CONTROLLING THE UNCONTROLLED

BY NOTICING THE UNNOTICED

SCOPE DEFINITION AND MANAGEMENT OF SCOPE CHANGES & SCOPE CREEP IN LARGE INFRASTRUCTURE PROJECTS IN CONSTRUCTION INDUSTRY FOR LUMP SUM CONTRACTS

MSc thesis | RAHUL SHARMA

Delft, November 2016

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SCOPE DEFINITION AND MANAGEMENT OF SCOPE CHANGES & SCOPE CREEP IN LARGE INFRASTRUCTURE PROJECTS IN CONSTRUCTION INDUSTRY FOR LUMP SUM CONTRACTS

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PREFACE

I hereby present you the results of my graduation research performed in order to conclude my MSc. Construction Management and Engineering (CME) at the Technical University of Delft. Being a civil engineer I was always very curious about the key reasons behind reworks and losses that occur in construction industry. After joining CME I got an opportunity to look at the problem of reworks and cost overruns from a holistic point of view, while following several course. My association with CME dispuut gave me a lot of opportunities to follow my interest. While organizing the study tour, I came across a very experienced project manager who shared his story of reducing the losses incurred in a project by a significant number. This event made me impatient to get to know more about project controls. That was the starting point of formulating my research topic. I am very thankful to Marcel and Afshin for acknowledging my interest and helping me in formulating my research topic.

I have spent last six months working on this research and without the guidance and support of some people this would have not been possible. First of all I would like to thank my graduation committee members. Marcel, for helping me formulate my research topic and for all the key feedbacks, Afshin the problem solver for providing me sufficient time, support and guidance whenever I needed, Martijn for always providing me a different perspective on the problem 'opening new opportunities' and lastly Jan for giving me an opportunity to perform my research at RHDHV and for giving me the freedom and guidance to define and execute my research as I wanted.

I would also like to thank all the people who contributed to this research one way or the other. My special thanks to Sjacco de Vos, project excellence managers and all the senior managers who took out time for interviews and for filling in the survey questionnaire. In addition I would like to thank RHDHV for proving me all the resources which were required to execute this research. Lastly, to TU Delft and CME faculty for making me acknowledge my strengths and helping me evolve as an independent confident individual.

There are many more who contributed by either going through my research document or by just having an informal discussion over my research topic. Thanks to all these awesome people! In the end I would like to thank my family: Dad, Mom, Brother and sister for their unconditional love and for always supporting me irrespective of how I am doing. Dad, you are going to be proud of your son soon!

Rahul Sharma

Delft, November 7th 2016

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EXECUTIVE SUMMARY

Project scope is the work that must be accomplished to produce a deliverable with specified features and functions. The deliverable can be a product, service or other result (Kerzner & Saladis, 2010). A project scope with clearly defined goals and objectives has been verified as a dimension for project success by some researchers. Furthermore, projects often seem to grow naturally as the project progresses from inception through design development to construction (Jennifer S. Shane, 2009). Observations from literature and practice show that poor scope management and control is the leading cause of project failure. O. Hussain, (2012) states that scope creep is one of the leading causes of project failure globally according to the 2010 Global Survey.

In this research the following definition of scope creep and scope change was derived from the literature and practitioners feedback

"*Scope change is an official decision taken by the project manager and the client to change, expand or reduce originally defined scope of work. A scope change always results in making adjustment to the activities, resources and contractual agreement affected by the change.*"

"*Scope creep is an uncontrolled and unnoticed scope change which occurs unofficially without addressing its impact on project activities and resources. These are the changes which occur without an official agreement between the client and the project manager*."

Scope creep is also considered as a concern in achieving project success in the design and engineering consultancy company Royal HaskoningDHV (RHDHV). RHDHV seeks ways to get more control on the management of scope creep, in particular in fixed price assignments (i.e. lump sum price contracts). Scope creeps occur most of the time unnoticed and unofficially and may in case of fixed price assignments have severe consequences if not timely prevented (during project scope definition phase) or timely detected and managed (during project execution phase). A number of studies describe what an ideal project control process for scope changes should look like. However, there is not much research on how these project control processes can be utilized in practice(Olawale & Sun, 2012).

