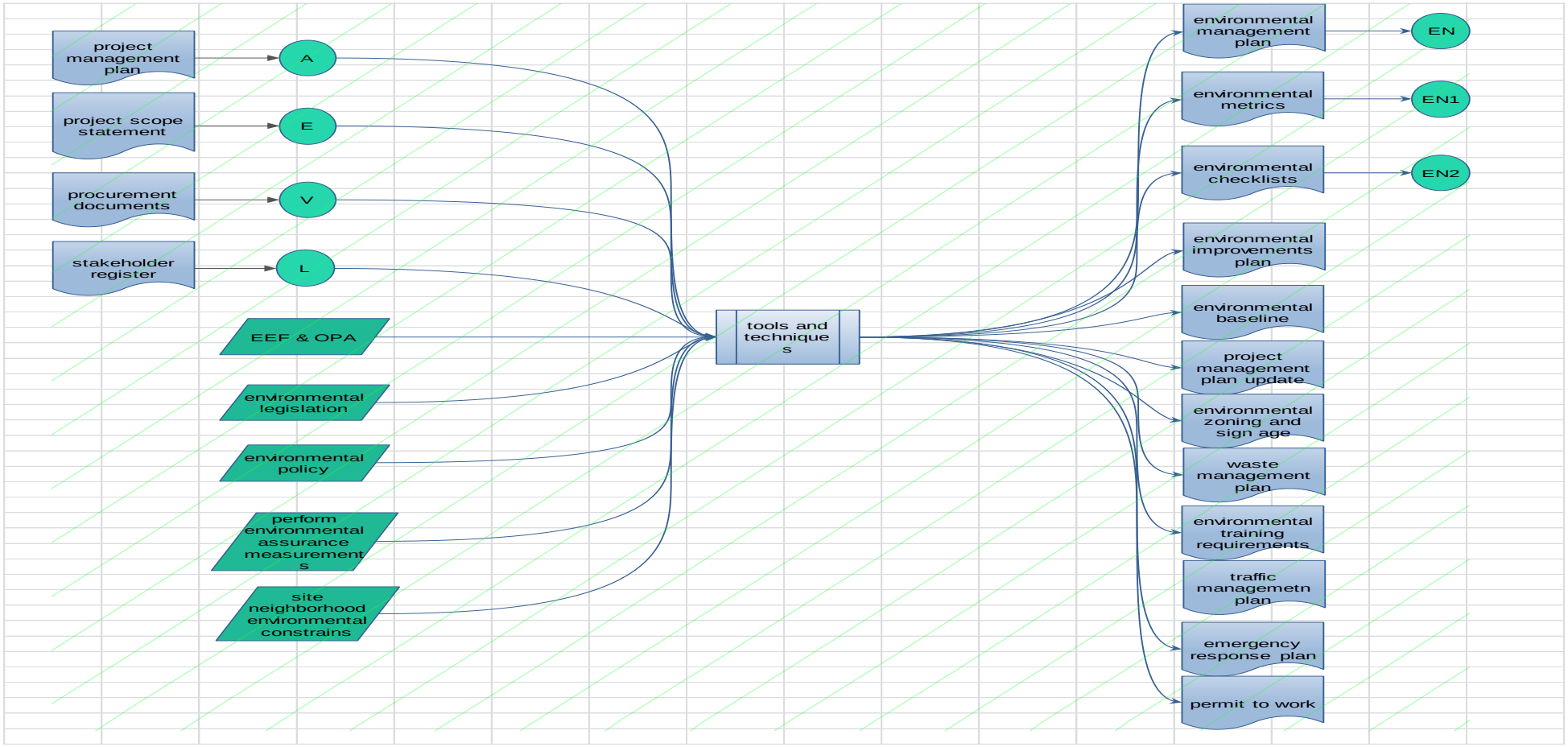

Figure 24: Plan EM

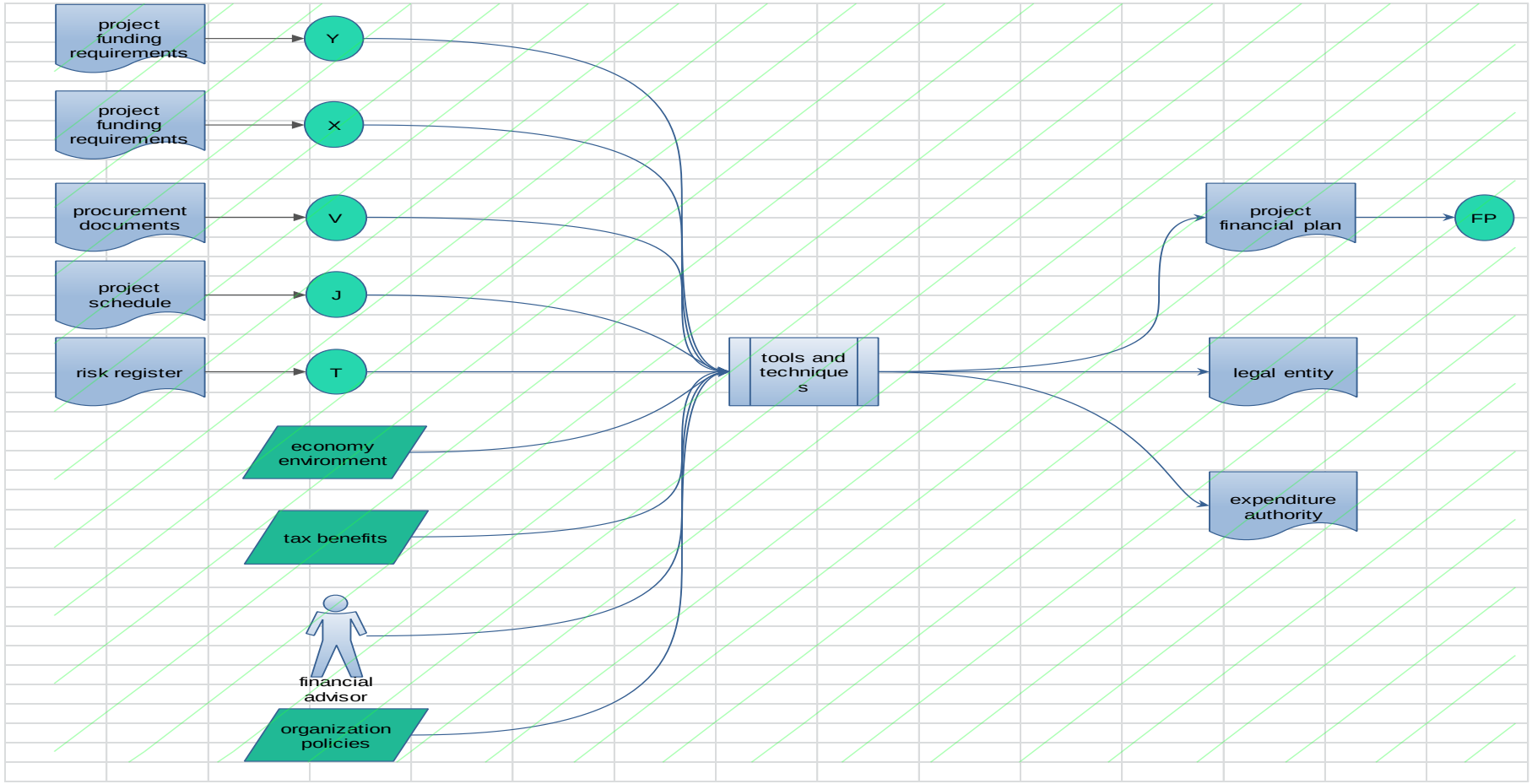

Figure 25: Plan FM

aa. Claim identification: Comprehending the scope and contract terms will help to realize when an activity is changing the scope or a term in the contract, but only interpreting activities as an extra to the contract is not enough; a verified description is needed to support it; the documentations should be created to state a claim.

bb. Claim quantification: When the activity is approved as a claim to be pursued, it must be quantified as compensation or time extension. The claimed activity usually has a cost resulting from it which will be gathered in this step, the time extension can be developed by analyzing the schedule and comparing the “as planned” and the “as built” schedule.

Figure 25 demonstrates the aa and bb processes and define a flowchart to address the issue.

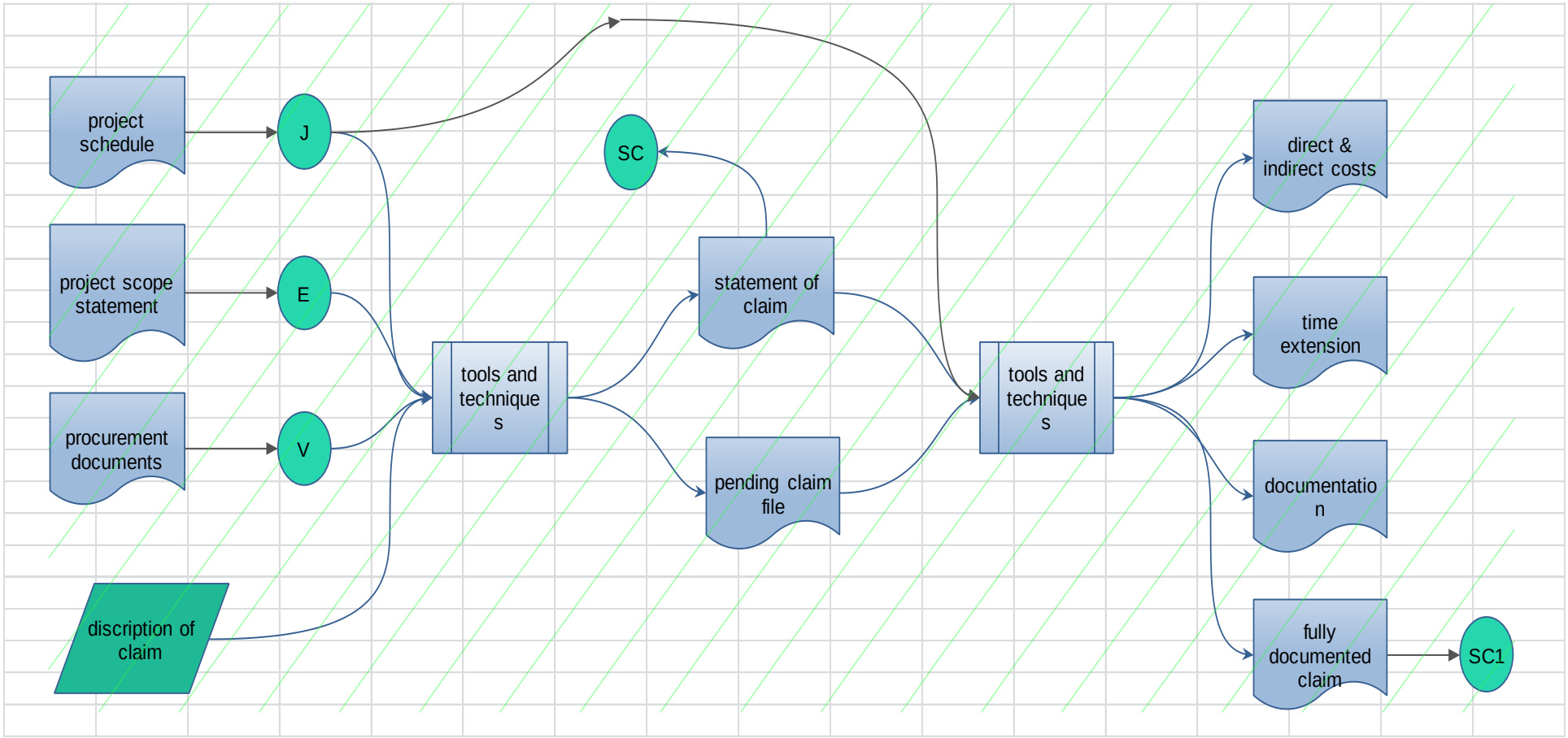

Figure 26: Claim identification and qualification

4.2.3 Executing phase

Executing the project according to the PM plan to fulfill the project requirements, by coordinating resources and people, managing all participants in an integrated manner, this step requires consuming a high percentage of the project funds. Executing phase is consisting of 10 steps as explained here after:

a. Direct and manage project work: Mostly what this step does, is managing the project by performing activities listed in PM plan and applying changes approved by the PT to reach project goals. This step's focus is to update the plan and create change requests upon necessity. (figure 26)
b. Perform quality assurance: Using data derived from quality measurements and comparing them with quality requirements of the job to verify the quality standards has been made and the operational characterizations are applied. This step creates change requests based on its results to ensure the desired quality is reached. (figure 26)

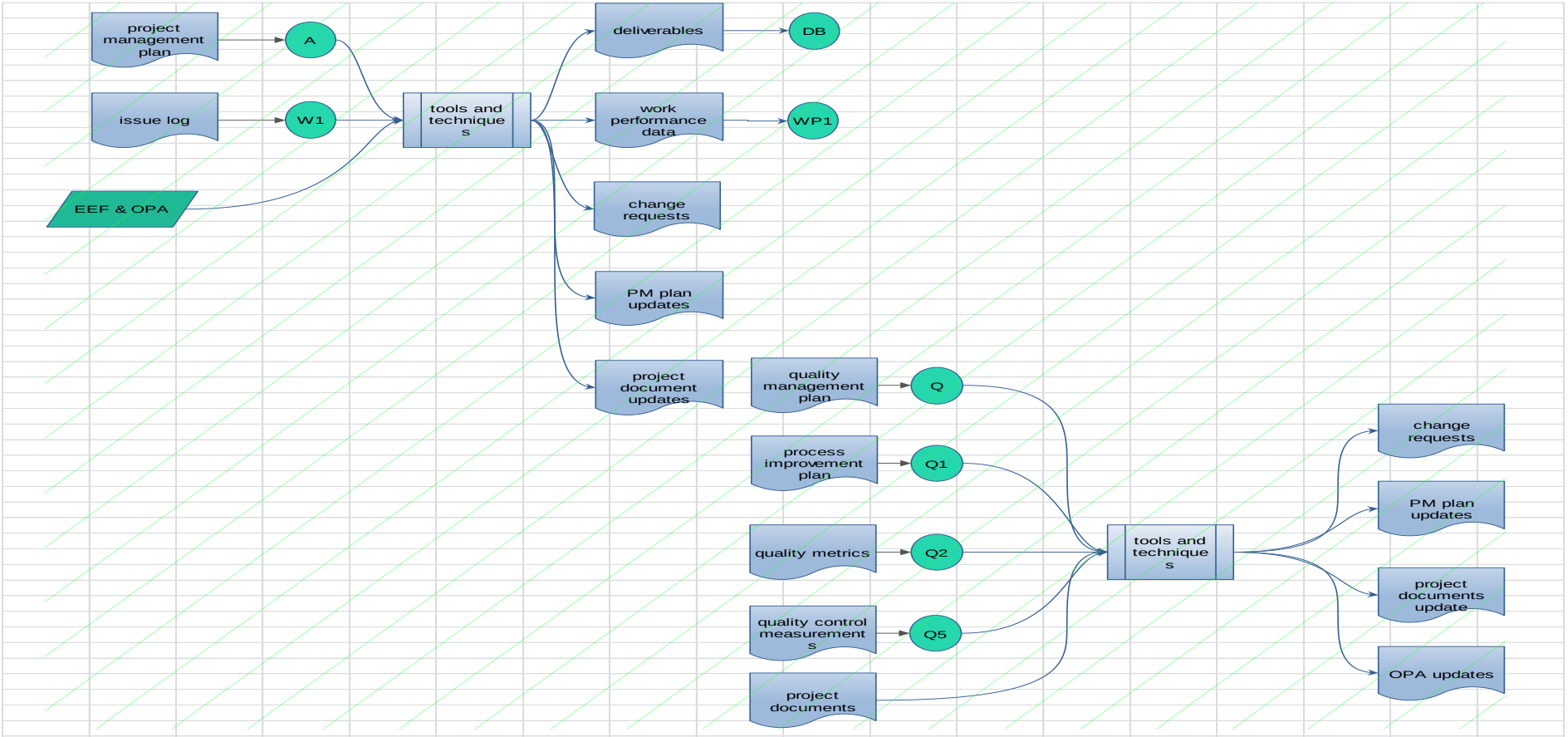

Figure 27: Direct and manage the work, performing the quality assurance

c. Acquire PT: Gathering the required team to finish project work, verifying the human resources accessibility and demonstrating the team selection and their roles assessment to create an effective team and creating a dependable calendar by illustrating and clarifying each team member availabilities, regarding all constrains including holidays and vacations and etc.

d. Develop PT: This step works on improving the PT results and performance by increasing the team skills and capabilities, motivating them and smoothing their interactions towards each other.

e. Manage PT: As the name is obvious, this step focuses on managing the team, auditing the team performance and resolving issues and making changes needed to optimize the performance. Change requests and project document updates are the main outputs of this stage.

Figure 27 illustrates the flowcharts developed for c, d and e processes.

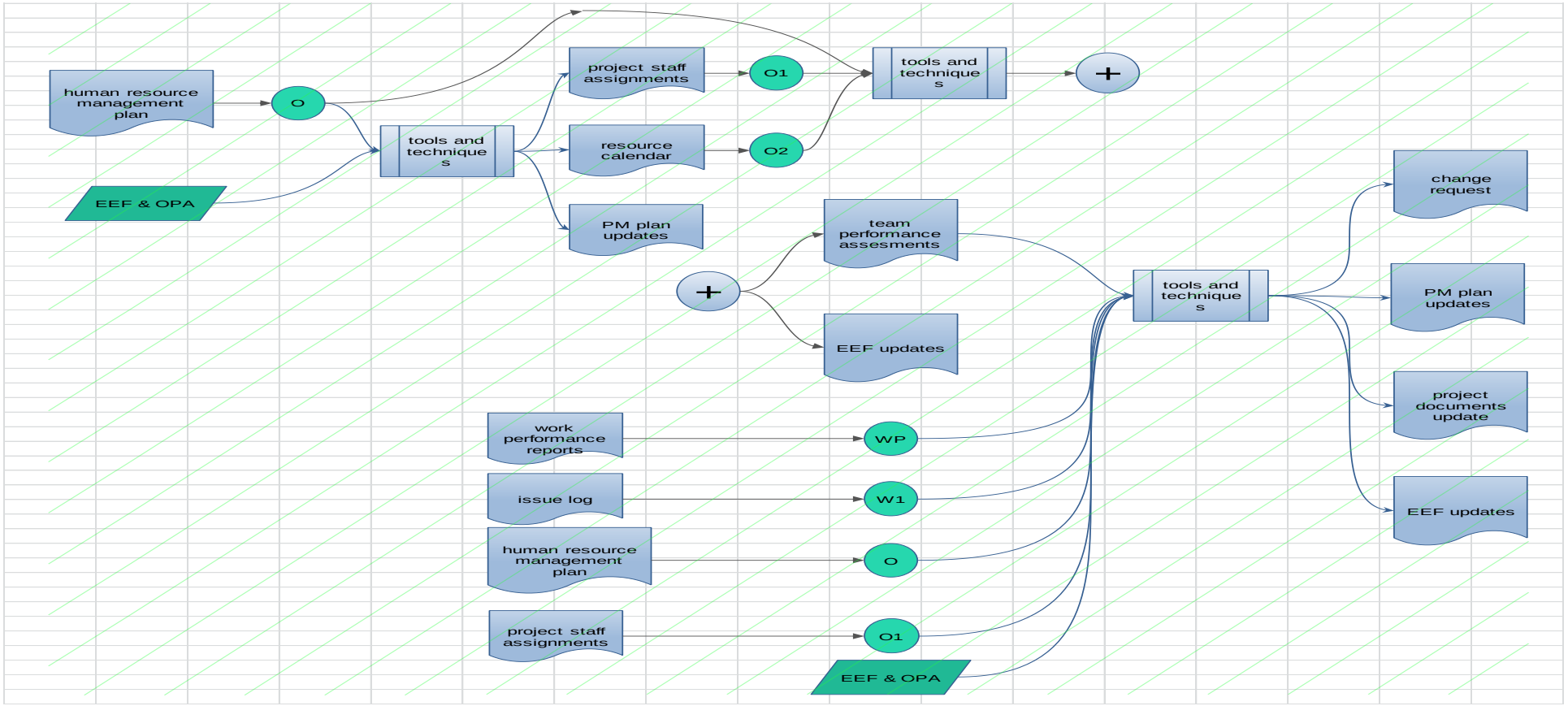

Figure 28: Acquiring, developing and managing the PT

f. Manage communications: This step is used to manage information, meaning it focuses on how to retrieve, store, distribute, collect and create information that can increase the effectiveness of communications flow. (figure 28)