The frequent occurrence of scope creep in projects was chosen as the subject, for problem definition of this research: "O*bservations show that projects in construction industry are facing with a lot of uncontrolled scope changes"*

According to the research problem statement a research question is formulated. By answering the research question a possible solution to the problem statement will be provided. The research question is:

"*How to manage scope of large infrastructure projects for lump sum price contracts in construction industry in order to reduce uncontrolled scope changes?"*

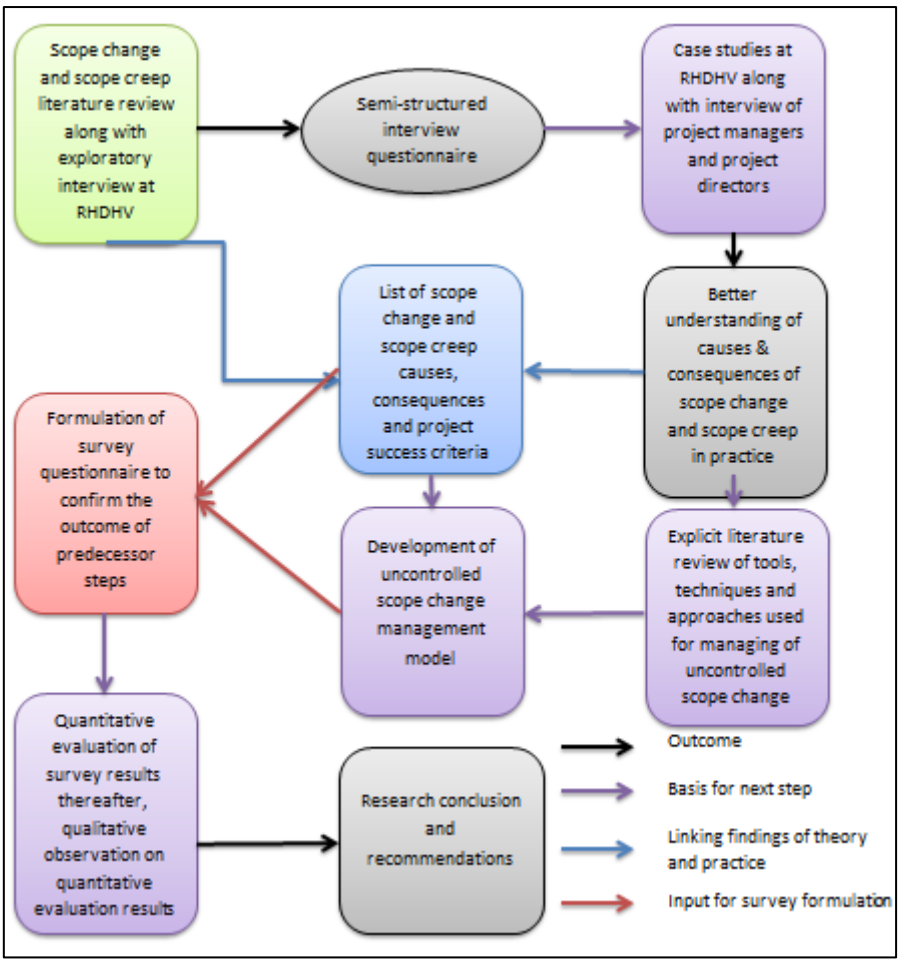
To come to a clear answer to the research main question seven sub-questions are formulated which are elaborated further in chapter one.

By answering the sub-questions and composing an answer to the research main question the objective of this research will be met: The objective of this research project is to make recommendations to design and engineering firms i.e. RHDHV on how to improve scope definition and scope management with regard to lump sum price contract in large infrastructure projects in

construction industry by making an analysis on the factors that are leading to poor scope definition and poor scope management.

This objective of the research is achieved by making an analysis on the factors that are leading to poor scope definition and poor scope management and relating these factors to a number of tools, techniques and approaches selected from literature review and input from practitioners at RHDHV.

The research steps that were followed are displayed in the flow chart below



The research resulted on the following findings after taking the steps portrayed in the flow chart.

A. Four extensive lists of scope change and scope creep causes and consequences were developed and validated in context to projects executed on lump sum price contracts. The extensive lists of scope creep causes and consequences were reduced to manageable sets using factor analysis, which are as following.

- Scope creep causes components
  1. Execution phase scope creep issues
  2. Frontend loading scope creep issues
  3. Project governance scope creep issues and
  4. Client related scope creep issues

- Scope creep consequences components
  1. Hard scope creep impacts
  2. Soft scope creep impacts

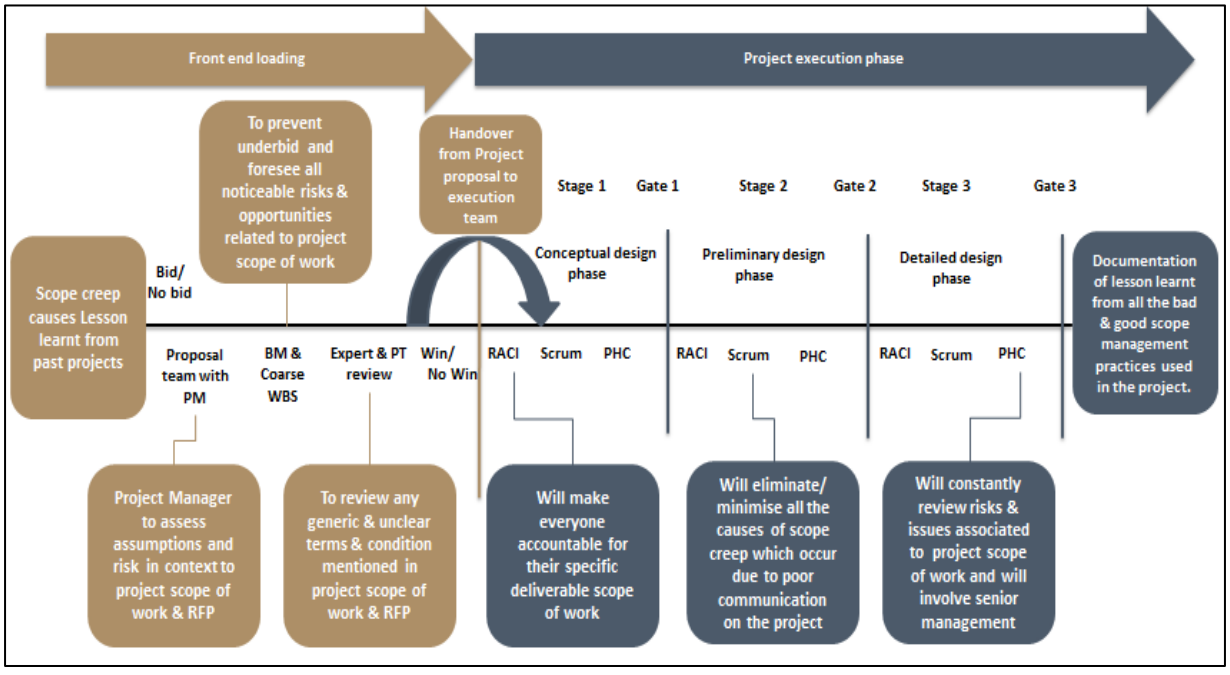
B. The validated causes of scope change and scope creep were ranked based on their frequency of occurrence and correlation analysis. The ranked lists can be used as lessons learned checklist while planning and executing any project. The first approach ranks causes on the basis of their frequency of occurrences in a project, while the second approach ranks causes on the basis of potential impact a cause can have on the project success. These lists can be found in chapter 5 (sub-section 5.2.4). While, the top five ranked causes of scope creep on the basis of their frequency of occurrence are mentioned below:

1. Bad management of project changes, and absence of scope management and control systems.
2. Client requirements.
3. The data was not enough when the scope was defined.
4. Ignorance of key stakeholders until the project is underway.
5. Misappraisal of the original scope of work.

Out of the top five ranked causes, four causes occur specifically due to mistakes made by the project team members. While scope creep occurrence due to '*Client requirements*' may occur because of various reasons such as contractual terms and conditions, offering client some extra work to earn his/her confidence, etc.

C. A validated (through review by RHDHV experts) conceptual scope creep management model. The model provides useful tools, techniques and approaches to prevent scope creep during project scope definition (frontend loading phase) and timely detect and manage scope creep (project execution phase) in lump sum price contract engineering projects. The developed model can be seen below

Abbreviations in the conceptual scope creep management model stands for:
(PM) Project Manager
(RFP) Request for proposal
(PT) Project team
(RACI) Matrix Responsibility, Accountability, Consult and Informed
(PHC) Project Health Check tool



Recommendations:

For further research:

Considering the boundary conditions of this research, it is recommended to execute the same research from contractor's and client perspective. As the uncontrolled scope change causes variables for the contractor and the client will be different than that of a consultant. Correspondingly, it is recommended to investigate problem of uncontrolled scope changes in contracts other than lump sum price contracts. In this research relationship between causes and consequences of scope change and scope creep variables was investigated. However, due to large number of variables a qualitative context was not provided to all the obtained relations. It is recommended to establish a qualitative argument on all the relationship that exits between causes and consequences variables together with, finding causation of consequences due to occurrences of a cause. Lastly, it is recommended to tailor the developed model for small infrastructure projects.

For Royal HaskoningDHV:

In order to efficiently manage project scope of work, organizations need to have a structured scope management process. Therefore, it is strongly recommended to RHDHV to establish a structured scope management process which all the project managers are obliged to use. In addition, as the company has a lot of international projects, it is strongly recommended to formalize a structured way of documenting and communicating lessons learned preferably in the three categories suggested in this research. Lastly, the company advised to focus on minimizing causes of scope creep identified in this research, by using the suggested model and scope creep causes checklists.