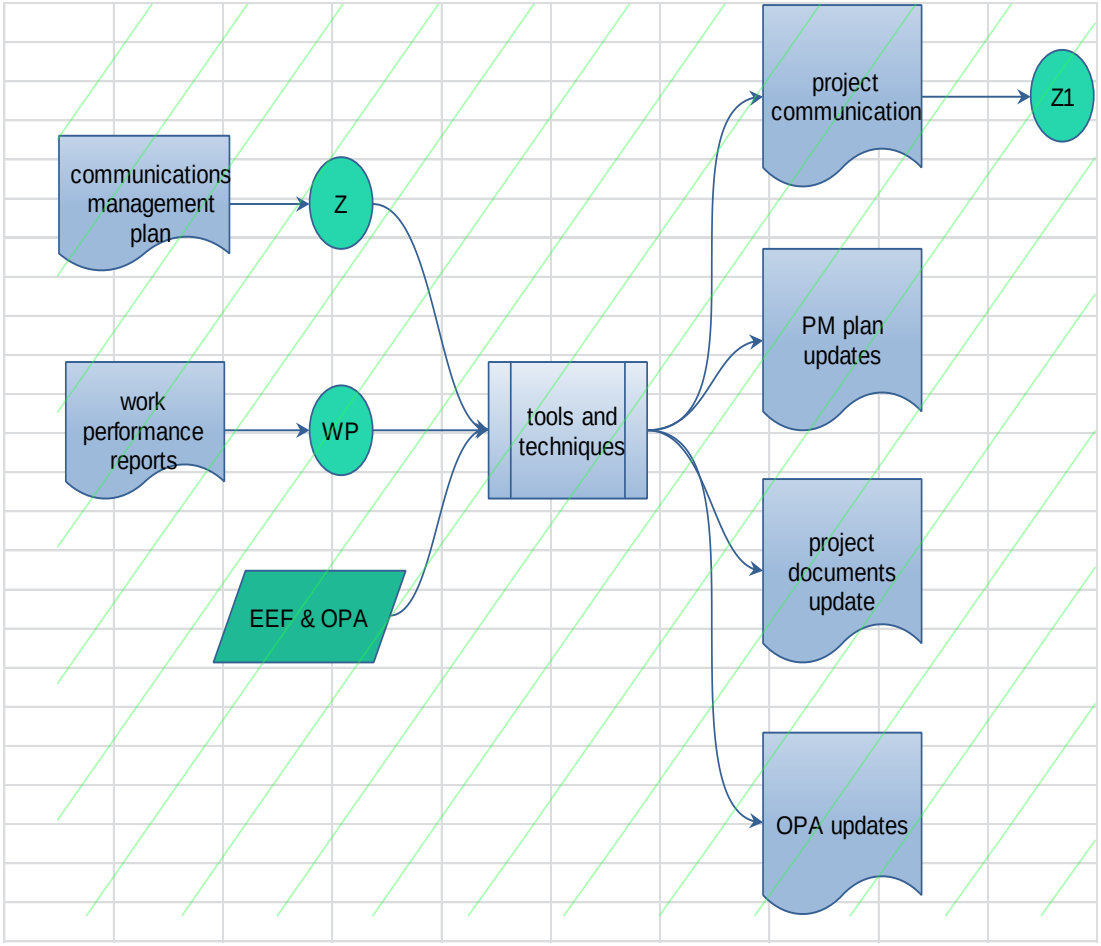

Figure 29: Manage communication

g. Conduct procurements: The process of finding a seller and award them with a contract which aligns the stakeholders expectation within agreements, it is the PT job to ensure they meet other stakeholders requirements and providing the sellers list and resource calendars that provide the dates of contracts availability. Figure 29 illustrates the flowchart according to this process.

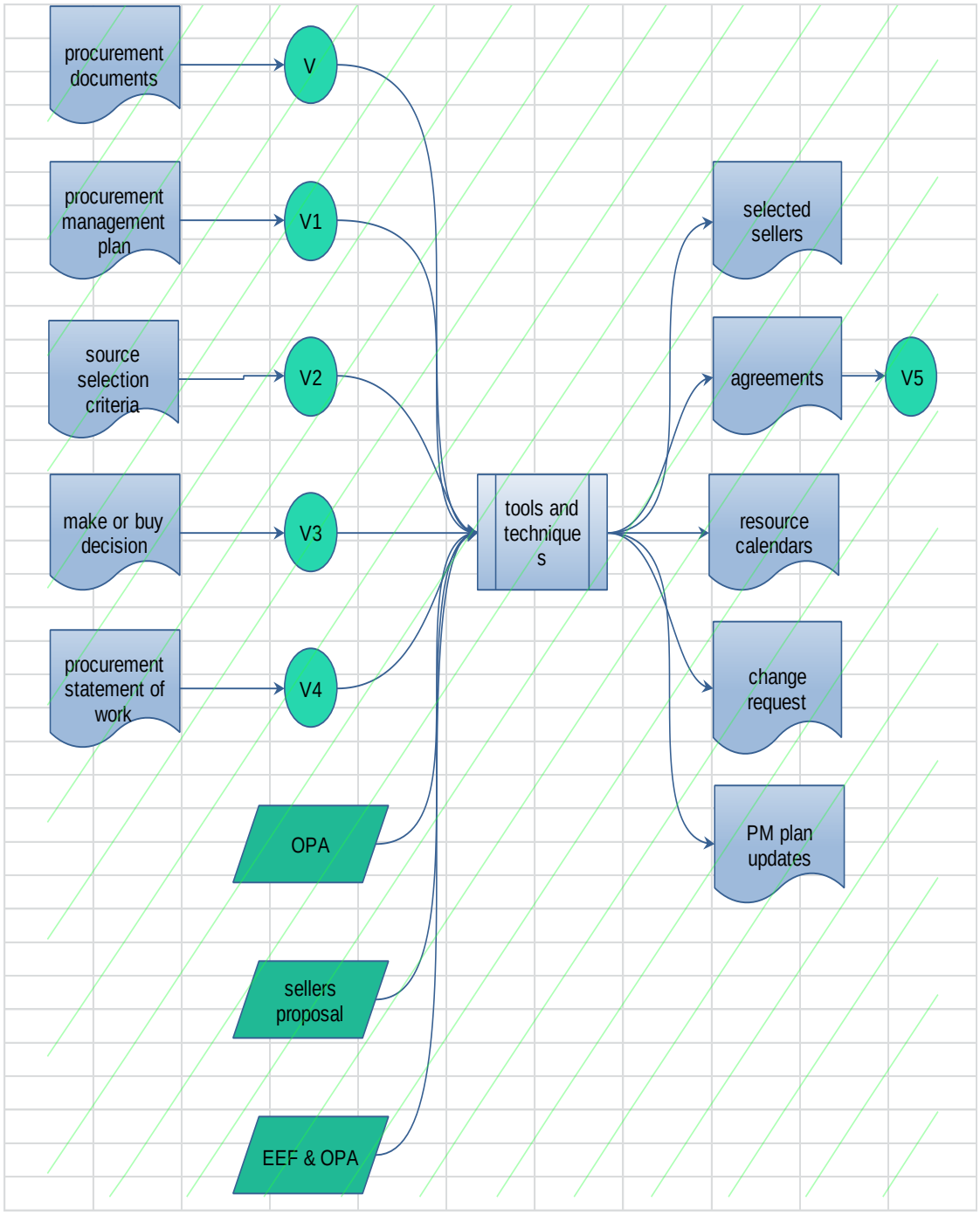

Figure 30: Conduct procurement

h. Manage stakeholders: Dealing with different stakeholders regarding their needs and foster engagements of stakeholders through PLC. This will help the PM support stakeholders and reduce their resistance. Creating an issue log is one of the outputs of this process that aims to resolve problems and identifying new issues. Figure 30 presents the flowchart of stakeholder management plan.

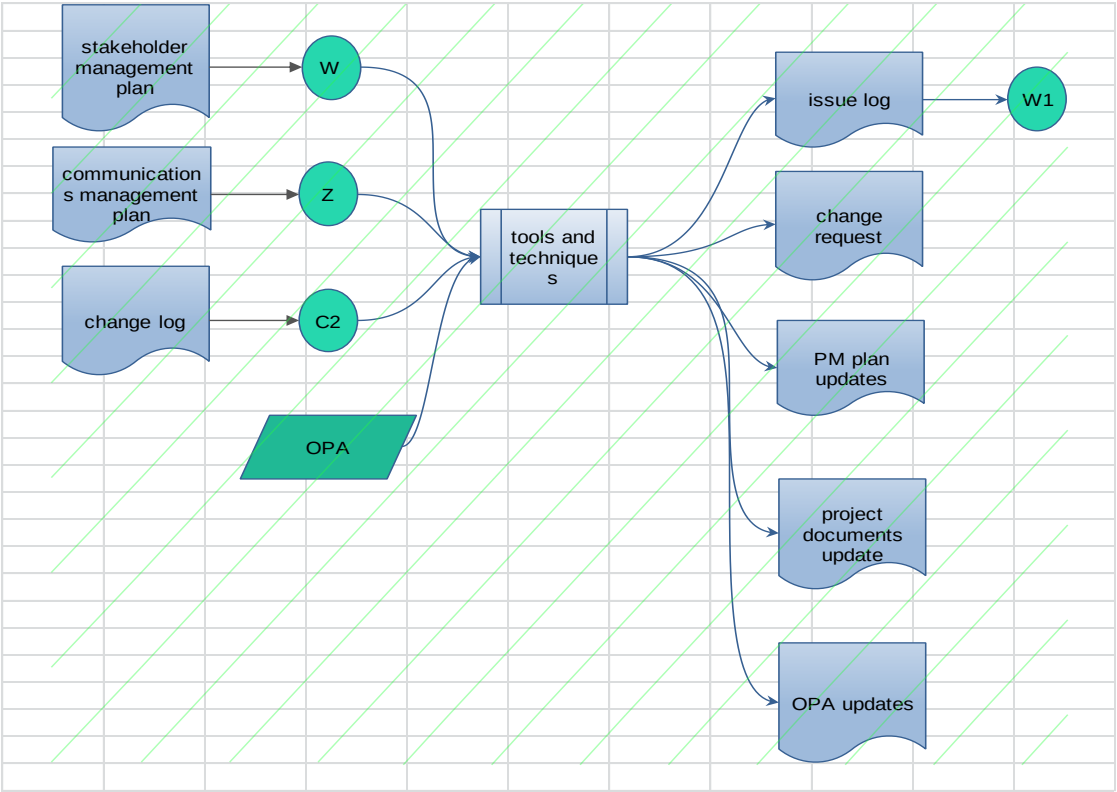

Figure 31: Manage stakeholders

i. Safety plan execution: Executing the safety plan regarding the standards and safe construction practices by the hand of the safety officer which has been awarded the authority to do so, this may take practice to instruct all the workers to meet the goals of safety plans, yet it is the best way to prevent accidents which will lead to enhancing the contractor reputation and increase productivity and reduce the cost of insurance.

j. Environmental assurance: According to environmental standards and to satisfy the system, what has been planned before must take place to assure all the stakeholders of environment conservation which is globally important.

4.2.4 Controlling and monitoring processes

The activities of tracking, reviewing and coordinating a project and its performance are taken place in this group. Main goal is to measure the progress of the project to achieve an understanding of how the project is performing, its healthiness and the areas requiring changes. This stage includes 13 processes of controlling and monitoring group according to PMBOK:

a. Control project work: Tracking and reporting the activities of PM plan to assist understanding the project's current state by all the stakeholders. Comparing the planned processes and the actual results to report the work performance and creating change request as required.

b. Perform integrated change control: During the PLC many change requests are created, which one is permitted and which is not, is the main focus of this step. Also reviewing all of the requests and considering all of the projects to reduce risks. Requests will be recorded in change log whether approved or not. Figure 31 demonstrates the flowchart created for process a and b.

c. Validate scope: The completed deliverables must be accepted by the client, the process of formalizing the deliverable acceptance by the client is validate scope, by validating each goal, chance of acceptance of the final product is increased, and also Creating a change request for those deliverables that have not been approved in order to repair and fix them.

d. Control scope: Monitoring the PS performance and scope changes to maintain the scope baseline throughout the PLC, comparing how the project

scope is performing to the project baseline, categorizing the changes and the scope variations that have been made and the reasons, assisting with the scope decision making and defining whether the scope needs any changes or not.

Figure 32 is the flowchart that depicts the processes of validating and controlling scope.

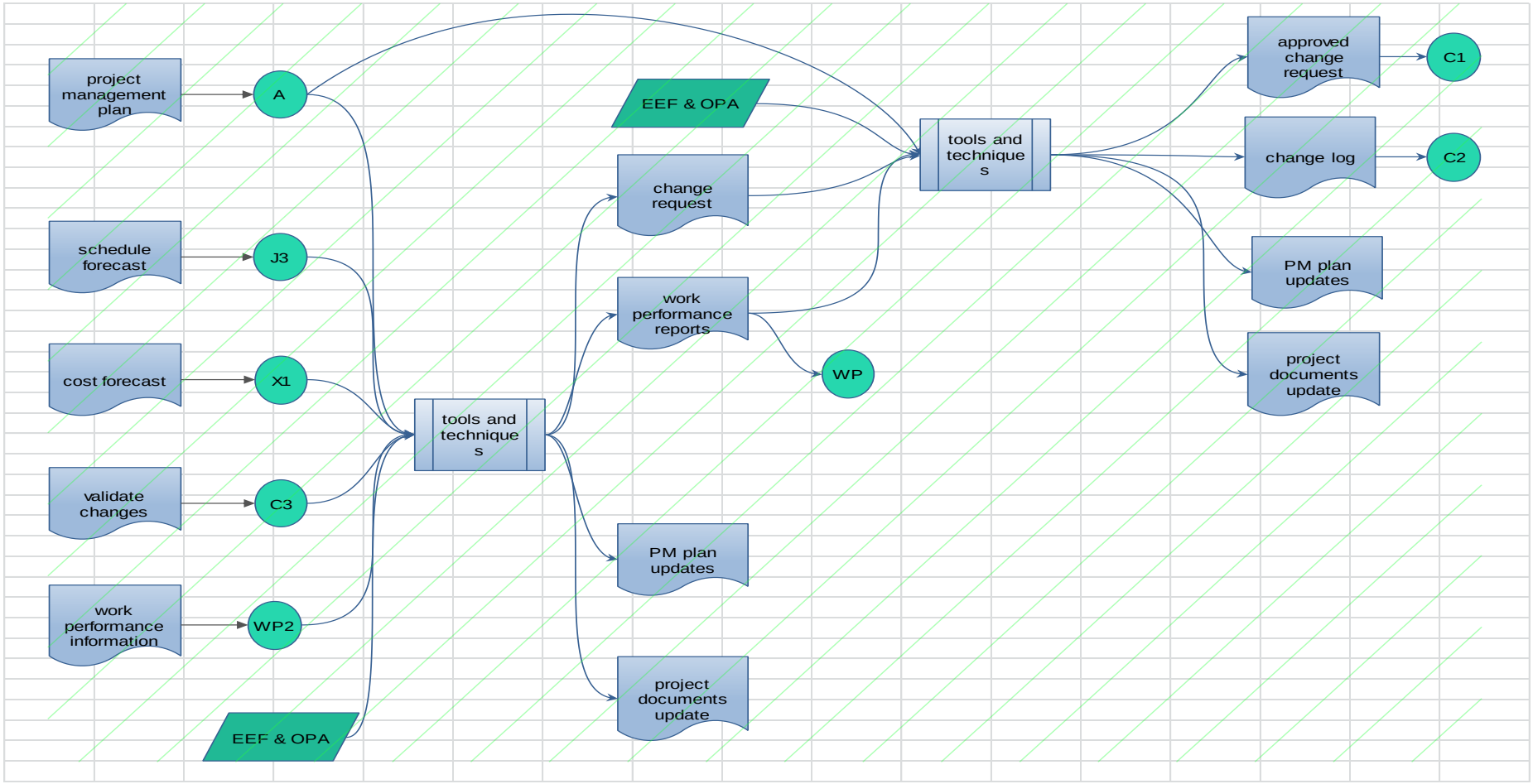

Figure 32: Control project and perform integrated change control

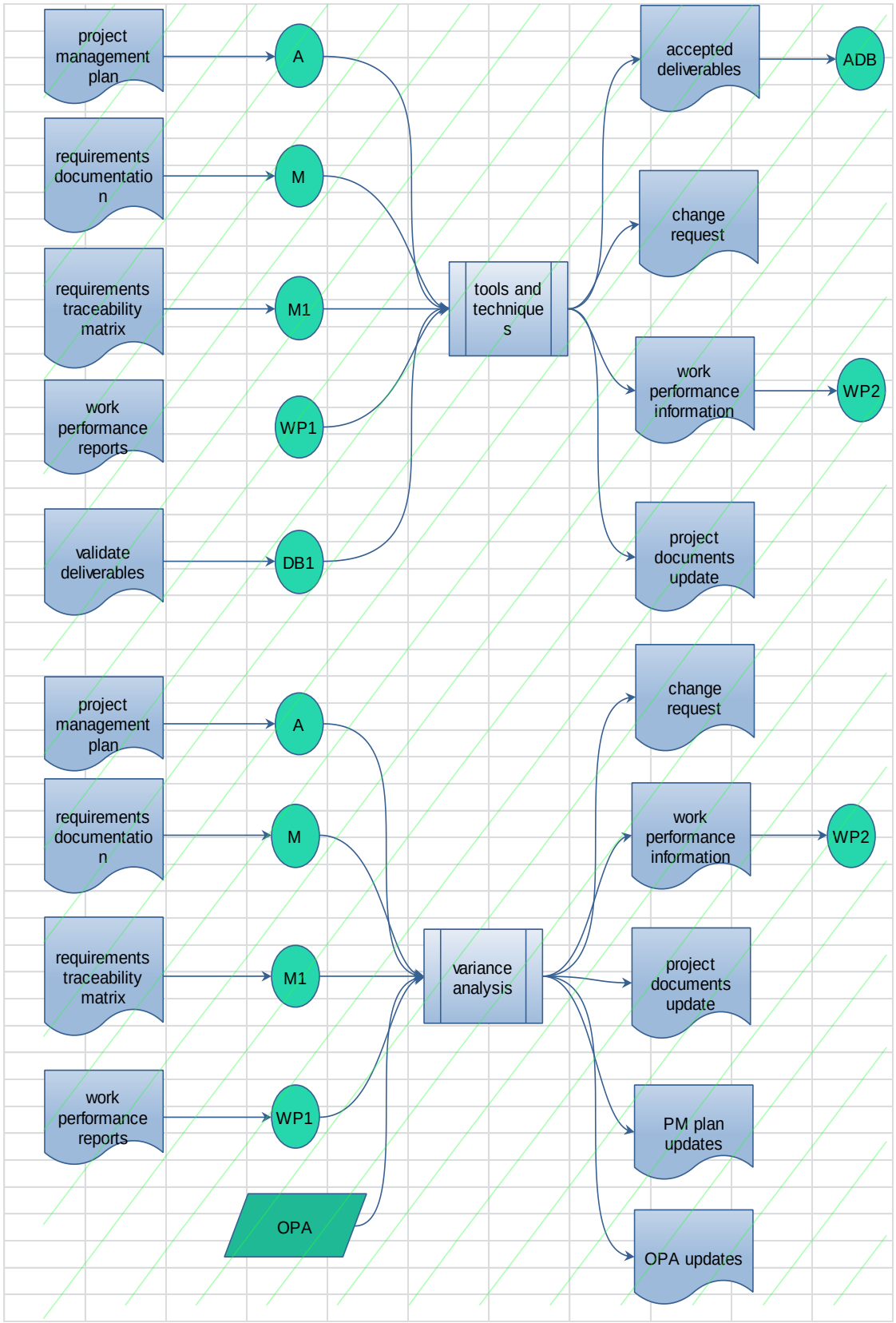

Figure 33: Validate and control scope

e. Control schedule: Performance of the project activities is monitored to request for changes if needed to reach the plan goals. Main purpose of controlling the schedule is that it clarifies plan deviations and undertakes preventive and corrective actions consequently resulting in reducing risks. Updating the project plan and creating change requests to eliminate the chance of negative plan variances. (figure 33)

f. Control costs: Monitoring the progress of the project and updating project costs, and managing cost baseline changes. It signifies the plan variations and undertakes corrective actions which reduce the risks. Creating the EAC (Estimate At Completion) is a part of this step. (figure 34)

g. Control quality: Monitoring the processes and their results to identify reason of poor quality and undertaking actions to remove them and validating if the deliverables are adequate for the final acceptance. (figure 35)

h. Control communications: Monitoring whether the information needed by different stakeholders are communicated through the PLC. This step's main purpose is to make sure each participant has the information at any time. Communications often need adjustments. Change requests can be created regarding the issue to create an optimal data flow throughout the stakeholders. (figure 36)

i. Control risks: Tracking known risks, recognizing new risks and estimate the RM plan within PLC. This step increases the effectiveness of the risk approaches and improves the risk responses. (figure 36)

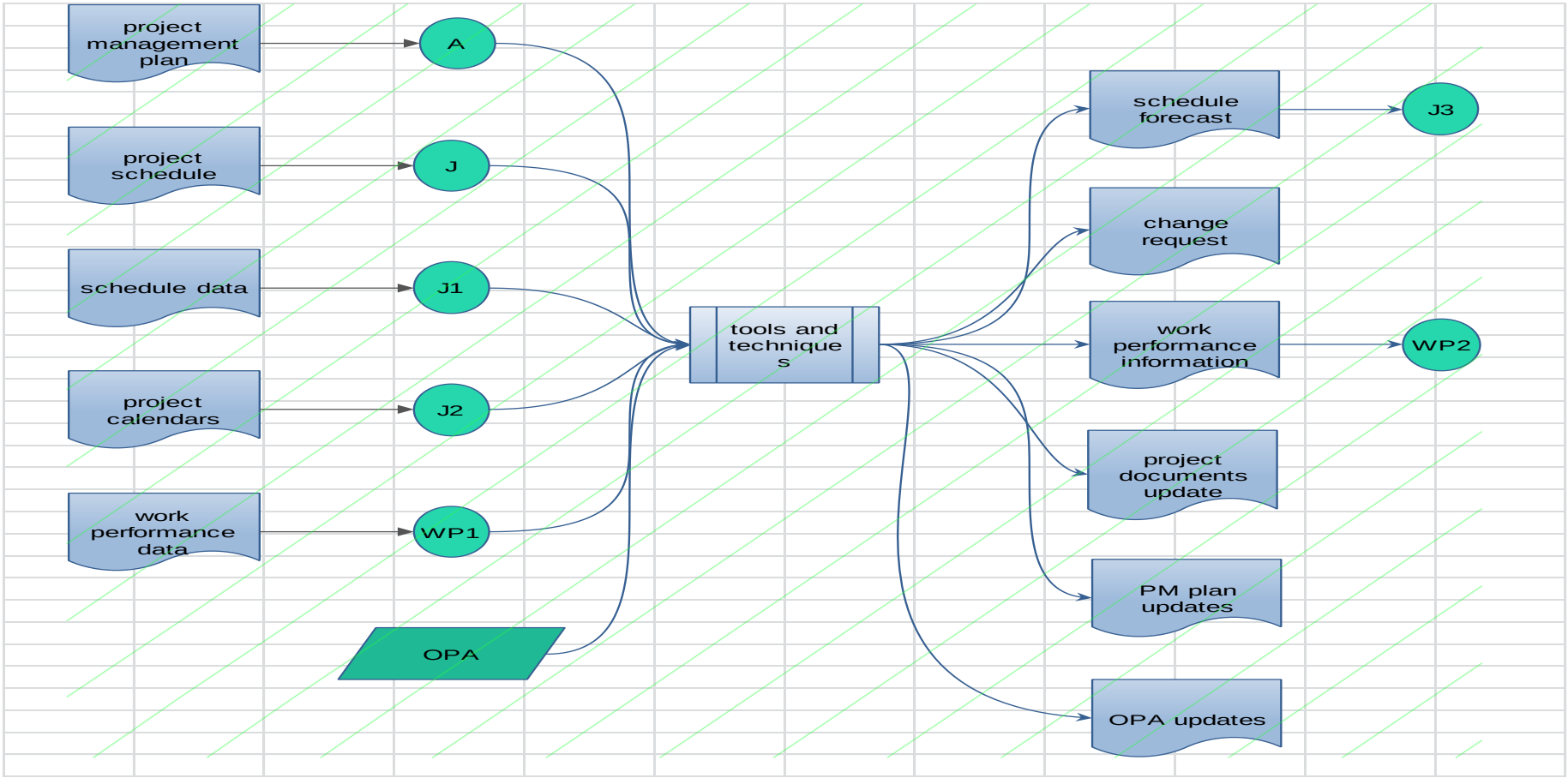

Figure 34: Control schedule

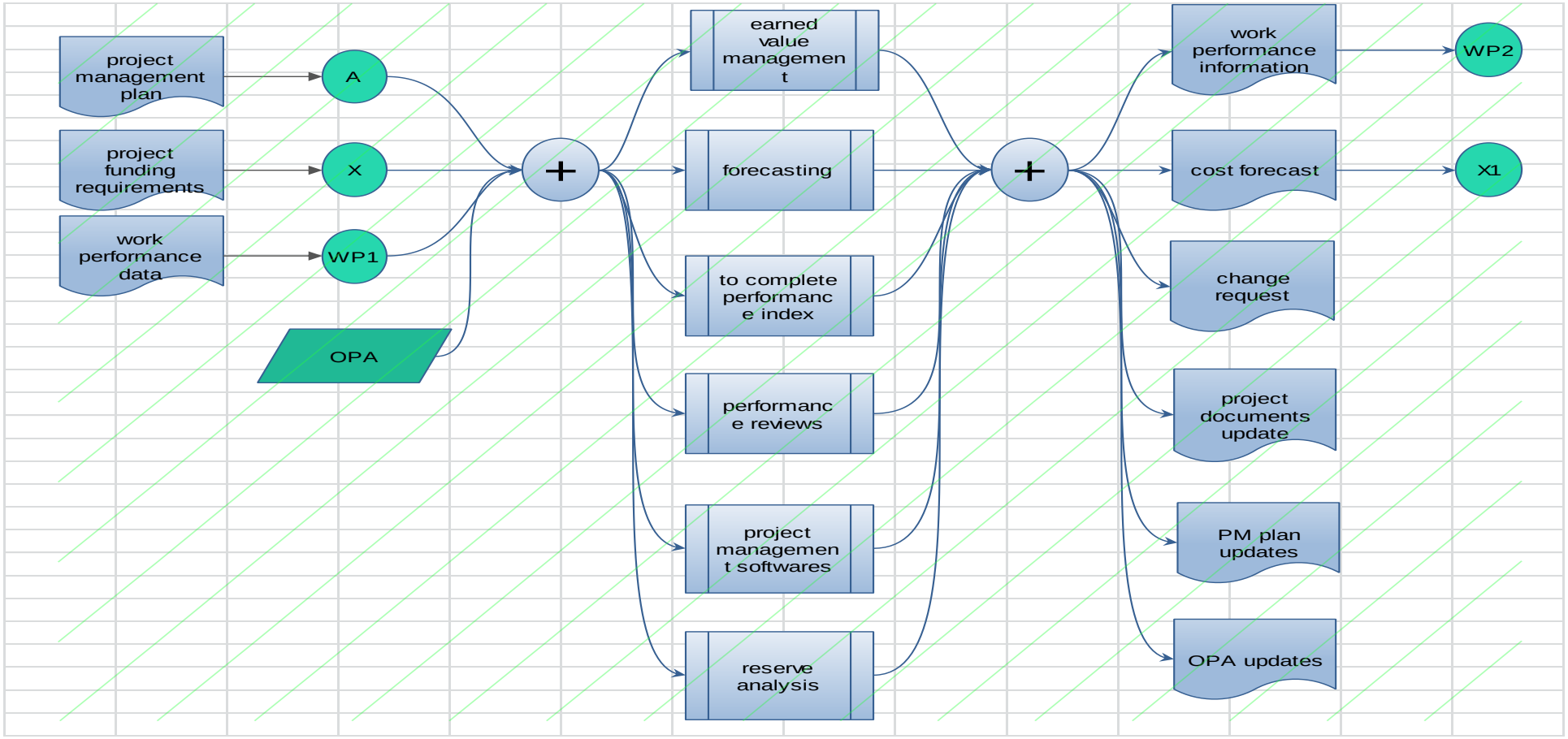

Figure 35: Control costs

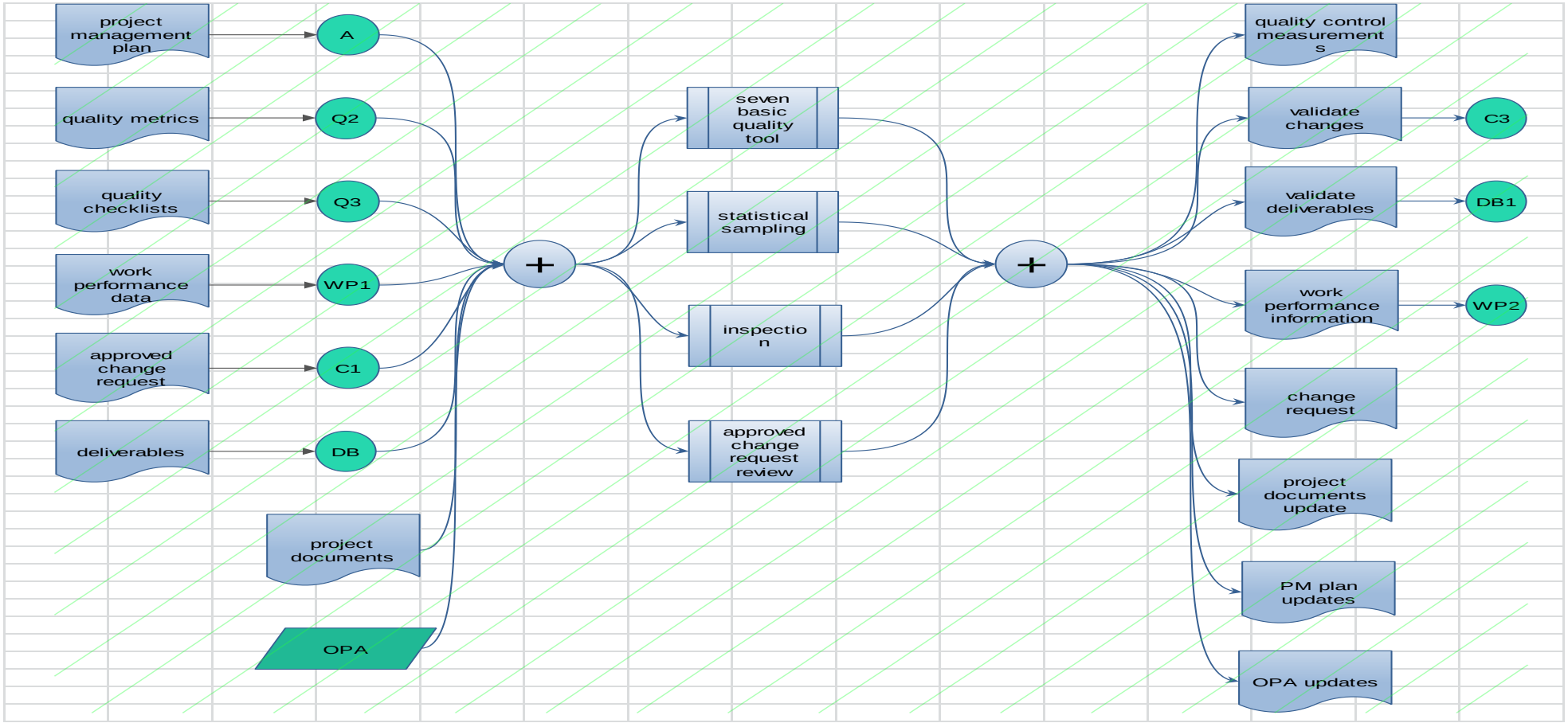

Figure 36: Control quality

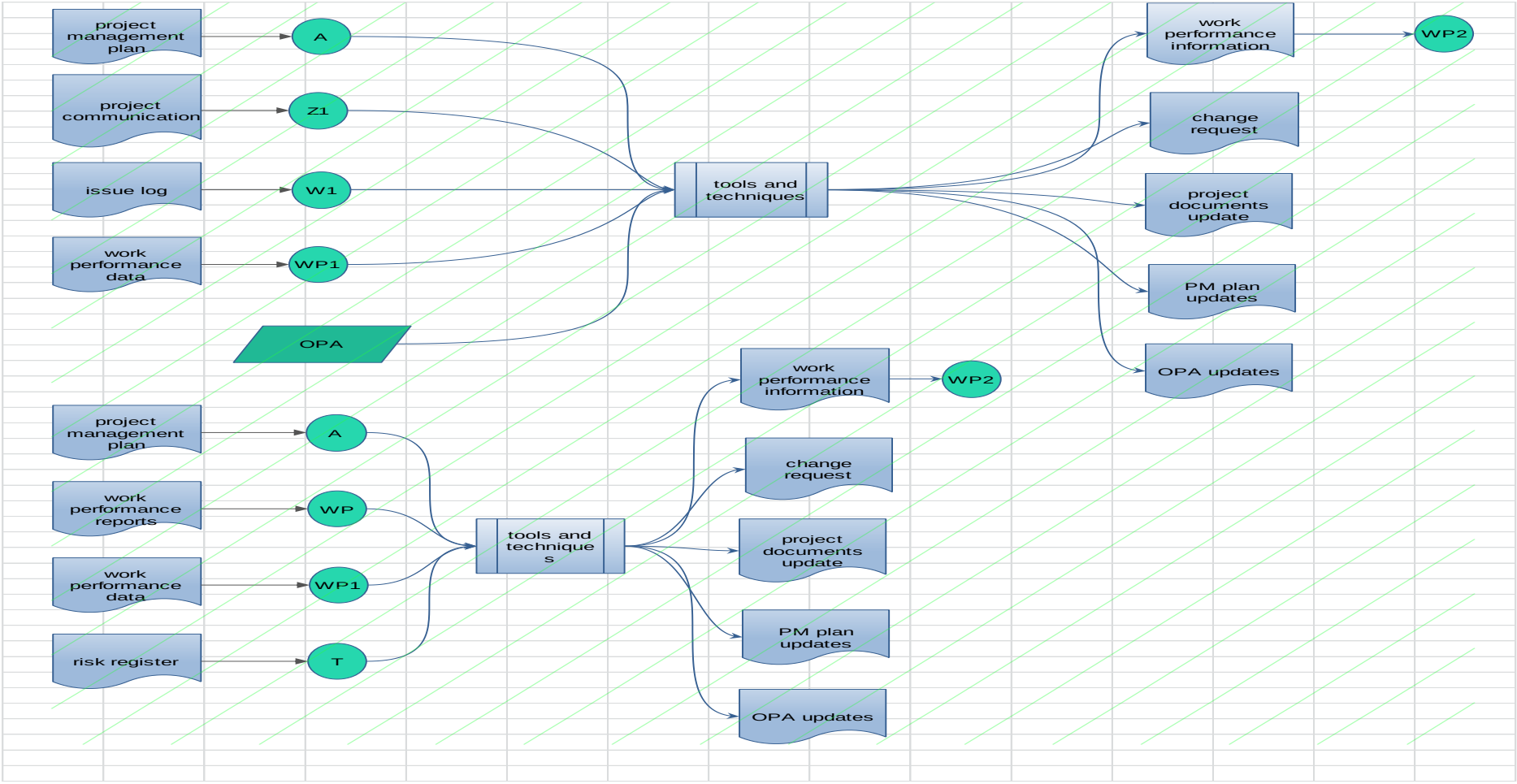

Figure 37: Control communication and risks

j. Control procurement: Controlling both sellers and buyers functioning in a way to reach the procurement requirements. Monitoring the contracts progresses and making correction changes if needed. (figure 37)

k. Control stakeholder engagements: Monitoring stakeholders' engagements and relations, this step increases the stakeholder engagements efficiency throughout the PLC. (figure 37)

l. Environmental control: This step involves around the project interrelation with the surrounding environment, monitors the effects of the project and reduces the unsatisfactory results regarding the standards. Although prevention is always better than inspection, environmental accidents consequences might not be easily handled or might have a significant impact that cannot be faced. (Figure 38)

m. Safety control: Controlling and evaluating specific project aspects to assure safety compliance and eliminate the unsatisfactory performances regarding the safety plan. (Figure 38)