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CHAPTER ONE

Introduction

1. INTRODUCTION

1.1 INTRODUCTION TO RESEARCH TOPIC

Project scope is the work that must be accomplished to produce a deliverable with specified features and functions. The deliverable can be a product, service or other result (Kerzner & Saladis, 2010). Scope and objectives are the guiding principles that direct the efforts of the project team. They determine project success or failure (Ward, 1995). Without a well-defined scope, the objectives of information system development can be vague and people may start to lose sight of what they are trying to develop (Clarke, 1999).

A good project scope document specifically defines what tasks are to be performed, the specific dates when these tasks are due and the budget allocated for them. Therefore, quality, schedule and cost are three basic dimensions of project scope (Kerzner, 2013). Moreover, WBS (Work breakdown structure) is a tool that facilitates in organizing and defining the total scope of work of the project. Each activity in WBS has its own scope, similar to that of project, which can be split into three key aspects i.e. quality, schedule and cost (Seyedhoseini, Noori, & Hatefi, 2009). A project scope with clearly defined goals and objectives has been verified as a dimension for project success by some researchers.

Collins & Baccarini, (2004) considered a rigorous scope to be a factor which is necessary for meeting the owner's needs and thus achieving project success. Kerzner, (2013) believes criteria for judging project success includes considerations of time, budget, specification, customer satisfaction, and maintaining status quo within the organization. He emphasized that scope changes need to be curtailed, failing that control they have the potential to destroy not only the morale on a project, but the entire project.

If the project cost or schedule exceeds their planned targets then the client satisfaction is compromised. Due to this budget limitation, the project group and designers have to be very stringent in preventing scope creep (Giezen, 2012). Scope creep is the tendency for accumulation of many minor scope changes to increase project cost. While, individual scope changes may only have minimal cost impact, the accumulation of these minor changes which are often not essential to the intended function of the facility can result in a significant cost increase over time. Many of these minor changes are real needs that are recognized as more is known about the project but others are often only non-essential additions.

Project often seem to grow naturally as the project progress from inception through design development to construction (Jennifer S. Shane, 2009). However, scope changes may include modifications in project construction limits, alterations in design and/or dimensions of key project items such as adjustments in type, size, or location of project components, as well as other increase in project elements (Jennifer S. Shane, 2009).

These alterations in scope are being experienced by the Dutch civil design and engineering consultancy firm Royal HaskoningDHV. RHDHV is facing with the problem of poor scope definition and poor scope management (in projects with lump sum price contracts). This problem is recognized as the root cause of poor project performance in terms of loss of money, poor quality, delayed delivery, client and stakeholders dissatisfaction. Moreover, recent research papers on project management also acknowledge poor scope management as leading cause of poor project performance.

In order to mitigate this problem, RHDHV is implementing number of measures such as the Project health check tool to improve project management practices. Project health check tool is implemented

with the aim of using the existing project management practices more rigorously by encouraging dialogue between Line and Project managers. This timely pro-active dialogue takes place on a monthly basis to stimulate continuous improvement and to escalate issues and risks at early stage, so that proper action and mitigation measures can be taken. However, it is unknown whether the Project health check tool is effectively minimizing poor scope definition and scope management problem. Therefore, it is essential to investigate effectiveness of all the relevant tools and techniques that are being used in construction industry to minimize uncontrolled scope changes. In order to analyse the effectiveness of the tools and techniques a root cause analysis of poor scope definition and poor scope management has to be done in this research.

1.1.1 PROBLEM DESCRIPTION

A very common reason for projects failure is the poor scope management and control. Scope creep is one of the leading cause of project failure globally according to the 2010 Global Survey (O.Hussain, 2012). Correspondingly, construction industry is facing with the problem of scope creep, which is resulting in project failure in terms of cost/budget overrun, time/ schedule overrun and inferior quality of deliverables. Alp & Stack, (2012) states that poor scope definition and control efforts unnecessarily increases project cost and duration which negatively impacts profit margin and bottom line project finance.

While, problems related to the elicitation of client requirements are, to a large extent, linked to designer & client communication issues (Haug, 2015). Additionally, communication between project team members play a critical role in the performance of how scope changes are identified, documented, and managed. Three consequences that occur when communication within the project team is not controlled that affect scope management are confusion, reaction, and results (Alp & Stack, 2012).

In addition to, scope definition and communication, change management in construction is an important aspect of project management. As changes constitute a major cause of delay and disruption, and is widely accepted by both owners and constructors that change effects are difficult to quantify and frequently lead to disputes (I. Motawa, C. Anumba, S. Lee, & F. Peña-Mora, 2007).

The problem is that existing tools and techniques, although beneficial, would always be used as part of a project control process and do not constitute a control process on their own. Although a number of studies describes what an ideal project control process should look like diagrammatically, mathematically or with isolation of a project management control success factors. However, there is not much research on how they can be utilized in practice (Olawale & Sun, 2012).Based on the abovementioned problem summary a problem statement is formulated.