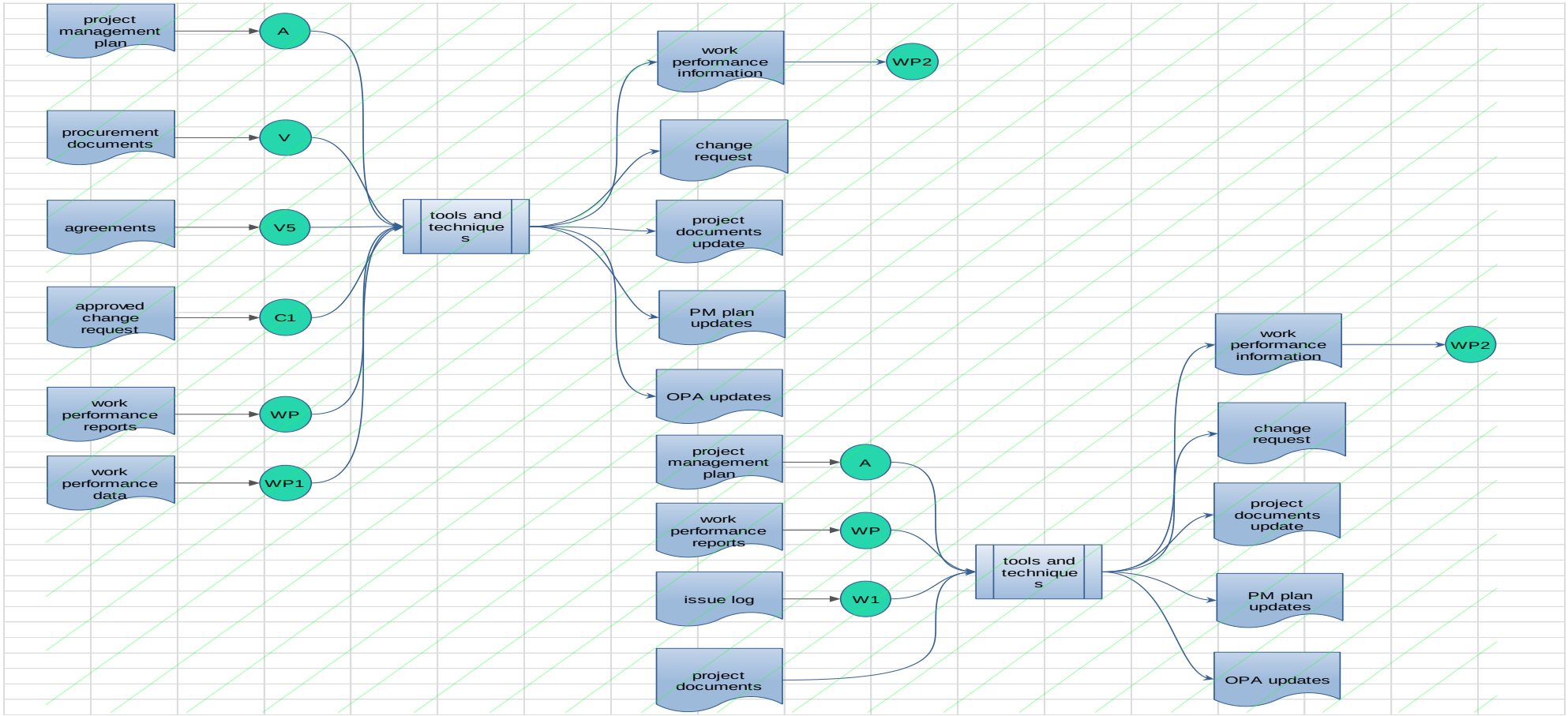

Figure 38: Control procurement and stakeholder engagement

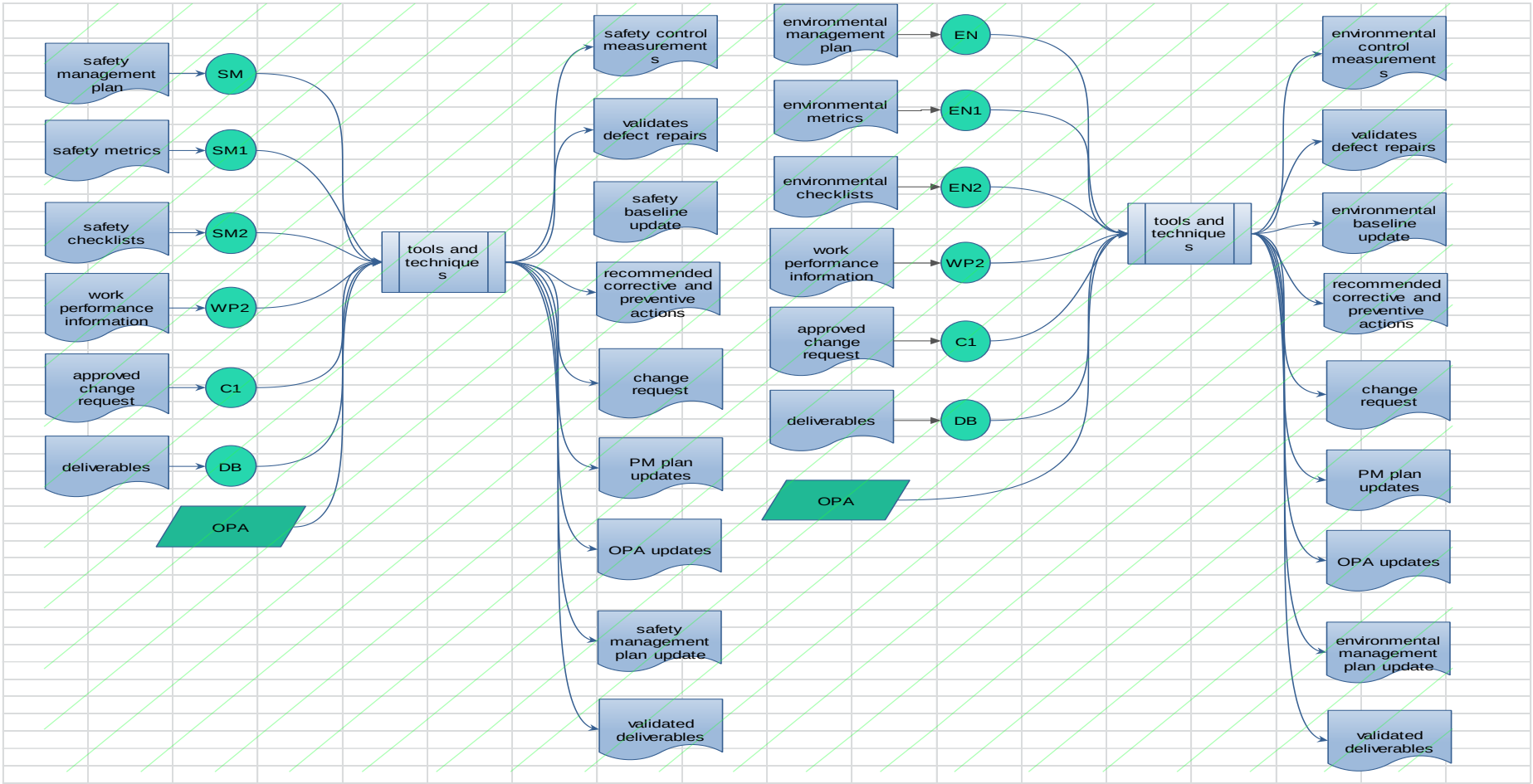

Figure 39: Safety and environmental control

n. Financial control: Reducing bonds when needed, asking for fund from sponsors and controlling the insurance and banking actions are as planned to be executed in most efficient way, also revisiting budgets and changing them according to current status of the project. (figure 39)

o. Claim prevention: How to reduce or eliminate claims is the main purpose of this section. Basically well-formed contracts which has been well executed will not create any claims, since perfection is unavailable, working on how to reduce them is being undertaken here by careful plan and allocate risks adequately and sound contract terms. (figure 39)

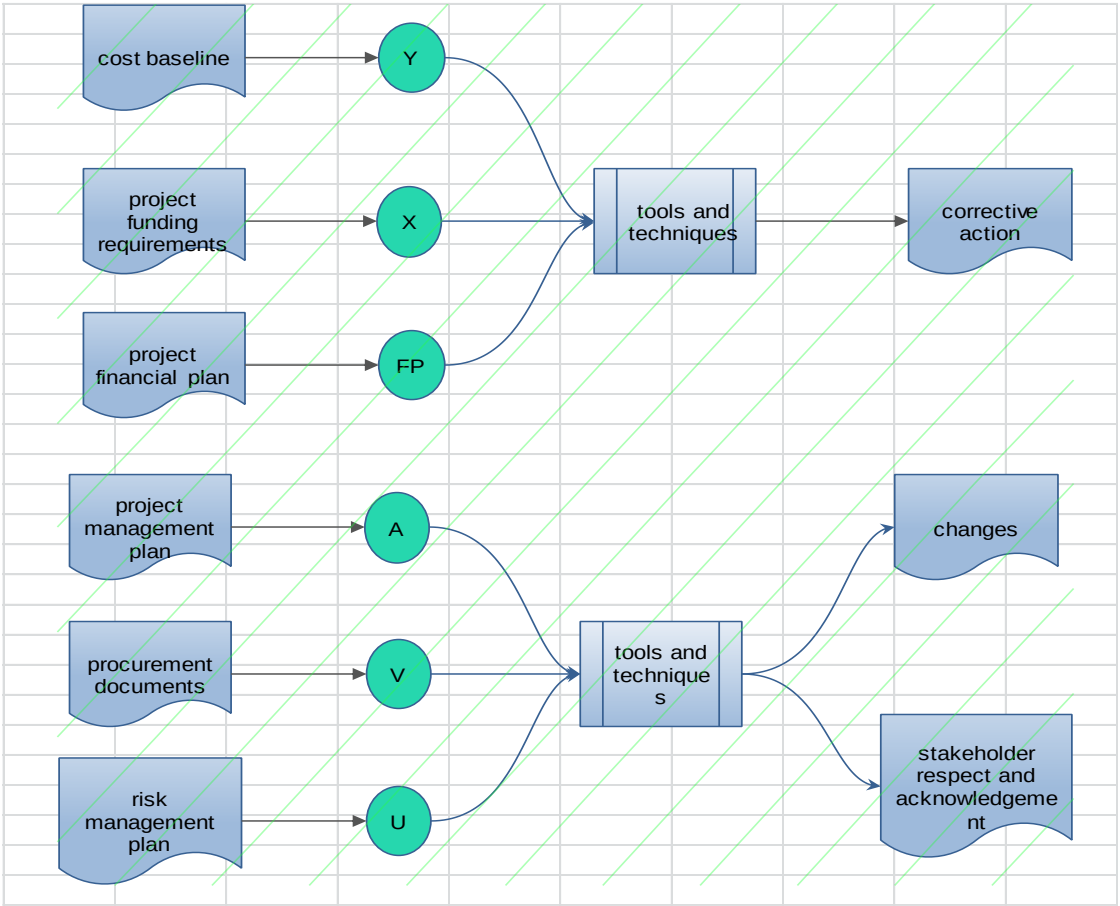

Figure 40: Financial control, claim prevention

4.2.5 Closing processes

This stage is formally finishing the project assigned to PT. This stage is aimed at verifying the completion of defined processes. This stage deals with a project premature closure. Closing process is the last phase of the project according to PMBOK which has 5 steps:

a. Close project: Formally finalizing all activities through all of process groups, this process provides the management team with lessons learned and due to formally ending the project releases the resources to carry out new endeavors. Transmission of the final product is the main output of this stage. (Figure 40)

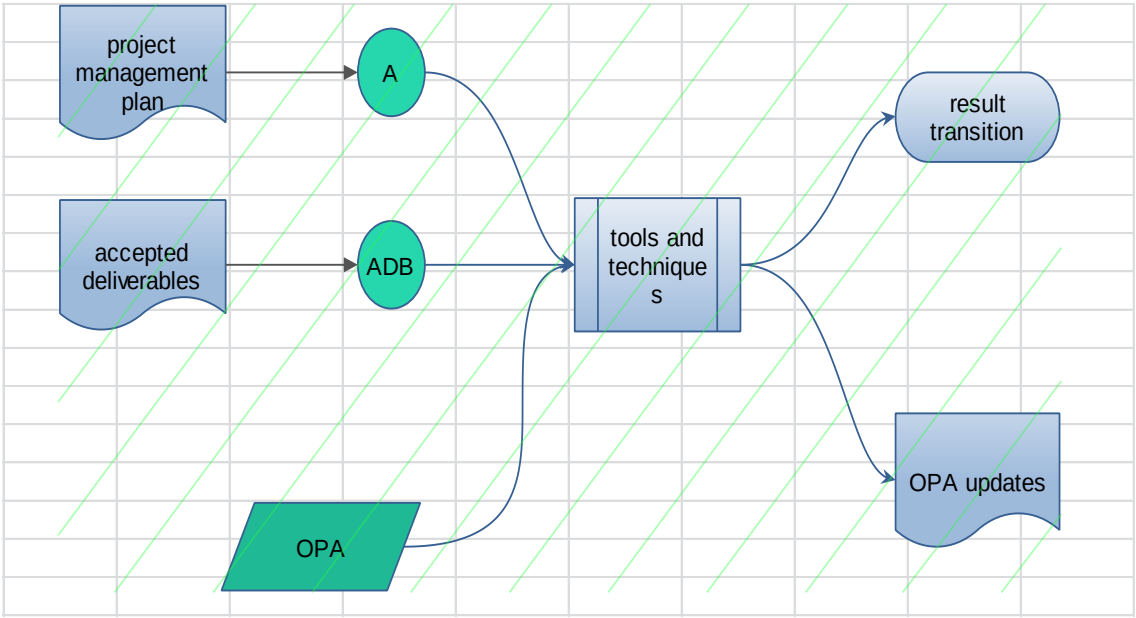

Figure 41: Close project

b. Close procurements: Completing procurements by gathering and documenting the agreements and other related papers for the future use.

c. Financial administration: This step is mostly important for the high ranked management team to check the financial healthiness of the project. Recording

the financial transactions makes traceability very easy which effectively helps controlling the financial issues of the project.

d. Claim resolution: No matter how hard the team tries to prevent claims at the end, there are most likely some claims arising. The process of settling this claim issue is the main purpose of this step which focuses on solving the issue soon and as low as the organizational practices allow. There are many methods described including negotiating and litigation and etc. which are all out of this study's interests. The contracts will be closed after the claim has been resolved. This stage can be named the last activity in a project.

Figure 41 demonstrates the flowcharts regarding to b, c and d processes.

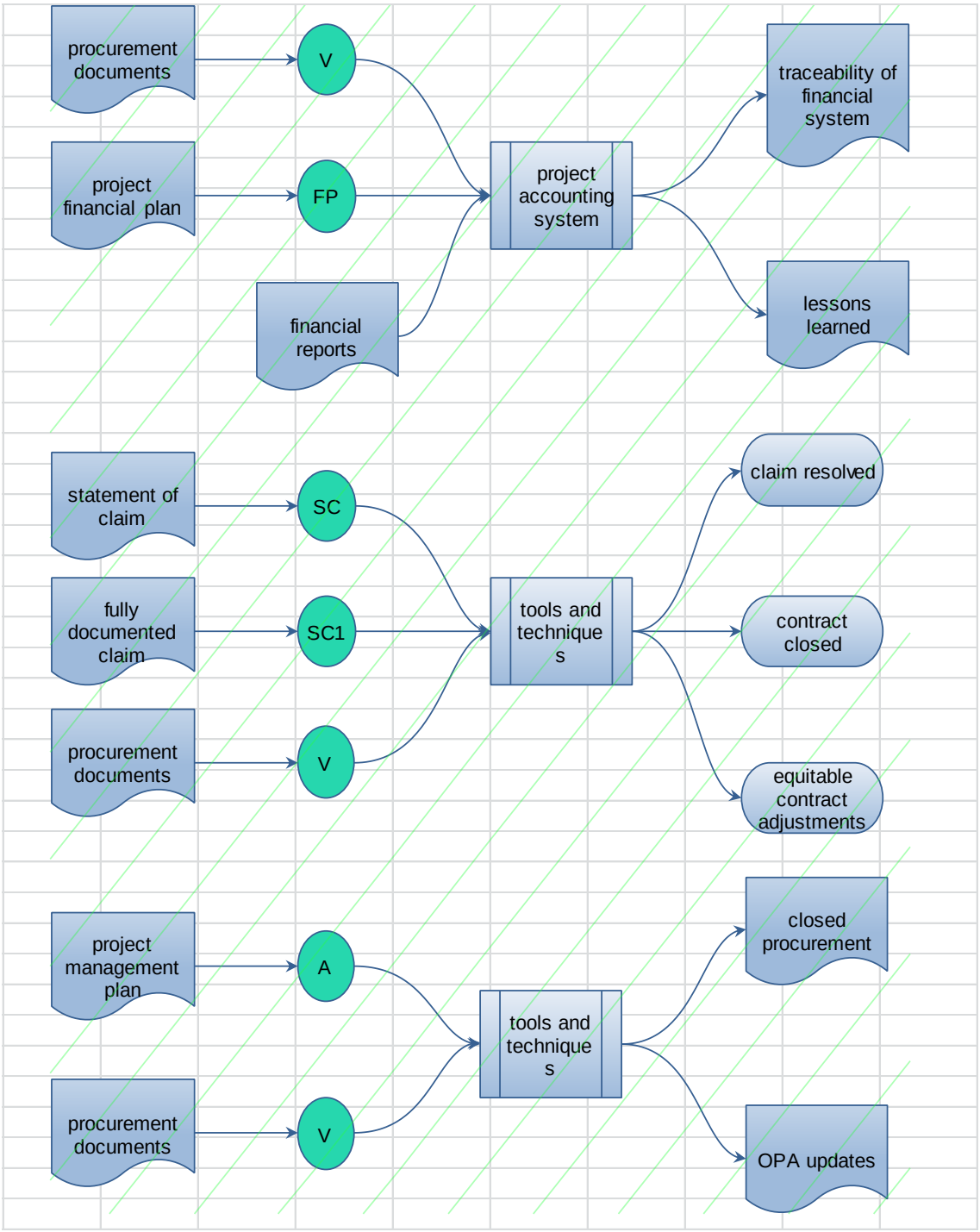

Figure 42: Financial administration, claim resolution and close procurement

4.3 Flowchart Preparation

This section focuses on developing the flowcharts and explaining the actions sequentially with a PLC approach to achieve the main purpose of this study which is establishing a framework for CM based on PMBOK.

4.4 Construction PLC Stages and Framework

Based on what has been introduced in the literature review, a PLC approach is being selected which has been considered most effective based on this study approach toward PMBOK.

4.4.1 Pre-project phase

Bennett (2003) defined the first phase as the pre-project phase, which puts the owner or the client in the acting position to make two essential decisions; how the project should be delivered and what sort of contract should be selected.

1. Project delivery system and how the project is going to be managed through each phase, each part of this step has its own special field of study which is not covered by this study, due to their vast range of information.
2. Deciding about the contracts types and approaches.

Figure 42 demonstrates the pre-project phase flowchart.

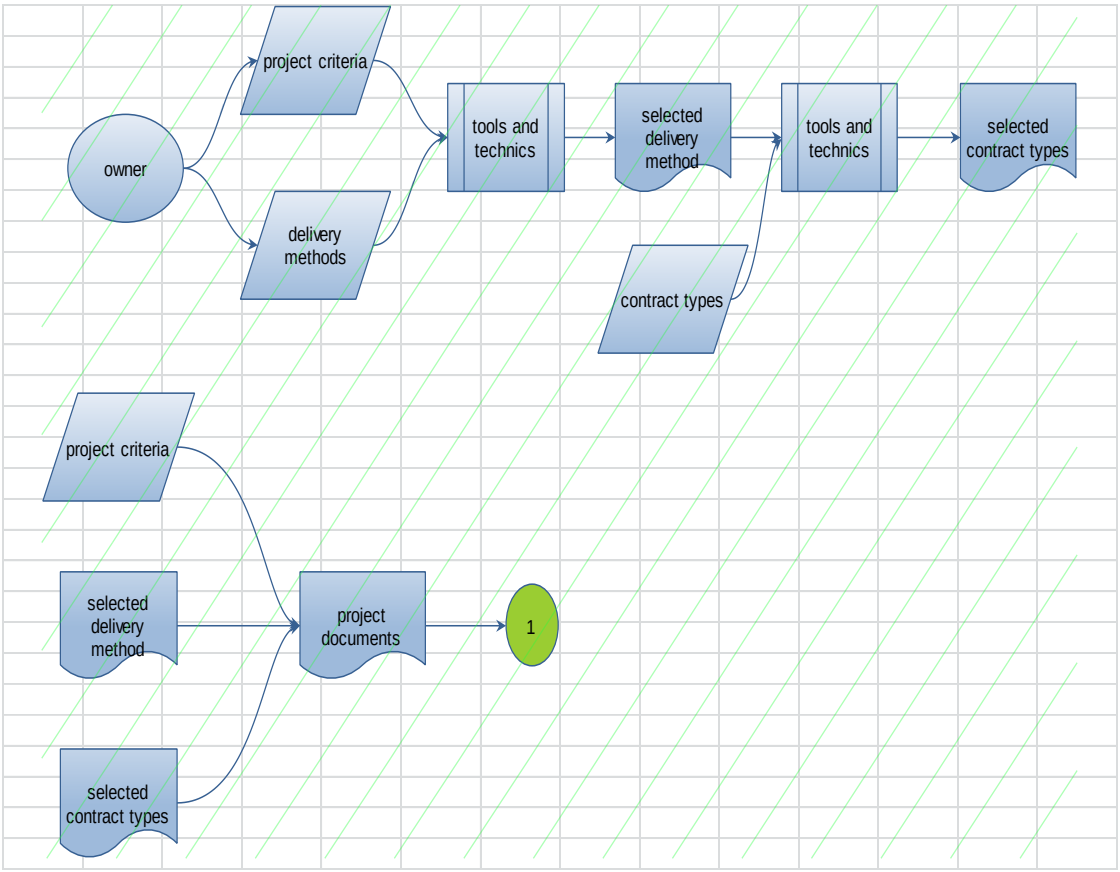

Figure 43: Pre-project phase

4.4.2 Planning and design phase

Bennett (2003) described the second stage of a PLC as planning and design which consists of three steps. First two steps are feasibility study and planning which is to state and elucidate the project scope, run the feasibility study and selecting and acquiring a land suitable for project purposes. Third step is design stage which is creating the architectural and structural plans and any other documents required in the contract.

1. Parties and their roles: This focuses on identifying an initial stakeholder registry.
2. Consultant selection: Based upon project requirements, consultants will be selected through specific methods.

3. Creating a defined document which contains the main projects aspects and objectives (“The project brief”).
4. A clarified communication system between the owner and the PT must be established to define roles and duties.
5. Consultant selection methods and tactics; this step mostly focuses on selecting the design consultant.
6. Identifying other alternatives in order to be capable of developing the best possible design.
7. Site investigations have to be done during this stage. Many aspects will be considered including soil conditions, access, cost, traffic flow and etc.
8. Constructability analysis is the process that happens at the early stages of the design stage which focuses on the projects’ constructability, cost efficiency and etc.

Figure 43 is the flowchart which is created for steps 1-10.

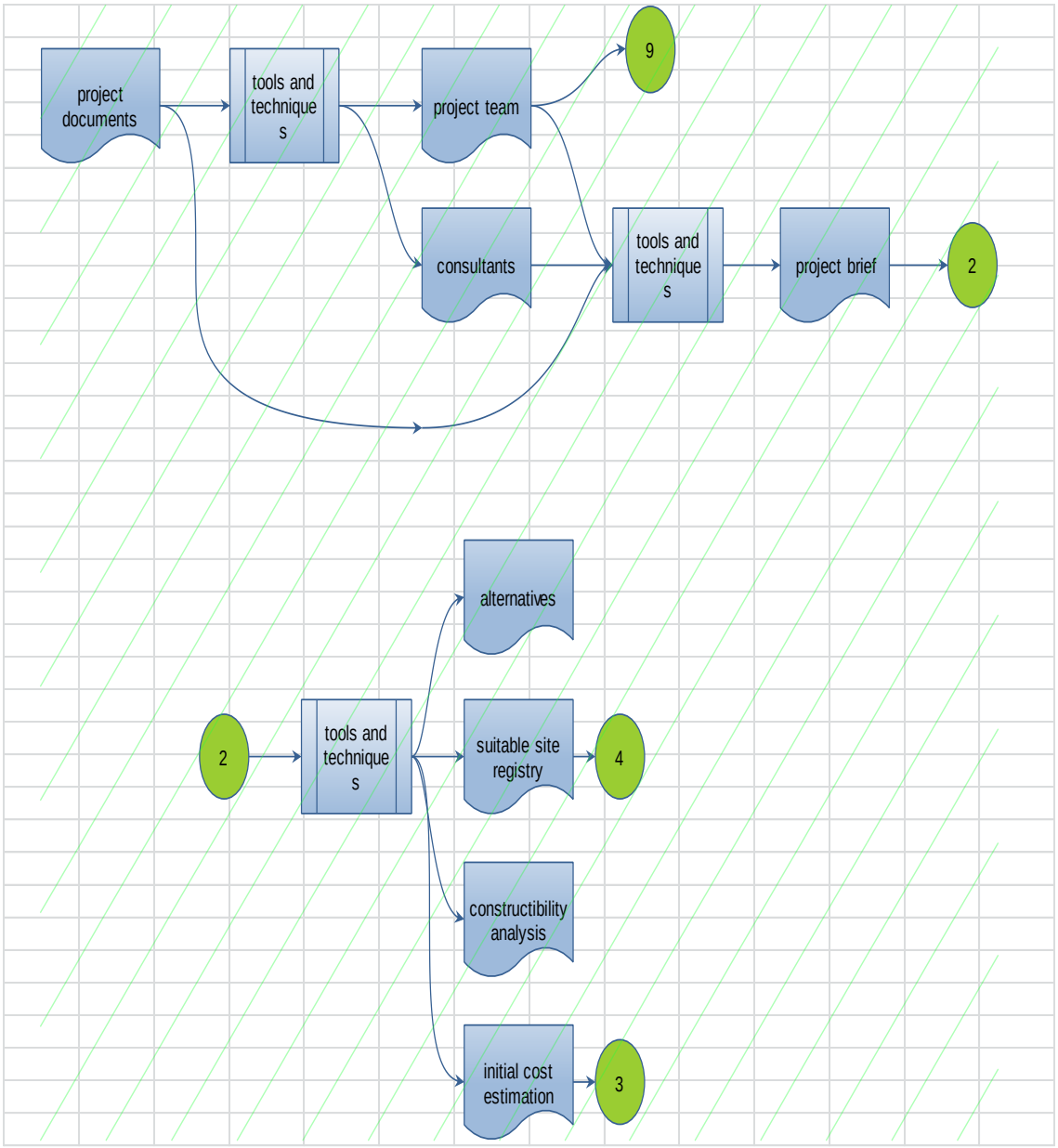

Figure 44: Planning phase step 1-10

9. Code analysis: The process of considering the codes and regulations. The planning phase must be compliable with the codes.
10. Initial cost estimating is the process in which the cost of the project is predicted with a large precision degree.
11. Financial feasibility study must be developed to define the project viability according to financial issues; after all, the project must have an economical return to be worthy of investing.
12. Funding plans and approvals is a stage that might even take place a lot earlier than the planning phase but it depends on the nature of the project.
13. Site selection and acquiring according to site investigation and the approved funding method, is the last step of planning and feasibility study which focuses on obtaining a site if not already owned.
14. Creating the schematic designs of the project by the designers to gain the approval of the owner; this starts by the architecture design of the project and then the civil engineers will prepare structural designs. Many building sections such as structure, foundation, roof, exterior and interior walls and finishes, stairs and etc. must be formed during this stage. Site utilities and other cost estimations regarding the new updates should be produced.
15. Design developments are naturally based on the documents created in the last stage. This stage focuses on refining the designs and estimations. After finishing this step, the project is fully developed. The results of this stage will be the documents of the contracts.
16. Developing and gathering the documents needed in the contract from the previous stages which include drawings, general and special conditions, technical specifications, schedule, tender invitations and etc.

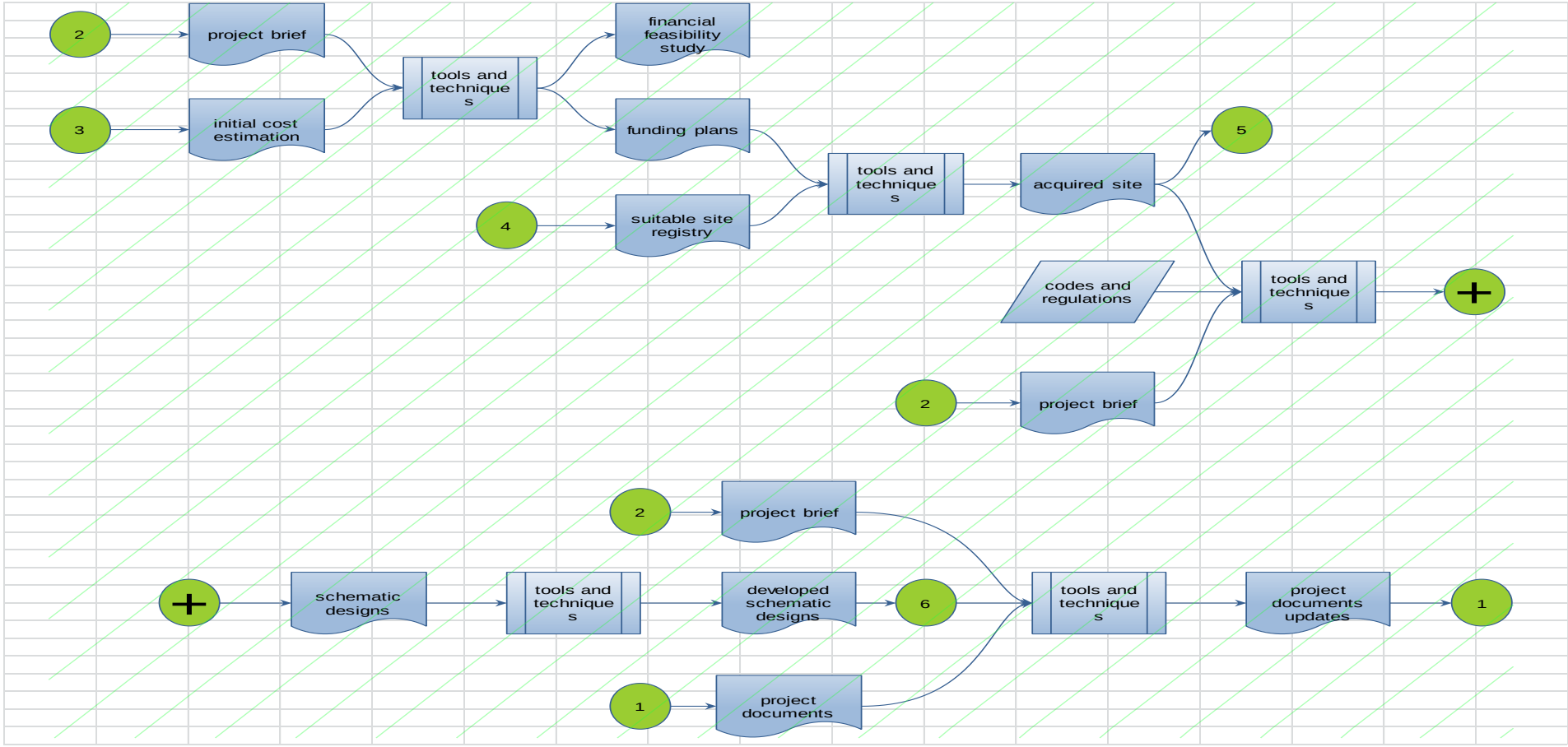

Figure 45: Planning phase steps 11-16

Figure 44 is the demonstration of flowchart for processes 11 to 16.

4.4.3 Contractor selection phase

Selecting the contractor is another stage which has been described by Bennett (2003) which focuses on the approach toward how to select the contractor, and the tactics that might be applied to best serve the project goals. Also estimating the project cost in an organizational manner. The tendering processes and related activities are occurring during this phase similarly. These processes are defined and introduced accordingly in this part;

1. Defining methods for contractors selection including pre or post qualification, open tendering, invited tender, negotiation. Each of these methods has a field of study which is out of the scope of this study.
2. Cost estimating is the next step; but it is different than before. This time, it is more accurate and is according to various elements such as design schemes and etc.
3. Submittal and opening process is when the contractor submits the proposal regarding to times schedule, cost estimations, value engineering and etc. which the contractor has developed.
4. Selecting the contractor which might be based on different aspects of a tender ranging from the price alone to wider complicated criteria other than just the lowest price.
5. Qualification is the process in which contractors try to qualify the changes they want to make to the project by giving reasons and explanations. This step is allowed in some tendering processes and is not allowed in some others.

6. The notice to proceed is a document to be sent to the contractor by the owner in order to let them know about their acceptance and leading them to commence the project.
7. The final step in this phase is awarding the contract by formally issuing a contract agreement.

Figure 45 is the flowchart developed based on the contract selection phase of the project.

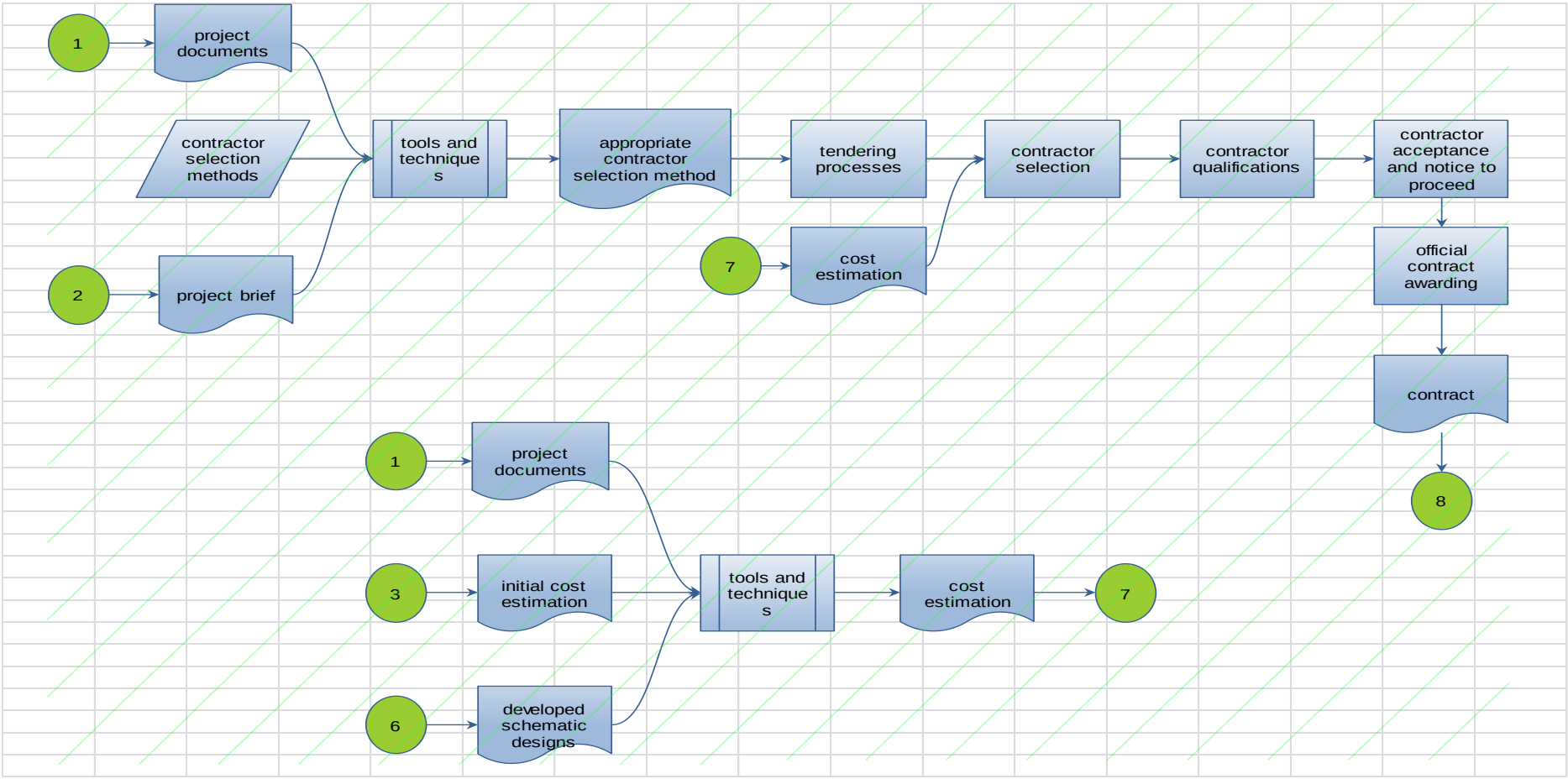

Figure 46: Contractor selection processes

4.4.4 Mobilization phase

Mobilization phase is introduced to place between the contract awarding step and the commencement of the construction work on site and it generally means site preparations, which includes bonding, permits and insurance, site planning including temporary utilities and facilities, Security, project site signage and etc. are some of the activities that would take place in this stage. These activities are described here and the flowchart created for this phase is given in figures 46, 47, 48 and 49.

1. Legal issues, permits and licenses are parts of the preconstruction mobilization process. These vary from project to project based on its characteristics, the country, obtaining the building permits, which might consist of structural, plumbing, safety and etc.
2. Bonding occurs in this stage to guarantee the proposal and the contractor performance.
3. Insurance requirements and obligation which might vary from project to project; but in this stage the contractors always have to arrange for insurance.

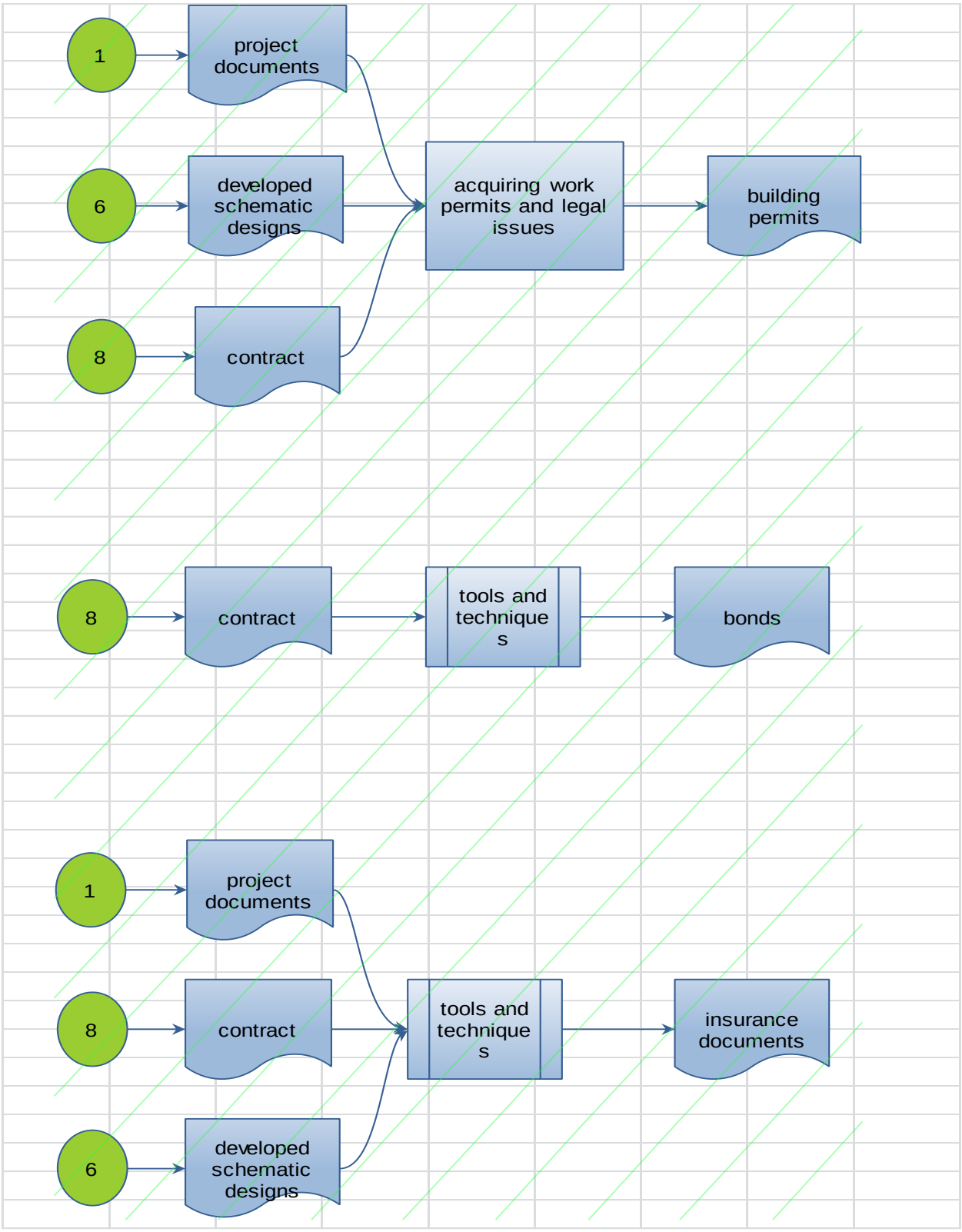

Figure 47: Mobilization phase steps 1-3

4. Partnering, a non-legal act which might take place in different stages based on type the project delivery method; this step focuses on establishing mutual goals amongst the stakeholders of a project.
5. Creating the WBS to help the planner identify the total works that should be done in a project.
6. Creating bar charts and schedule networks to indicate how various activities are going to be carried out during the construction phase.
7. Planning and scheduling: regarding the contract that has been awarded to the contractor the best and most efficient detailed plan and schedule will be developed.
8. After awarding the contract, the cost estimations will become the basis of budgeting system and controlling and monitoring costs.
9. Organizing the worksite is another important activity that the contractor must do as he commences the work on site. Preparing offices, workshops and indoor storage, many temporary utilities and sanitary facilities are amongst the site preparation steps.
10. Buying out which refers to obtaining and procuring the materials and jobs required in the project that should be supplied by other parties. This stage consists of two fields; material procurements and subcontracting.