"O*bservations shows that projects in construction industry are facing with a lot of uncontrolled scope changes"*

1.1.2 RESEARCH OBJECTIVE

The objective of this research project is to make recommendations to design and engineering firms i.e. RHDHV on how to improve scope definition and scope management with regard to lump sum price contract in large infrastructure projects in construction industry by making an analysis on the factors that are leading to poor scope definition and poor scope management.

1.2 RESEARCH DESIGN

1.2.1 RESEARCH QUESTION

Introduction

In the previous section the research problem statement has been defined, based on that a research objective has been formulated. In order to realize the research objective, a research main question has been developed together with seven research sub-questions to answer the research main question. The research main question and the research sub-questions are mentioned below.

The Research Main Question is

How to manage scope of large infrastructure projects for lump sum price contracts in construction industry in order to reduce uncontrolled scope changes?

Consequently the Research Sub-Question are

1. How is scope change and scope creep defined in literature?
2. What are the causes of scope change and scope creep for projects executed on lump sum price contracts? (Mentioned in literature and found in practice)
3. How is scope management practised, in design and engineering consultancy firm?
4. Which tool and techniques have been chosen to be used in conceptual uncontrolled scope change management model?
5. What is the relationship between cause and consequence of scope changes and scope creep?
6. What are the rankings of scope change and scope creep causes?
7. What is the relevant framework that should be used to fulfil a conceptual uncontrolled scope change management model?

1.2.2 RESEARCH METHODOLOGY

The research methodology on the basis of which this research will be executed is elaborated in detail, to pinpoint specific reasons behind choosing such a methodology. To begin with, a mixed methodology approach will be used to execute this research which will help in satisfying the research objective holistically. The research will be conducted in 5 phases which can be seen in figure 1**.**

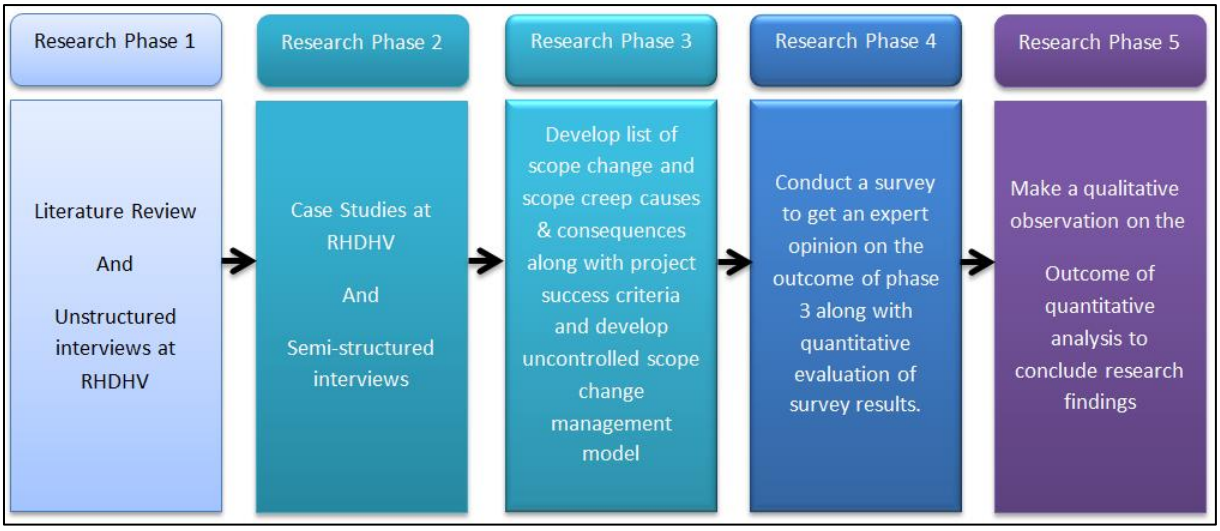


Figure 1 Research Methodology flow chart

Tashakkori & Teddlie, (1998) states that mixed methods typically refers to both data collection techniques and analysis given that the type of data collected is intertwined with the type of analysis that is used. Mixed methodology research uses both qualitative and quantitative approach to satisfy the research objective.

The reason behind using a mixed methodology holistically is to first satisfy the requirements of the research main question which focus on "How" question. Thereafter, satisfying the requirements of research sub-question which focus on "What" question.

According to Yin, (2013) "How" questions are more explanatory and likely to lead to the use of case studies. This is because such questions deal with operational links which are needed to be traced over time. In addition to operational link, the investigator has little control over events and the focus is on a contemporary phenomenon within a real-life context. In this research the use of case study method is preferred as it facilitates in satisfying research objective from research main question context.