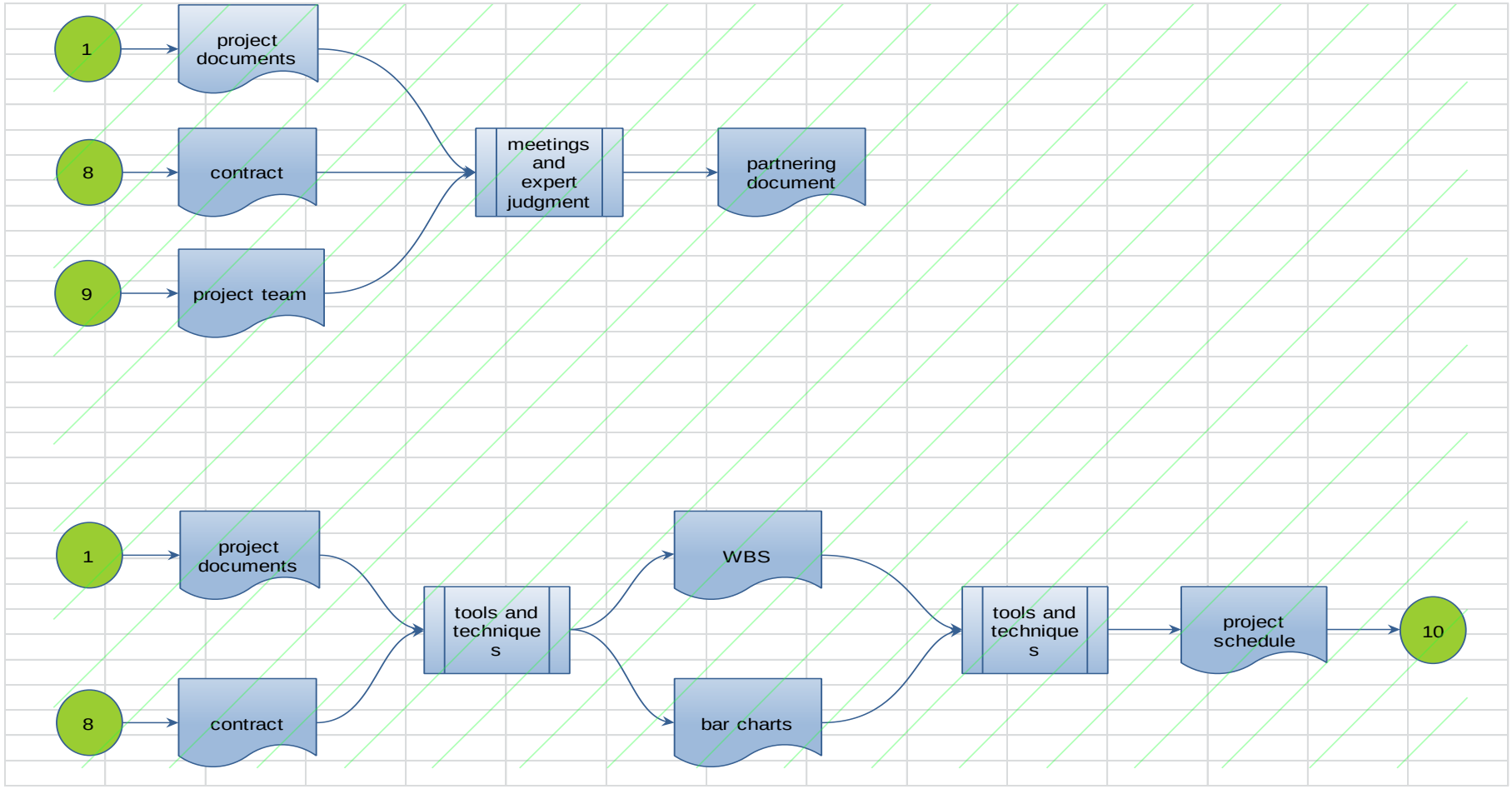

Figure 48: Mobilization phase steps 4-7

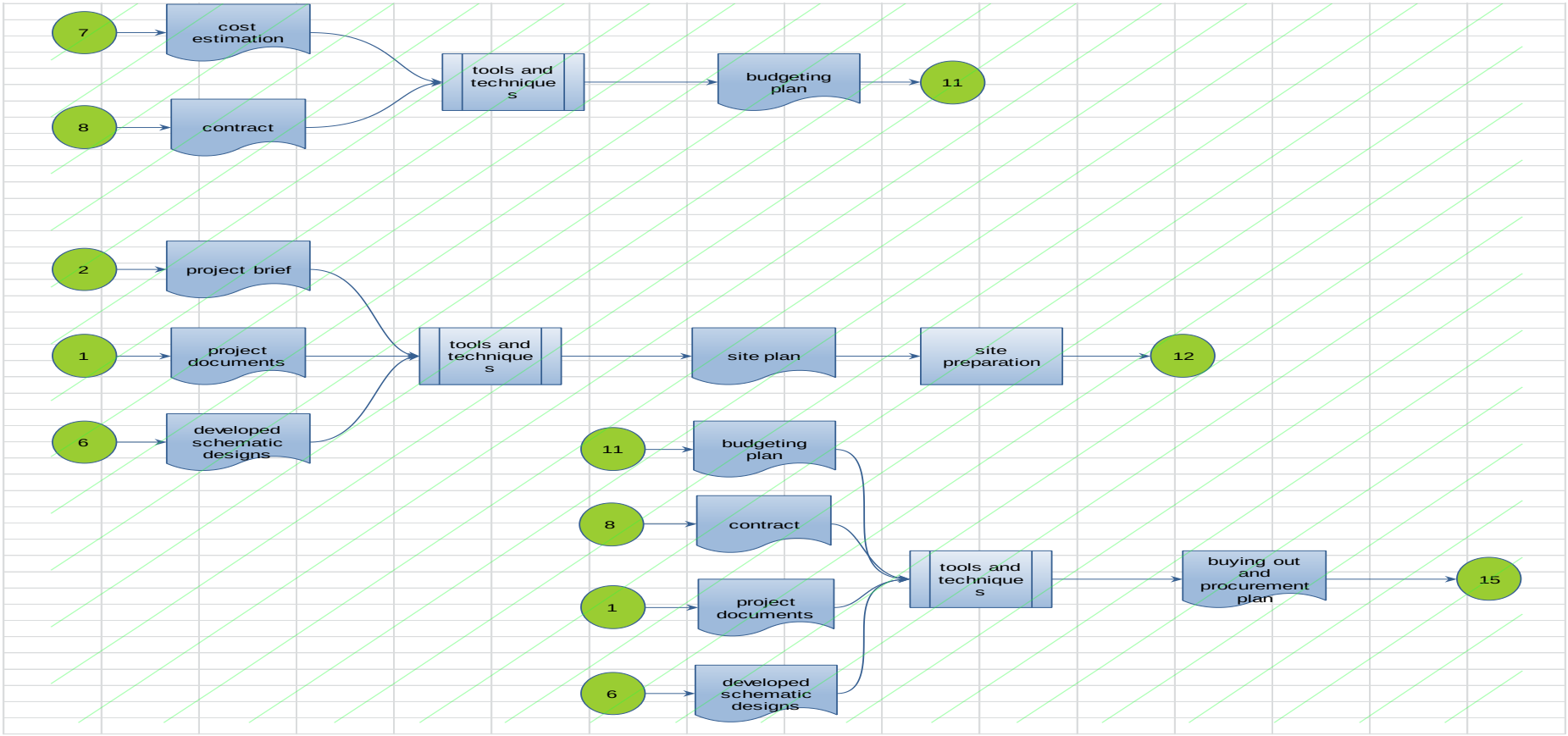

Figure 49: Mobilization phase steps 8-10

11. Project staffing focuses on assigning people into different positions and developing the organization structure at project. (figure 49)

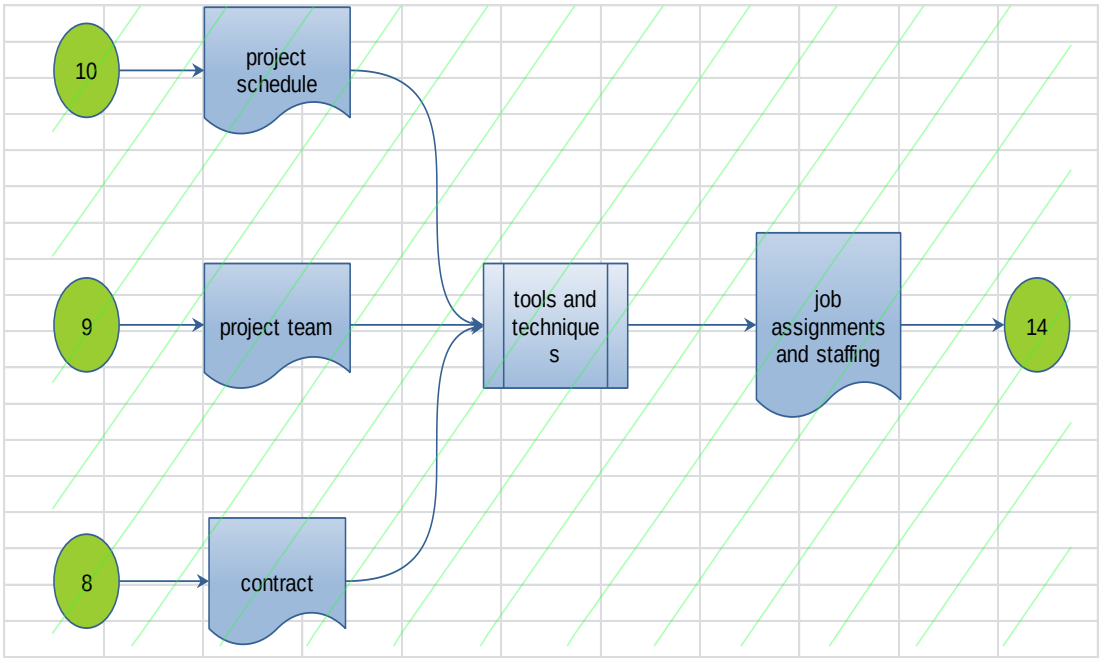

Figure 50: Project staffing

4.4.5 Operation phase

Operation phase was described by Bennett (2003) as where the project construction initiates and where all the earlier activities such as planning and designs are utilized. Some activities defined earlier like procurement may continue during this stage and have their impacts properly during the phase, mainly managing the project by managing resources, controlling the payments, communication, safety, environmental managements and other activities similar to them which have been described frequently in this study. Monitoring has been defined as part of this phase of the project. Bennett (2003) described the controlling stage of a project within the "operation phase" of a PLC. This phase has been introduced earlier, hence in this part only the controlling issues are covered. It is vital to compare the actual project performance to what has been planned in the earlier stages in every area. This

includes schedule updating, cost controlling and developing reports and etc. the processes named here are addressed and defined within 11 steps as follows;

1. Schedule updates: By comparing the schedule progress and the pre-planned schedule, the work progression is estimated. This usually occurs when a payment request is prepared. This step focuses on timing and project progress percentage described before. (Bennett, 2003)
2. Cost control: This step is to help comparing each activity's actual cost to its estimated budget to identify deviations and estimating the total project budget cost.
3. Data sources: Focuses on various resources including material, equipment and labor or subcontractors. Figure 50 is the flowchart developed for the first 3 stage.
4. Cost reports: These reports are designed to give information in specific intervals to help the managers to reduce the deviations of actual budget and the estimated budget.
5. Other financial control: Reports to company's project managers and senior managers and outside parties and stakeholders to increase the project efficiency and help the long term plans.
6. Quality management: This step consists of two main goals; monitoring, which is basically reviewing the work, and controlling that deals with the results of the last part to define the defects.

Figure 51 illustrates the flowcharts according to step 4 to 6.

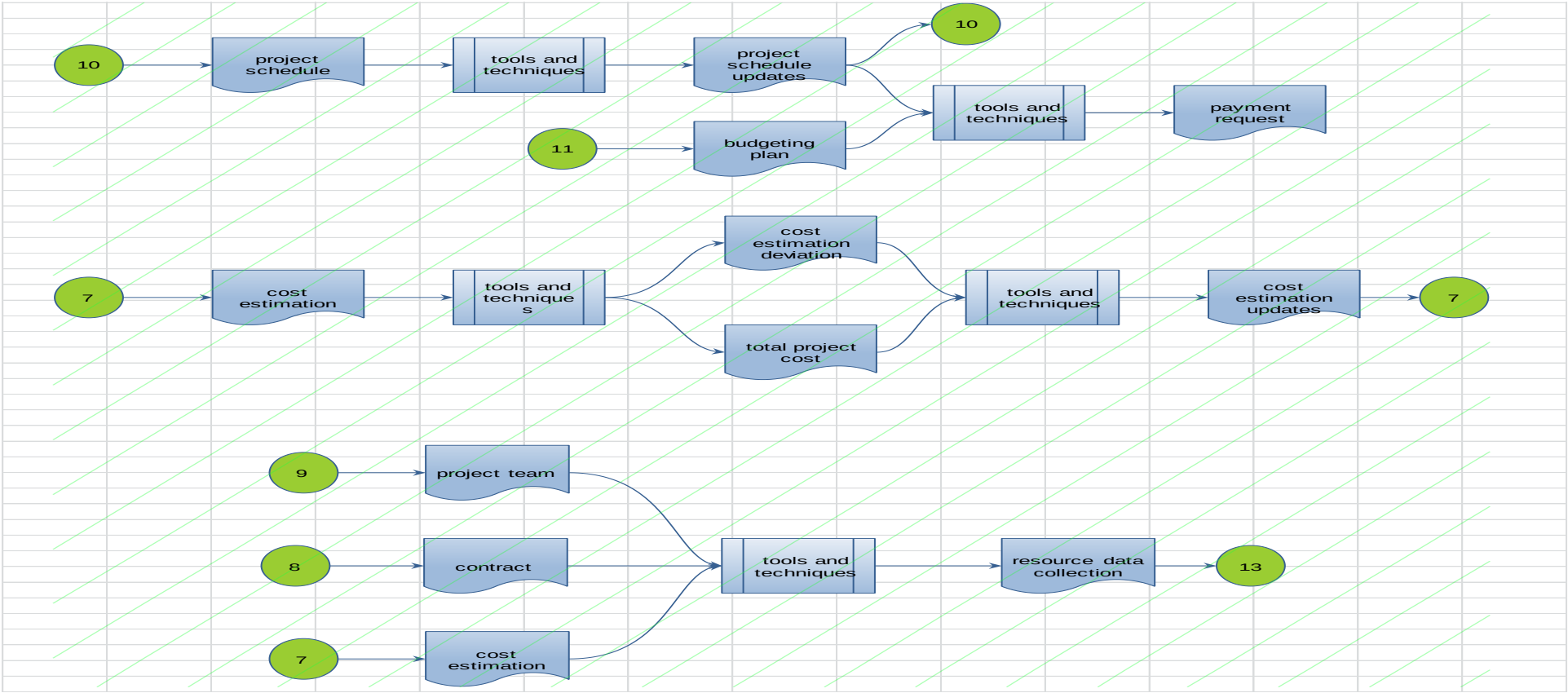

Figure 51: Operation phase steps 1-3

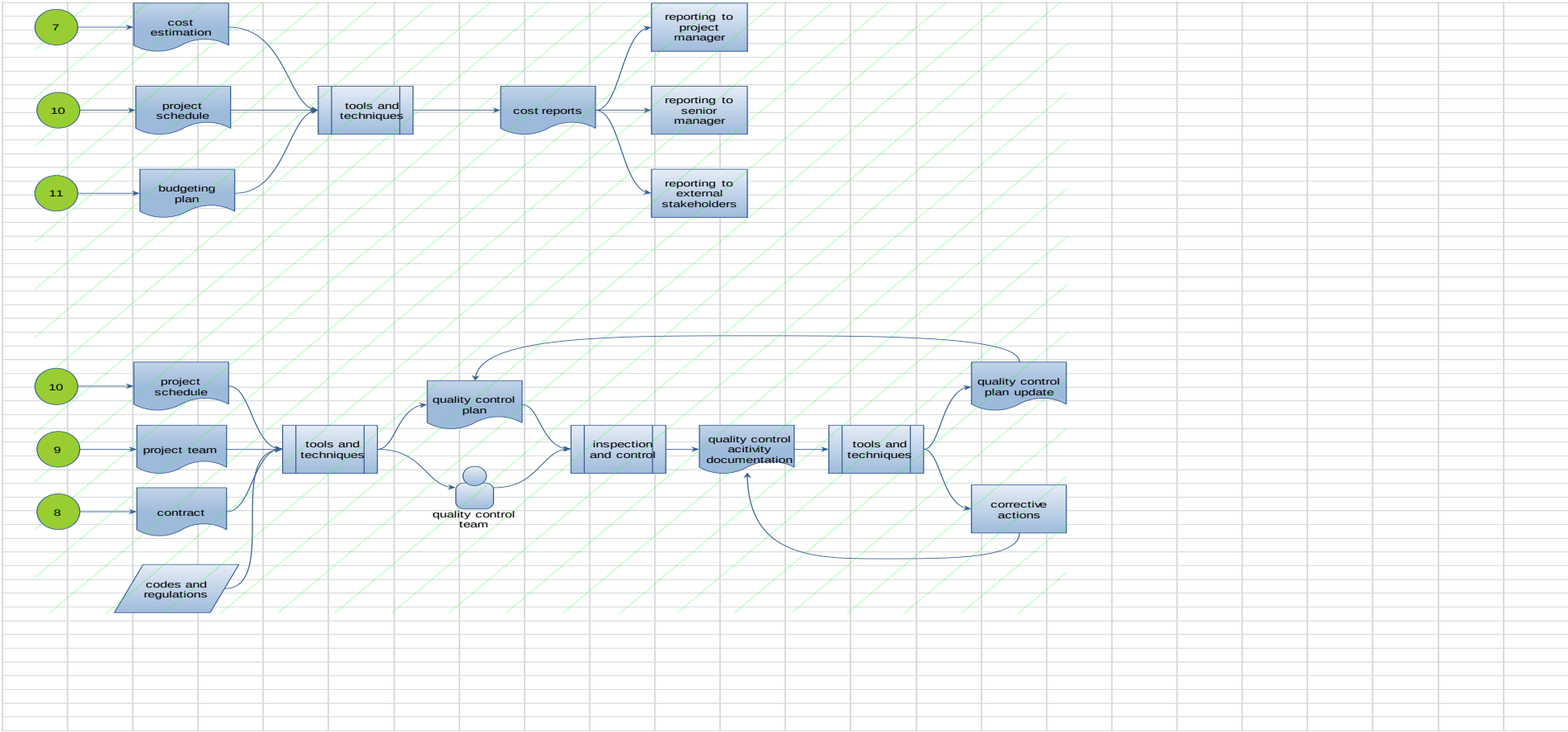

Figure 52: Operation phase 4-6

7. Safety management: Assigning tasks and responsibilities to supervisors and other regulation that has been named in order to reduce the hazards in the work area are this step's main goal. (figure 52)
8. Environmental management: Controlling the effects of the project on the area it located in, like pollutions and water drainage and etc. (figure 52)
9. Resource management: Focusing on the resources and how they can contribute to the project by the suitable management. Resources include the labor which might need training and motivating, the materials, and equipment. (figure 53)
10. Documentation and communication: Each project has a huge amount of paper work with the purpose of communication directions, permissions and etc. (figure 54)
11. Selected legal issues: The fact that legal issues arise as the project progress is undeniable. Claims and their resolutions, disputes and their preventions, delays and etc. occur and this step focuses on these matters. (figure 55)

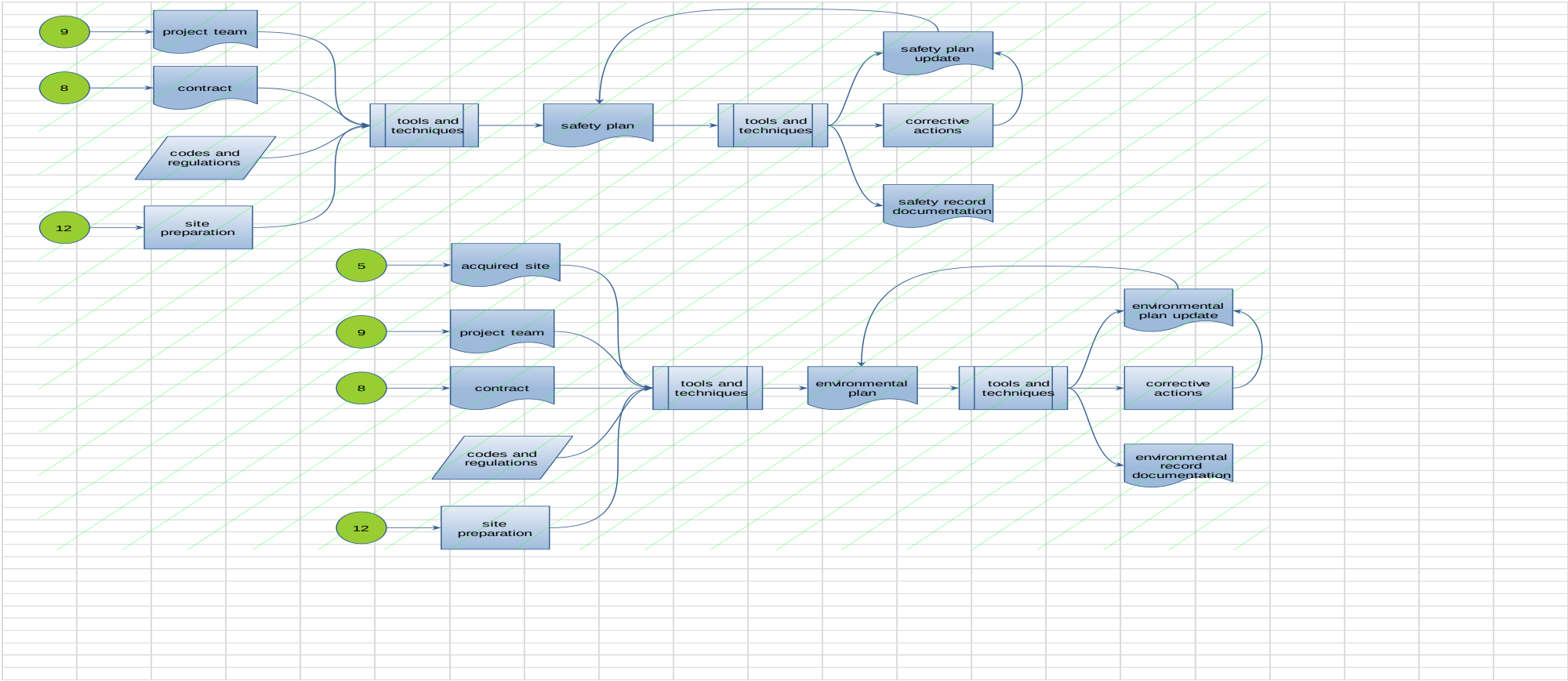

Figure 53: Safety and environmental management

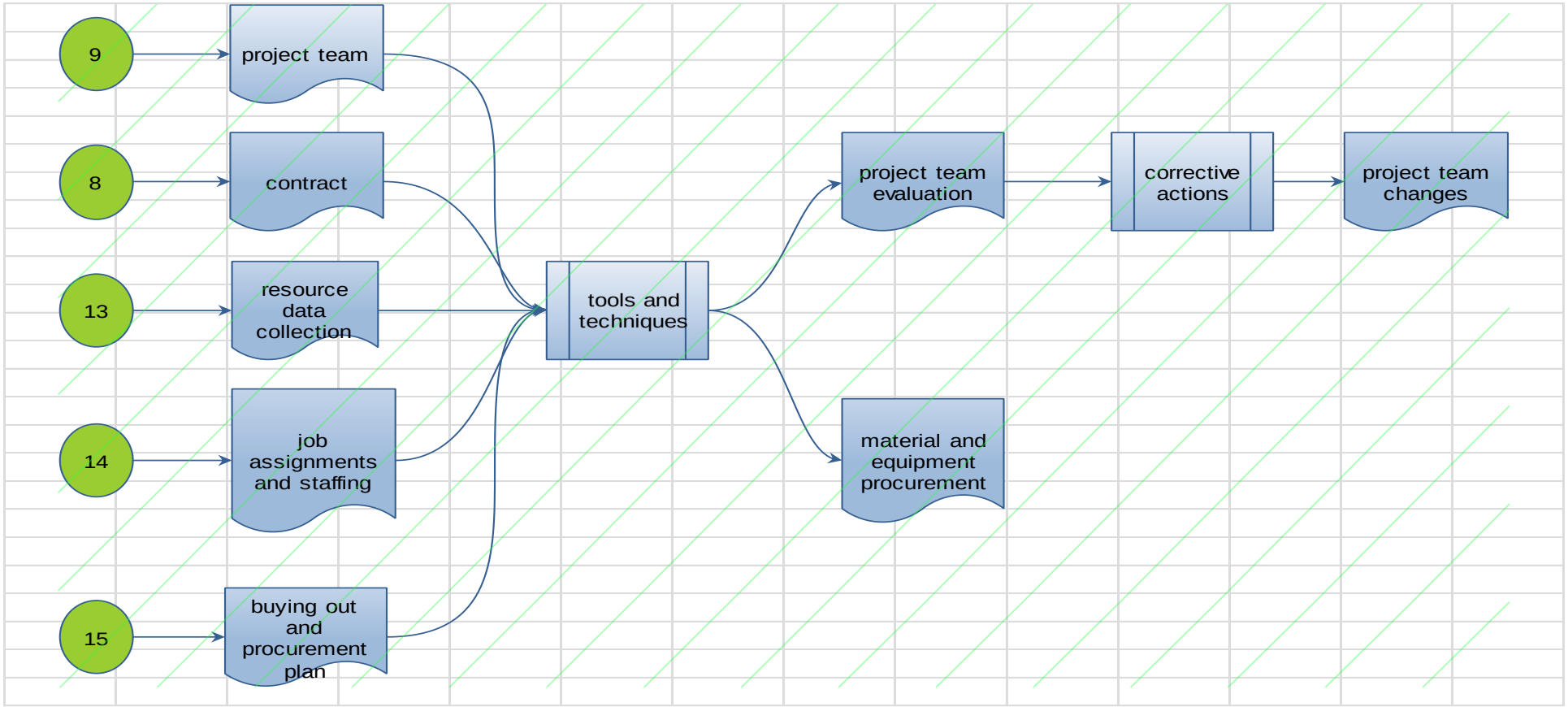

Figure 54: Resource management

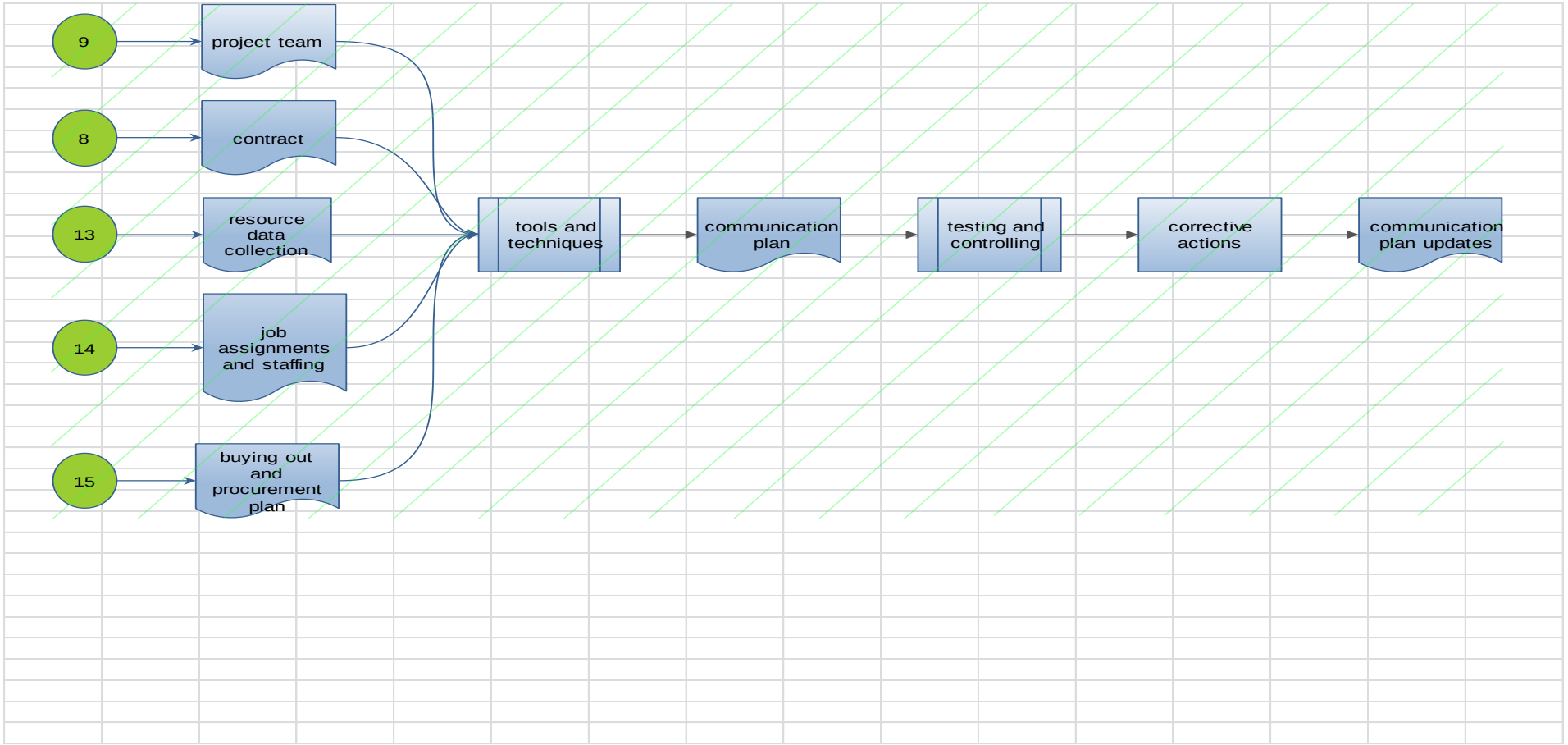

Figure 55: Communication management

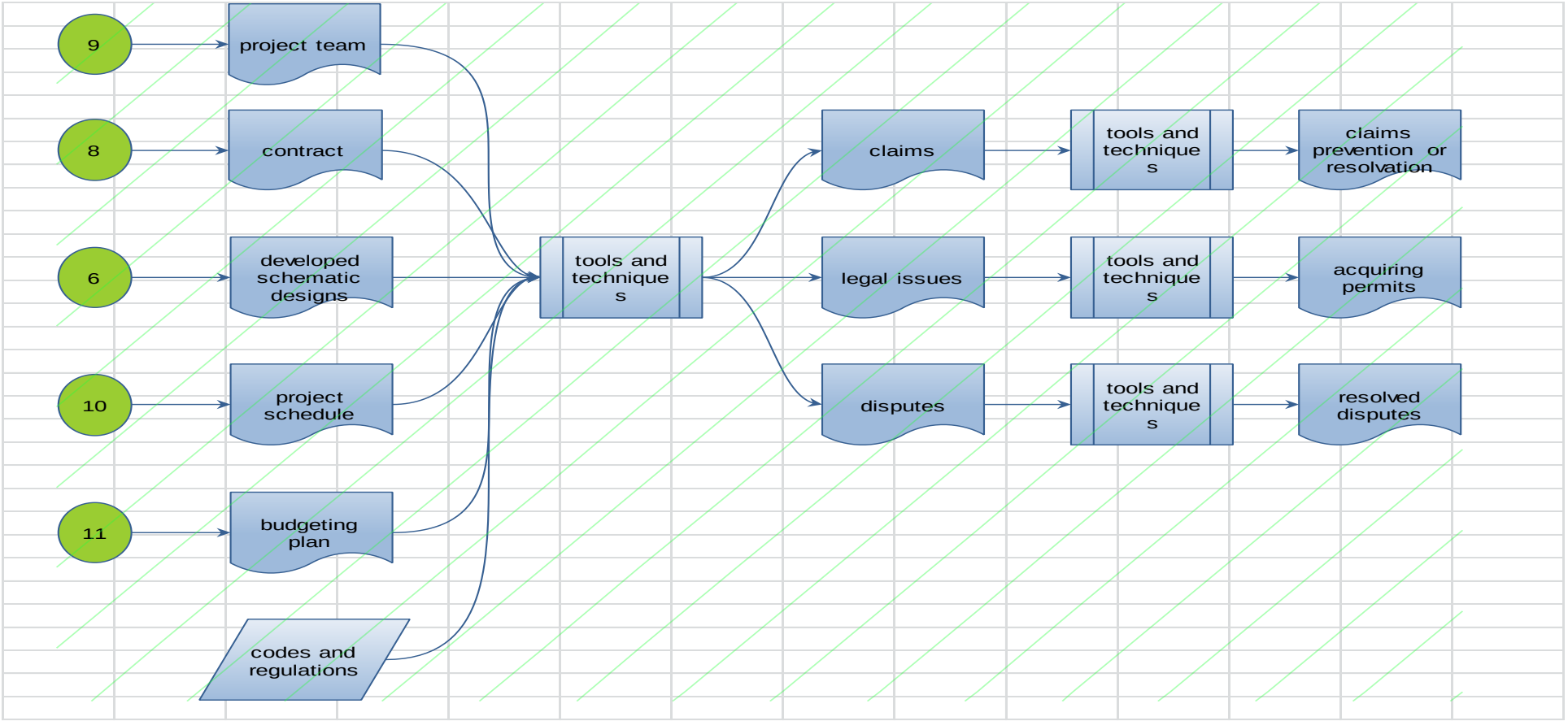

Figure 56: Legal issues

4.4.6 Project termination and closeout

Project closeout is the last phase of a construction project according to Bennett (2003). Bennett claimed that hardest part of the project is the finalization phase as he stated; “projects proceed smoothly until 95% complete, and then they remain at 95% forever!” This study divided this stage into two separate steps, completing the physical work and closing out which involves many paper works.

1. Completing the work: Testing and starting up the finalized project, site cleanup, final inspections, the beneficial occupancy, personal actions and closing of the office.
2. Project closing out: This stage includes actions such as paying the subcontractors, final release, consent of surety, final quantities, request for final payment, liquidated damages, final payment, accounting and cost control and certificates such as: payment certificates, completion certificate by contractor, substantial completion certificate, completion certificate, and occupancy certificate. The as built drawings, operating manuals, records archiving, trainings for the operation, warranties and guaranties are other activities that would take place in this stage.

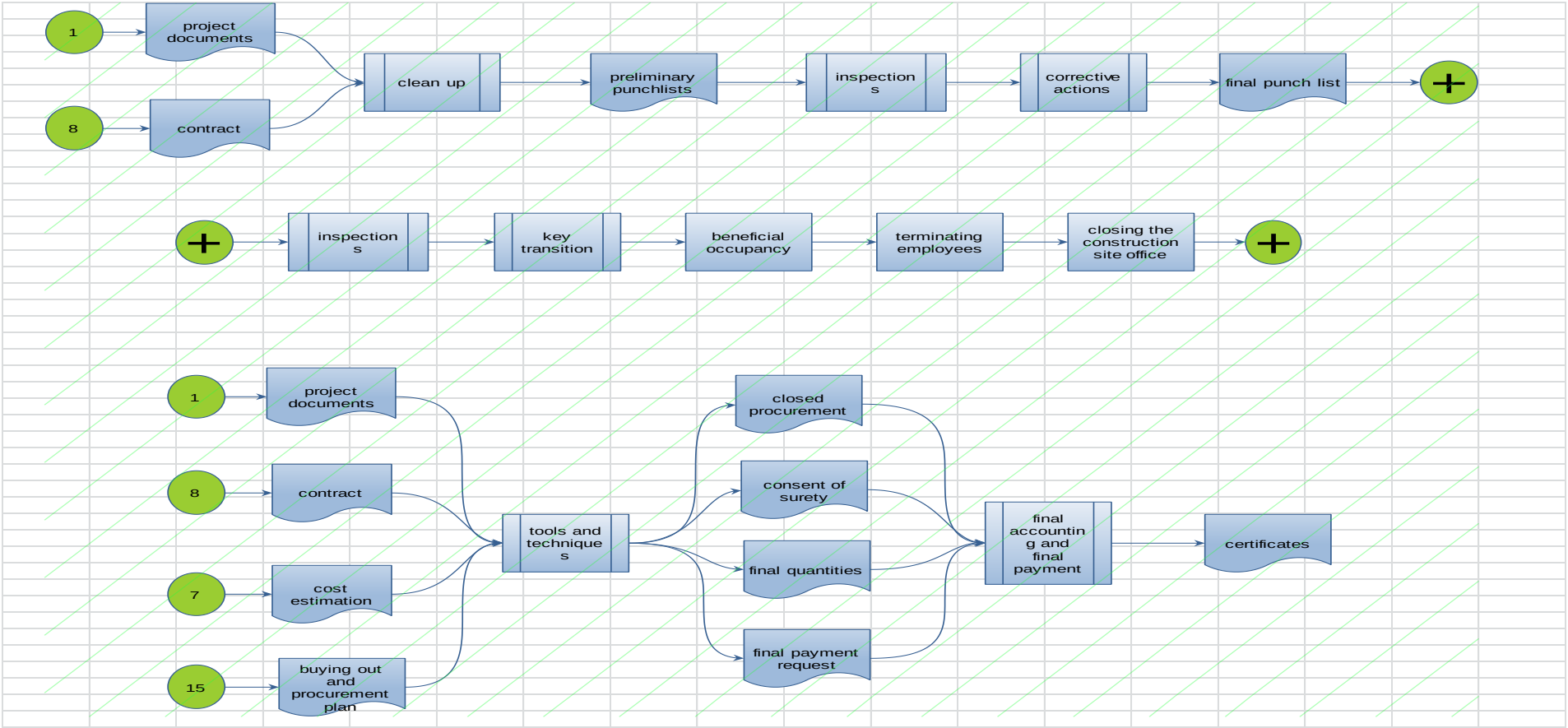

Figure 57: Project termination phase

Chapter 5

DEVELOPED MODEL

5.1 Introduction

This thesis was created regarding a guideline created by PMI. By searching the literature review and investigating the PMBOK, a model was created and introduced in the last chapter. although the construction PLC has been introduced and a model has been created in contrast with the PMBOK model to signify the differences in between.

The main purpose of this chapter is to combine two models presented in the last chapter and create a single model, based upon the PMBOK characteristics but with a construction PLC approach. As mentioned in PMI's book (2013), the PMBOK is not a methodology and many aspects of this book may not be used in different projects and everything depends on the characteristics of the project itself and the management team decisions. Using the previous studies that have introduced the construction PLC, a simple model has been developed in this chapter that unites both constructional and managerial issues and can be used as a methodology in construction industry.

5.2 Methodology

To avoid creating similar flowcharts and to avoid repetition, only the changed diagrams and new diagrams will be added and defined here, obviously the original flowcharts had been illustrated before in this study and will stay the same.

5.2 Highlighting the Differences

The processes introduced by PMBOK are scattered in several process groups which happen according to the project phase; these have been introduced in previous chapters. PMI claimed that these are not to be used uniformly and might change according to the project characteristics. By introducing the construction project in the second chapter and an overview of the models created in the last chapter, some deviations in some points of a PLC has been located which will be illustrated in this part.

A construction project arises from an idea. The owners desire to create an artifact with specific purposes. How this idea is going to be developed and carried out is the first step of a construction PLC. The PMBOK's first two processes focus on what the project is and identifying its participants. There are no activities in this part that clarify where did this project came from and how this project is going to be accomplished. Agreements are inputs of creating a project charter according to PMBOK and are considered a document which exists; but according to construction PLC, it is an activity and should be added to creation of project charter flowchart. Figure 57 demonstrates the differences mentioned here.

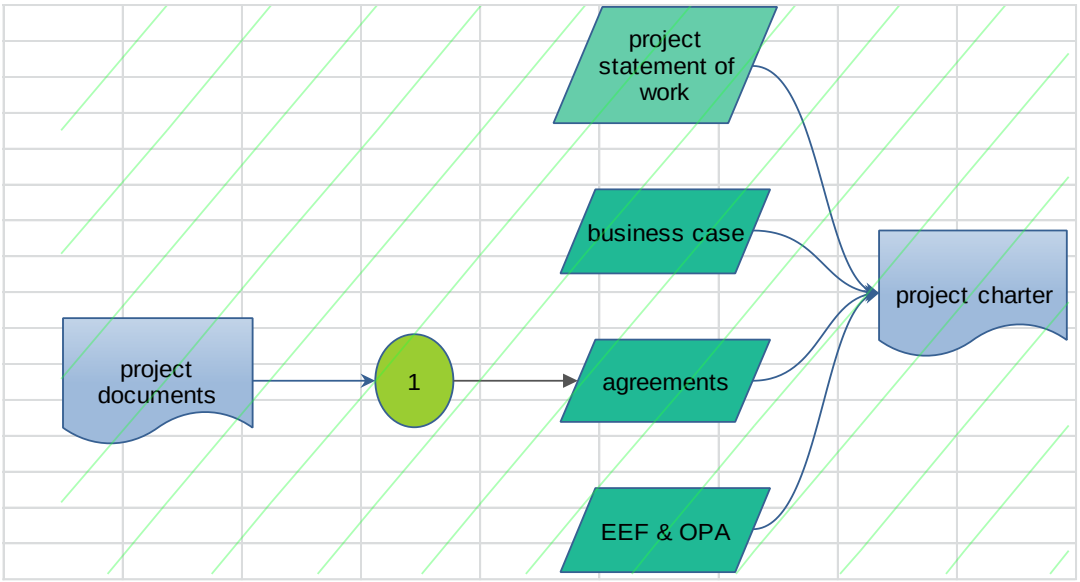

Figure 58: The updated process of creating a project charter, the project document update is from Figure 42

The process of designing the object, regarding the project brief or project charter which has been introduced earlier has been introduced in the PMBOK as a phase and considered a new project. Designing phase is the main element of the planning phase. While there is a procurement knowledge area presented but it does not have any impact on the scheduling and estimating processes. This is while in a construction project the results of procurement are required. The result is schematic design procurement that provides the project with in detailed designs. Therefore the designing phase will be considered a new project with its own lifecycle. Figure 58 is a demonstration of the schematic design phase which is considered a unique project; the outcomes are used later in other processes. Figure 58 and 59 demonstrates the impact of this issue in the flowcharts developed.