Similarly, Yin, (2013) also states that "What" questions are likely to favour survey methods. As this method is advantageous when the research goal is to describe the incidence or prevalence of a phenomenon or when it is to be predictive about certain outcomes. It is important to note, that the research sub-questions which focuses on "What" question can be satisfied using a survey research method and not by case study as can be seen in figure 2.

Method	(1) Form of Research Question	(2) Requires Control of Behavioural Events?	(2) Focuses on Contemporary Events?
Experiment	How, why?	Yes	Yes
Survey	Who, what, where, how many, how much?	No	Yes
Archival Analysis	Who, what, where, how many, how much?	No	Yes/No
History	How, why?	No	No
Case Study	How, why?	No	yes

Figure 2 Relevant situations for different research methods (Yin, 2013)

1.2.3 RESEARCH FRAMEWORK

Figure 3 portrays research approach on the basis of which this research will be executed. Furthermore, each step of this framework will be briefly explained in this section in order to represent author line of reasoning for choosing such a framework.

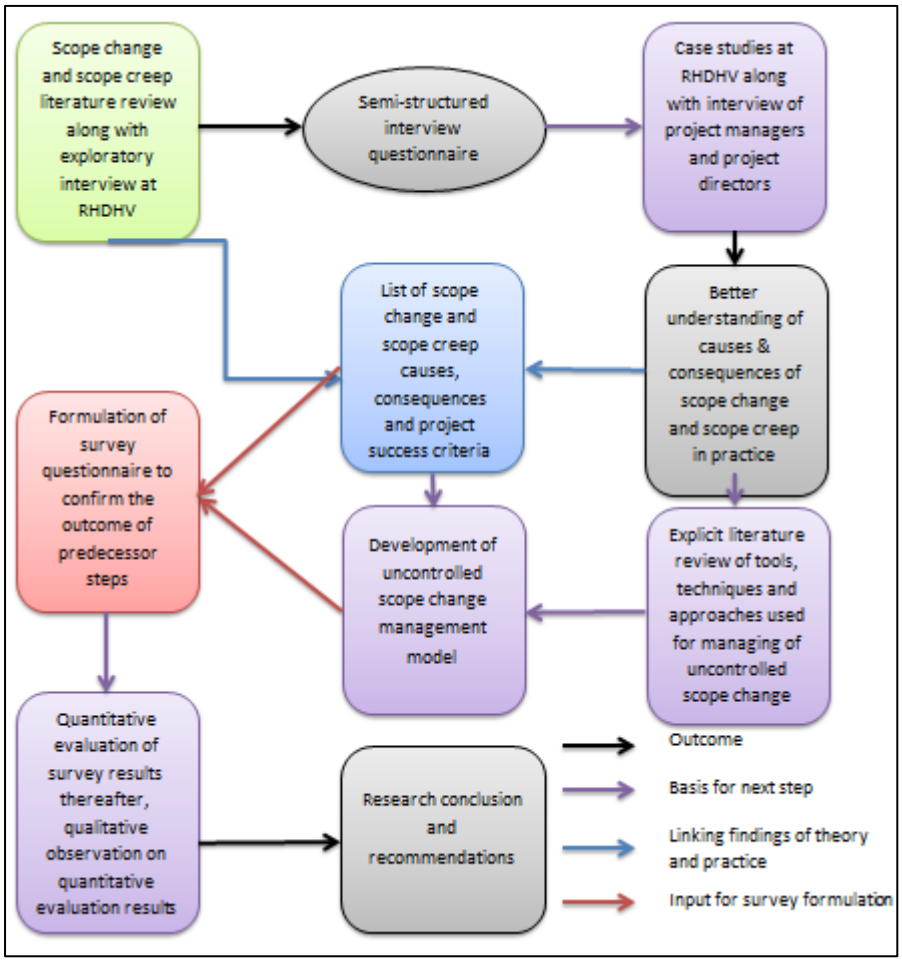


Figure 3 Research framework flow chart

Ten steps that are being followed in this research framework will be described in a sequential order which will be in line with the chosen dominant-less dominant sequential mixed research methodology. The chosen dominant-less dominant sequential mixed research methodology will be explicitly explained in chapter 4.

1. **Literature review on scope change and scope creep problem faced by construction industry along with exploratory interviews at design and engineering consultancy firm RHDHV**

   In the initiation phase of this research the focus will be on developing a better understanding of the research topic. In order to achieve this goal an explicit literature review will be carried out on causes, consequences of scope change and scope creep. Likewise, scope management approaches suggested by various project management standards (such as PMBOK, PRINCE2, ISO21500 and APM body of knowledge) will be studied in order to understand how scope is to be managed. In addition, along with literature review exploratory interviews will be conducted at Royal HaskoningDHV to get practitioners perspective over the preliminary findings, which will facilitate in developing a concrete semi-structured interview questionnaire.