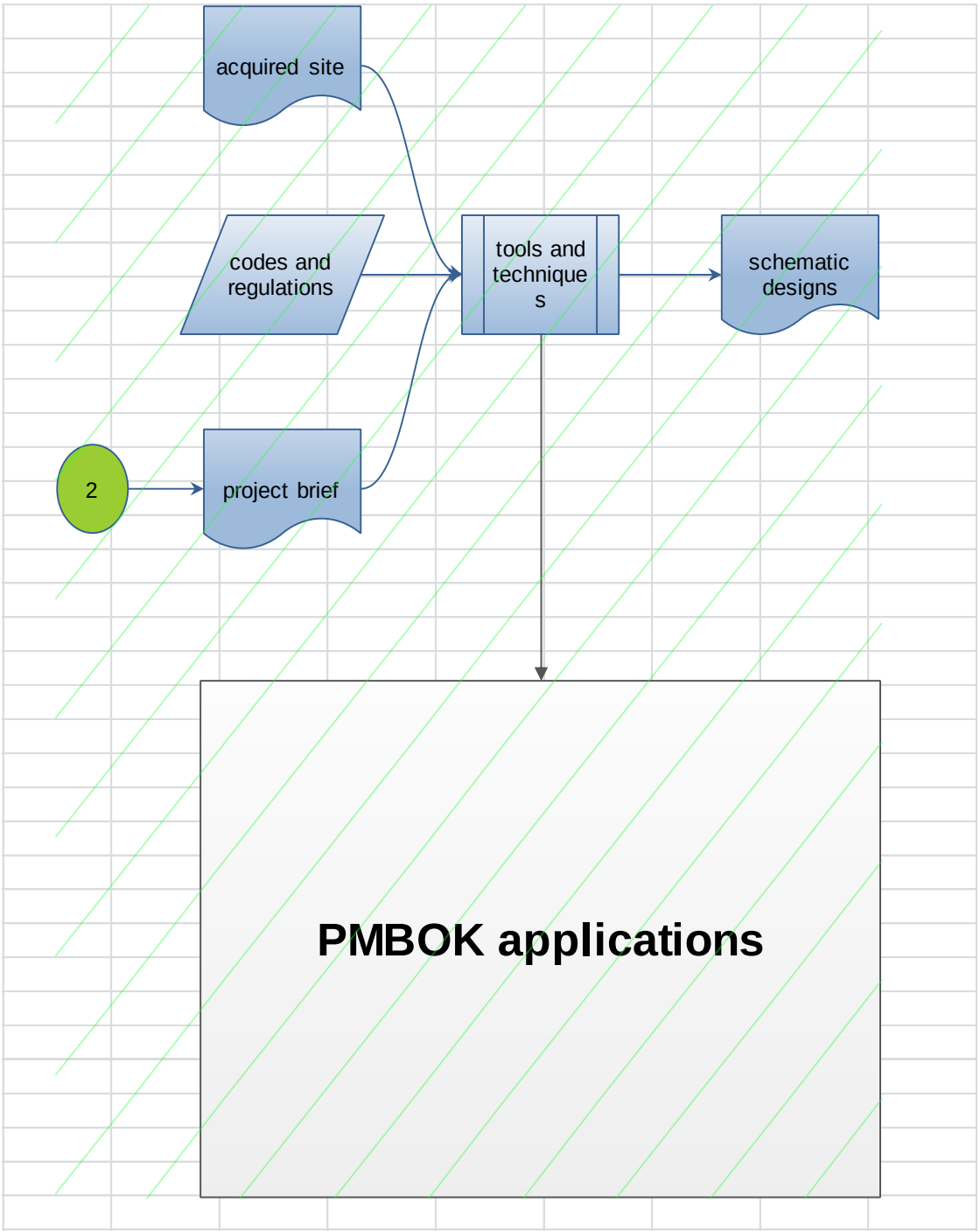

Figure 59: The design project (phase), the original flowchart is explained in Figure 44

The contractor is the one who carries out a construction project. Depending on his contract with the owner, other processes will be undertaken. Whether the management is on the contractor side or on the owner side, the process of

procurement should occur at the earliest stages of the project. This step has been introduced in the procurement knowledge area and according to a construction PLC, this step should be happening while the scheduling and estimating is at its earliest stages. This is while the outcome of this procurement affects many processes. Hence an initial procurement process occurs using the outcomes of the design phase. Figure 60 demonstrates the schedule management plan updates according to this study.

The results of the schematic design phase and the initial procurement documents which have been described earlier in this chapter will be used in many processes which will be demonstrated here.

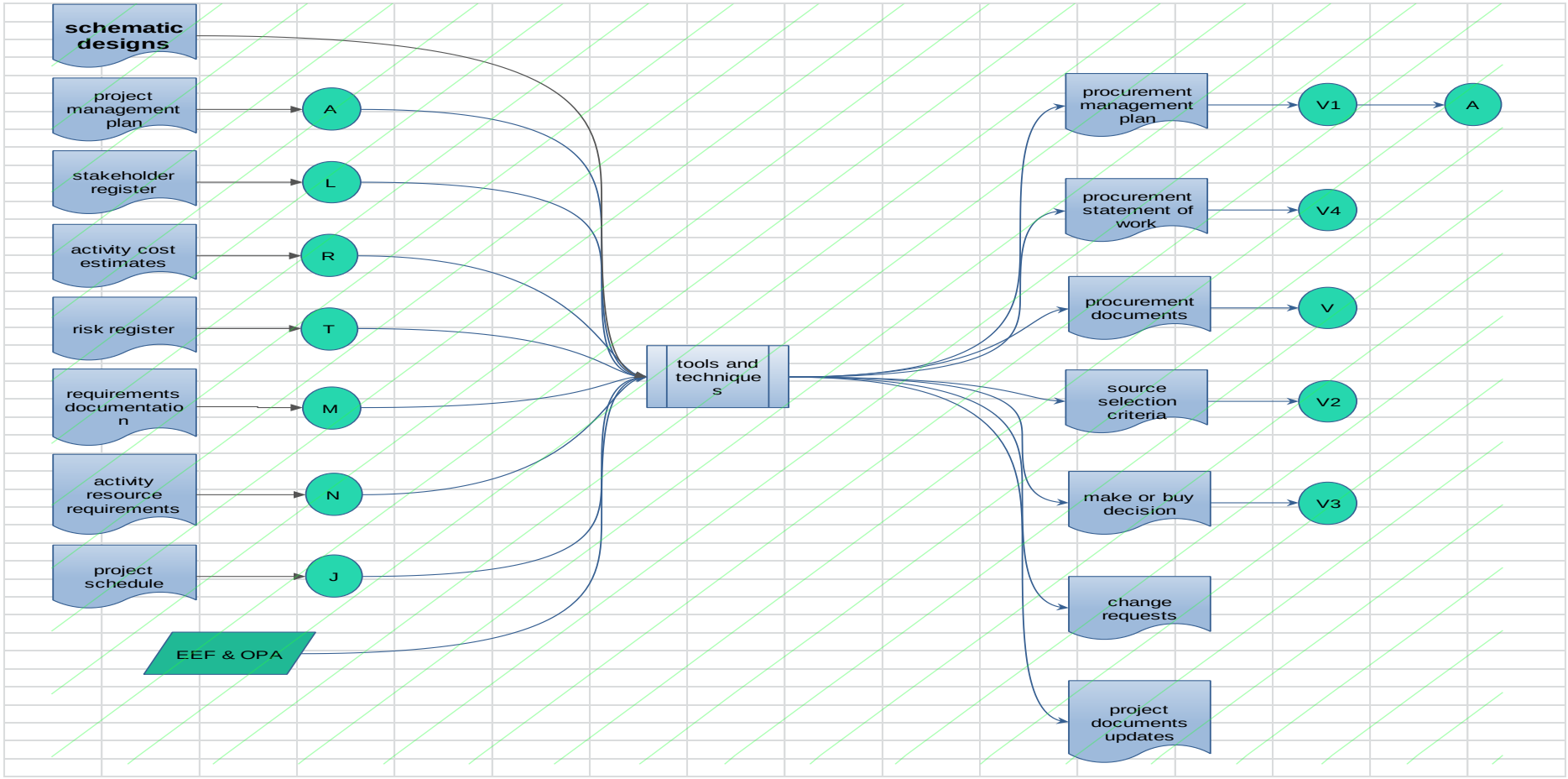

Figure 60: Initial procurement, the original process is presented in Figure 21

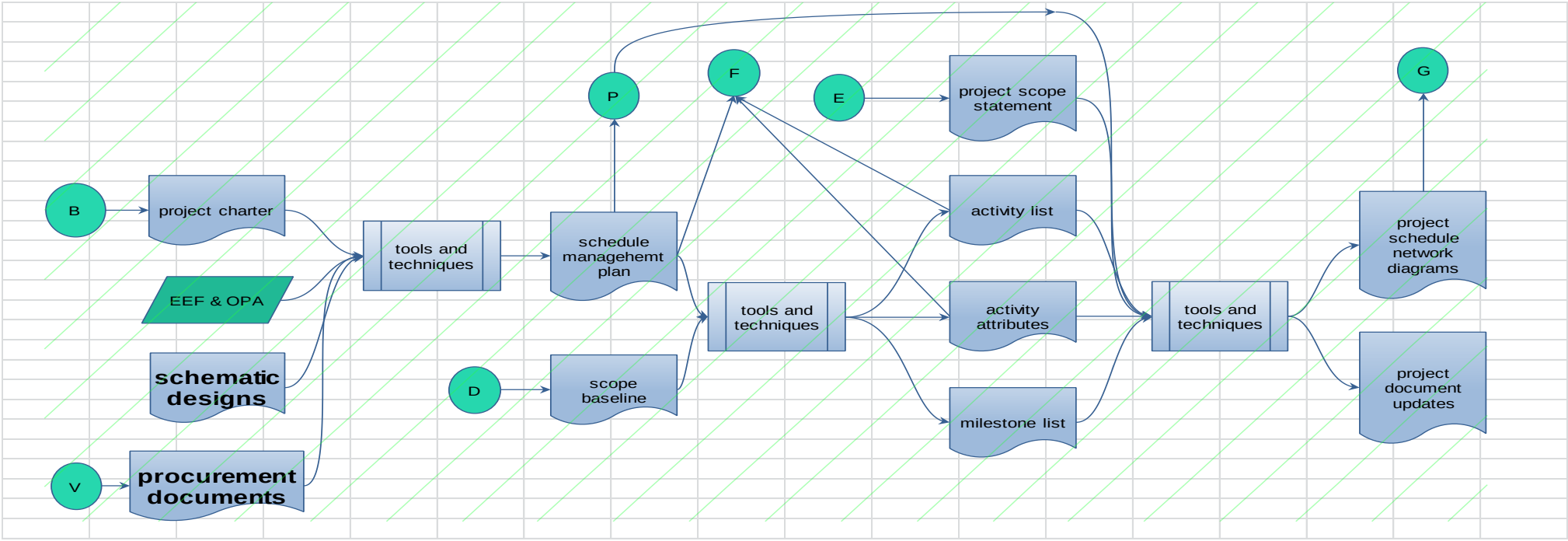

Figure 61: Process of schedule management plan, updated version of Figure 11

As illustrated in figure 60 and 59, the schematic designs and initial procurements are inputs to process of schedule management plan, as well as all of the other knowledge areas. These are the main reliable sources of information which are accepted by law in the construction industry. In order to reduce the repetition of similar diagrams, the updated versions of other processes will not be presented in this chapter; but the updating method is exactly the same as the one shown earlier.

Many permits and legal issues should be followed before a construction project can initiate. In the PMBOK, the quality, safety and environmental permits are described and mentioned which can cover major permits needed; the process of acquiring these permits occurs before the project initiation. The construction license (building permits) in many cases of the construction industry is required; this activity is inserted into the PMBOK as a part of initial step in the process of "direct and manage" the project work (Figure 26). The bonding process and the processes of acquiring insurance are the activities to be considered as a part of the direct and manage process. The process of setting up the project site is an important activity which affects the project performance a lot and should be considered in a PLC. This process also takes place before the project directing and managing. Figure 61 is the step by step models of starting a job in construction site.

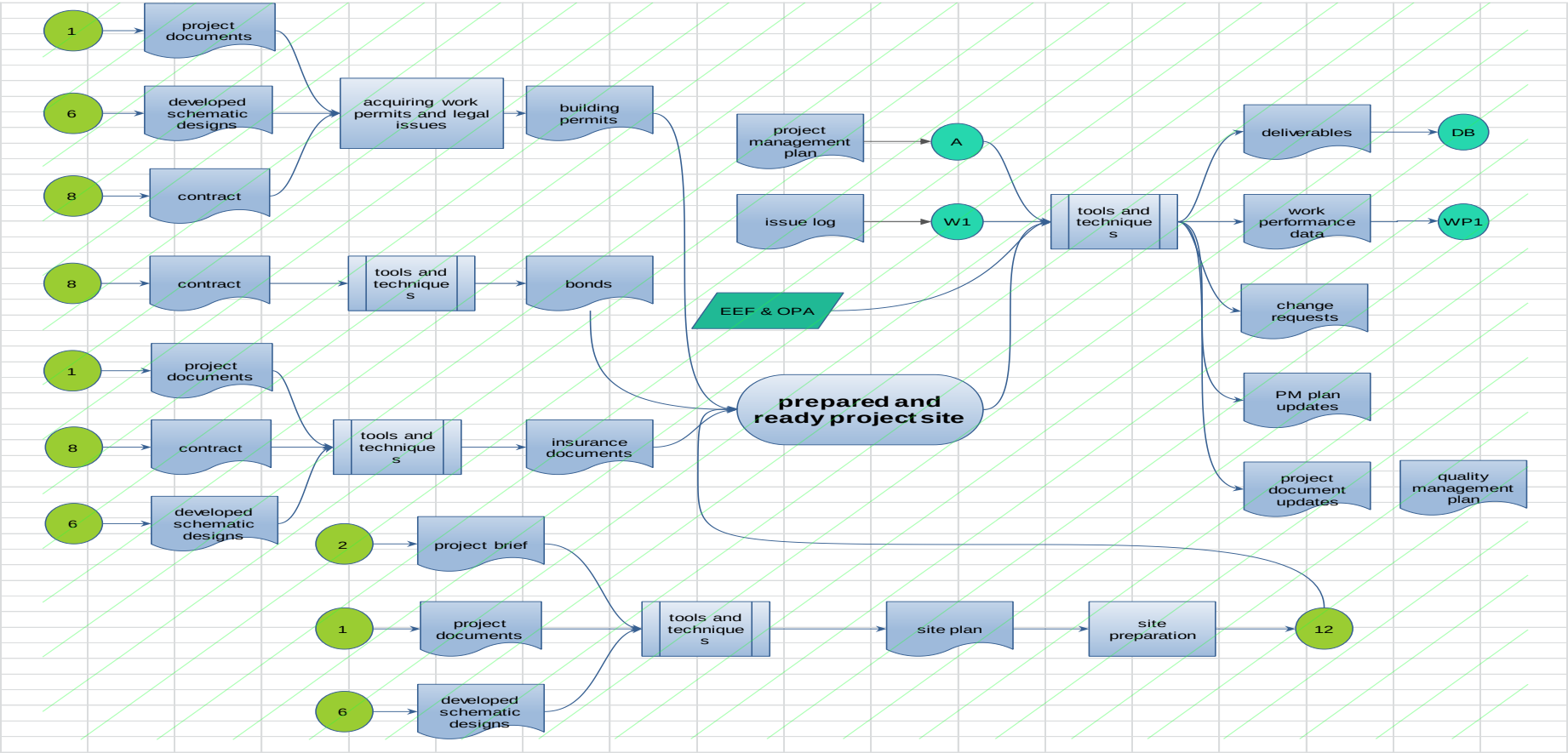

Figure 62: The initiation of physical project job, based on the original Figures 26, 46, and 48

Chapter 6

CONCLUSION AND RECOMMENDATIONS FOR FURTHER STUDIES

6.1 Introduction

PMI is one of the most respected institutes in management field and has been contributing to the industry since 1969 (PMI, 2014). The PMBOK guideline was first published in 1996 and it has been revised ever since. This book is considered to be gathering the best practices in every industry to create the most applicable list of process groups and knowledge areas. However, this has been proved and stated in this thesis that this guideline does not have the potential of being a methodology. Therefore, its processes may not be used uniformly. Construction industry characteristics made the PMI to publish an extension to accompany the guide and added several extra knowledge areas, yet the uniformity of the processes was not explained.

This chapter explains this study's main achievements and goals, gives a general understanding of what has been done and what has been gained through each phase. What can be done furthermore and cases that has been out of this study scope will be mentioned additionally.

6.2 Conclusions

This thesis argues that the PMBOK is not a sufficient guide for the construction industry by proving this point and indicating how this guideline lacks the ability to

aid managing a construction project. Hence a unique and single method is required to help and facilitate the managerial work of a project.

The key aspect discussed in this study is PMBOK guide and construction PLC, the literature has been explored in both fields and two flowcharts were developed and presented describing a PLC in both construction and PMBOK perspective.

Flowcharts presented in this study were defined to be a solution for the lacking uniformity in the PMBOK and the incomprehensive construction PLC approach. The issue focused on is the chaotic approach of PMBOK toward a project missing the collaboration with the PLC. While the central theme of this study is knowledge areas and process groups introduced by PMBOK, the orientation of the flowcharts supports a PLC approach.

To conclude, a PMBOK flowchart has been presented initially which has been interpreted and compared to the construction PLC flowcharts that have been created later on. The differences have been clarified and illustrated. Breaking a construction PLC into two projects, based on PMBOK was one of the largest changes that has been made, few activities has been added as well as some documents to the input of some processes.

6.3 Recommendations for Further Studies

The scope of this study was to facilitate the use of PMBOK in the construction industry. Due to the vast information and large scale of the study, many details have been left untouched. Therefore, the following topics could be considered for future study:

- The tools and techniques introduced by the PMBOK are too many; which technique to use and which one is the most efficient one could be investigated.
- The effects of knowledge areas in the industry have not been examined; perhaps a study can define and evaluate them.
- Implementing the outcomes of this study into an actual project and evaluating its effects.
- The design phase has been considered a project in this study which follows all of the PMBOK steps. An in-depth study could create a model for that project as well.

REFERENCES

Abadir, Y. H. (2011). Construction maturity in the construction industry in developong countries. College park, Maryland, United States.

Arthur, N., & Ghasemzade, F. (1999). An integrated framework for project portfolio selection. *International Journal of Project Management*.

Bennett, F. L. (2003). *The management of construction: a project life cycle approach.* Burlington: Butterworth-Heinemann.

Beringer, C., Kock, A., & Jonas, D. (2013). Behavior of internal stakeholders in project portfolio management and its impact on success. *International Journal of Project Management*.

Blichfeldt, B. S., & Eskerod, P. (2008). Project portfolio management - There is more to it than what management enacts. *International Journal of Project Management*, 358.

Bureau Of Labor Statistics. (2014, april 25). *Occupational outlook handbook*. Retrieved from United States Department of labor: http://www.bls.gov/ooh/management/construction-managers.htm

Celik, T. (2010). *Construction management in practice.* Magusa: Eastern Mediterranean University.

Chou, J.-s., & Yang, J.-g. (2013). Evelutionary optimization of model specification searches between project management knowledge and construction engineering performance. *Expert System With Applications*, 4412-4426.

Dai, C. x., & Wells, W. g. (2004). An exploration of project management office features and their relationthip to project performance. *International Journal of Project Management*, 523-532.

Ghaffari, M., Sheikhahmadi, F., & Safakish, G. (2014). Modeling and risk analysis of virtual project team through project life cycle with fuzzy approach. *Computers & Industrial Engineering*, 98-105.

Isik, Z., Arditi, D., Dikmen, I., & Dirgonul, T. m. (2009). Impact of corporate strengths/weaknesses on project management competencies. *International Journal Of Project Management*, 629-637.

Loosemore, M. (2004). *Essentials of Construction Project Management.* Sydney: University of New South Wales Press Ltd.

Munns, A. k., & Bjeirmi, B. f. (1996). Role of project management in achieving project success. *International Journal of Project Management*, 81-87.

PMI. (2000). *Construction extension to PMBOK.* Newtown square: Project management institute.

PMI. (2013). *A guide to project management body of knowledge.* Newtown square: Project Management Institutes, Inc.

PMI. (2014, june 10). *PMI.* Retrieved from PMI website: http://www.pmi.org/About-Us.aspx

Punmia, B. C. (1993). *Building construction.* New delhi: Laxmi Publications.

Sinha, A. a. (2014). Construction industry: remodeling project life cycle. *International Journal of Applied Engineering Research*, 241-246.

The Chartered Institute Of Buildings. (2002). *Code of practice for project management for construction and developement.* Malden: Blackwell.

Tony, F., & Powers, R. (1997). *Best practices of project management group in large functional organizations.* Project Management Institue.