2. **Developing semi-structured interview questionnaire**

   A semi-structured interview questionnaire will be developed based upon the findings of literature review and exploratory interviews. This questionnaire will address all the aspects of scope change and scope creep which are associated to design and engineering consultancy projects executed on lump sum price contracts.

3. **Case studies and interviews at Royal HaskoningDHV**

   It is imperative for this research to understand the nature of scope change and scope creep occurring in the industry, to confirm the findings of literature study. In order to satisfy this requirement it has been decided to study four large infrastructure projects which are executed on lump sum price contracts and are facing scope changes and scope creep. In addition to case studies it has been decided to conduct at least two interviews from each project with an aim of confirming the finding of project document review and to understand scope management approach being followed. The reason behind conducting two interviews from each project is to comprehend the difference in scope management approach suggested by the project manager and by any other empowered employee working on the project such as (project director, assistant project manager, project leader or the project controller).

4. **Better understanding of scope change and scope creep**

   An enhanced perception about the problem of scope change and scope creep will flourish post evaluation of case studies and interviews in this step of the research. Furthermore, the outcome of this step will be a list of causes and consequences of scope change and scope creep found in practice along with scope management approach being practiced in the industry.

5. **Develop list of causes and consequence of scope change and scope creep along with project success criteria**

   In this step a link will be drawn between the findings of literature study and the findings of case studies. On the basis of this observation the author will come up with a list of causes and consequences of scope change and scope creep. In addition to this, a list of project success criteria will be developed from the design and engineering consultancy firm perspective.

6. **Literature review on tools, techniques and approaches that can be used to minimize uncontrolled scope changes**

   An extensive literature review will be carried out on the available tools, techniques and approaches that can be used to control uncontrolled scope changes in a project. It is important to point out why it has been decided to do an explicit literature review, so late in the research. The reason behind taking such an approach is to first understand in which project phase are these uncontrolled scope changes occurring and the reason behind their occurrence. Thereafter, in the hind side it always becomes easier to find a possible solution to problem acknowledging all their respective characteristics.

7. **Develop uncontrolled scope change management model**

   An uncontrolled scope change (i.e. scope creep) management model will be developed after an explicit literature review on tools, techniques and scope management approaches. The uncontrolled scope change management model will be developed by acknowledging the findings of step 5 and 6 respectively. These two steps will prepare the foundation, over which this model will be developed. Furthermore, the basic idea behind developing a model is to link the causes of uncontrolled scope changes phase wise with the suitable tool, technique or scope management approach that can reduce or completely mitigate it.

8. **Formulation of a survey research questionnaire**

   A survey research questionnaire will be developed with an aim of validating findings of step 5 and step 7 respectively. This developed questionnaire will comprise lists of cause and consequences of scope change and scope creep along with their respective definitions. The objective behind conducting a survey is to get expert opinion on causes and consequence of scope change and scope creep, so that the data gathered using survey can be later used for ranking, clustering and for finding relationship between variables under investigation. Thereafter, the developed uncontrolled scope change management model will be validated using a focus group of expert at RHDHV.

9. **Evaluation of the survey research results**

   A quantitative analysis will be made on the data collected using survey, on the basis of which correlation between above mentioned variable will be found. Thereafter, the results of quantitative analysis will be subjected to a qualitative observation to deduce meaning out of correlation analysis.

10. **Research conclusion and recommendations to Royal HaskoningDHV**

    On the basis of step 9 findings and limitations of the research, this research will be concluded by answering the research main question and by providing recommendations to RHDHV.

1.2.4 SCOPE OF RESEARCH TOPIC

This section will elaborate on scope of research, within which this research will be executed. Oxford dictionary defines "scope" as "the extent of the area or subject matter that something deals with or to which it is relevant". Acknowledging the definition of scope this section will specify area under which this research will be executed. The scope of this research has three boundary conditions which have to be satisfied in order to conclude this research. These boundary conditions are portrayed in figure 4 and are elaborated in the following sub-sections.

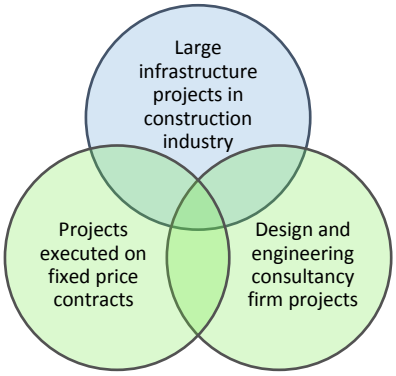


Figure 4 Scope of research

Large Infrastructure Projects in the Construction Industry

This research will focus on large infrastructure projects in construction industry. The choice of focusing on large infrastructure projects was made due to personal interest and because of the interest of RHDHV for whom this research is being conducted. PMBOK (Guide, 2001) defines project as "a temporary endeavour undertaken to create a unique product, service, or result ". The temporary nature of projects indicates a definite beginning and end. Although repetitive elements may be present in some project deliverables, this repetition does not change the fundamental uniqueness of the project scope of work. Furthermore, (PRINCE2, 2009) defines project as a "temporary organization that is created for the purpose of delivering one or more business products according to an agreed business case". Acknowledging both the definition mentioned above from leading project management guide, a project can be characterised as a:

1. Unique endeavour with a specified start and end date
2. Unique endeavour is realised by a temporary organization

The two project characteristics mentioned above have also been acknowledged by (Vrijhoef & Koskela, 2005), but exclusively in context to projects in construction industry. Vrijhoef & Koskela, (2005) states that there are three major peculiarities of production in construction which are site production, one-of a kind product and has a temporary production organization. The only difference between what has been

said by the project management guide and what have been proposed by (Vrijhoef & Koskela, 2005), is pointing out the fact that construction projects are realised on site. Since, large infrastructure projects possess all the characteristics of projects in construction industry as described above. This research will only focus on projects which satisfies all the three peculiarities of a construction project.

Projects Executed on Fixed Price (i.e. Lump Sum Price) Contracts

As large infrastructure projects in construction industry can be realised under different type of contracts, which have their own implication in managing project scope of work. However, it was decide to exclusively focus on scope management problems associated to projects executed on fixed price contracts. This decision was taken as the company for whom this research been conducted is facing scope management problems in fixed price projects. In addition to company's interest, it is widely known that fixed price contracts are not suitable for projects which are not standardized. According to Bajari & Tadelis, (2001) in fixed price contracts, the buyer (i.e. client) offers the seller (i.e. contractor) a pre-specified price for completing the project. Eccles, (1981) states that for fixed price contracts contractors are usually selected by competitive bidding among group of firms who have been qualified to bid for the project. In addition to selection, Bajari & Tadelis, (2001) states that both the client and the contractor share uncertainties about many important design changes that occur after the contract is signed and production begins.

The last point mentioned above about sharing the uncertainties on important design changes makes management and awareness of scope changes very important. According to Akinci & Fischer, (1998) in fixed-price contracts, risk is allocated primarily toward the contractor. Here, risk is defined as the possibility of a financial loss which may occur during the course of a project. In fixed-price contracts, contractors bear all the financial burdens of cost overruns if scope or site conditions do not change. The reason for contractor sharing large part of risks is the fact that the terms and condition in the contract are imposed on him/her by the client. Considering the point made above, it can be said that managing projects uncertainties is very crucial for the contractors, especially for projects executed on fixed price contracts, as they have a higher stake. This research will only focus on uncertainties possessed by fixed price contracts on project scope management.

Design and Engineering consultancy firm projects

As explicitly mentioned in the introduction section, that this research is being conducted for a design and engineering consultancy firm Royal HaskoningDHV. Hence, it becomes obligatory to focus on management of scope changes in projects executed by design and engineering consultancy firms. Furthermore, there was a personal interest as well in conducting a scope management research from design and engineering consultancy firm perspective, as there are very few research conducted from this point of view.

Royal HaskoningDHV is an international engineering and consultancy firm, with headquarter located in Amersfoort, the Netherlands. The company actively works in several fields such as planning, transport, infrastructure, water, maritime, aviation, industry, energy, mining and buildings. Royal HaskoningDHV consists of 100 offices in 35 countries, employing more than 7000 professionals worldwide. It is one of Europe's leading project management, engineering and consultancy service provider, ranking globally in the top 10 of independently owned, non-listed companies and top 40 overall.

1.3 DOCUMENT OUTLINE

Regarding the problem statement, a solution will be put forward and there will be investigated whether this solution will be able to manage project scope of work efficiently by minimizing occurrence of uncontrolled scope changes in projects. In order to come to a substantive advice regarding the solution proposed, the research outline as shown in figure 6 will be followed. As can be seen, this research is divided into six parts. The first two sections are part of chapter one, the introduction. In part two a theoretical framework will be provided. In section one of chapter two a distinction is made between scope change and scope creep using literature study, section two uses literature study to describe scope management process suggested by project management manual and on problems faced in managing project scope. While, section three describes tools and techniques which will be used in developing conceptual uncontrolled scope change management model using literature study. Chapter three, section one describes scope change and scope creep problems encountered in document review of four projects, while section two describes interviews of senior manager from the studied projects. Chapter four focuses on validation strategy chosen by the author in two different sections. Section one explains survey validation approach and sections two explains scope creep management model validation strategy. Chapter five analyses data gathered from the survey research and scope creep management model validation under two sections. Thereafter, the results are also explained under these two sections in chapter five. In the end, chapter six will highlight research limitations and will conclude each research findings to eventually answers research main question and provide recommendations.

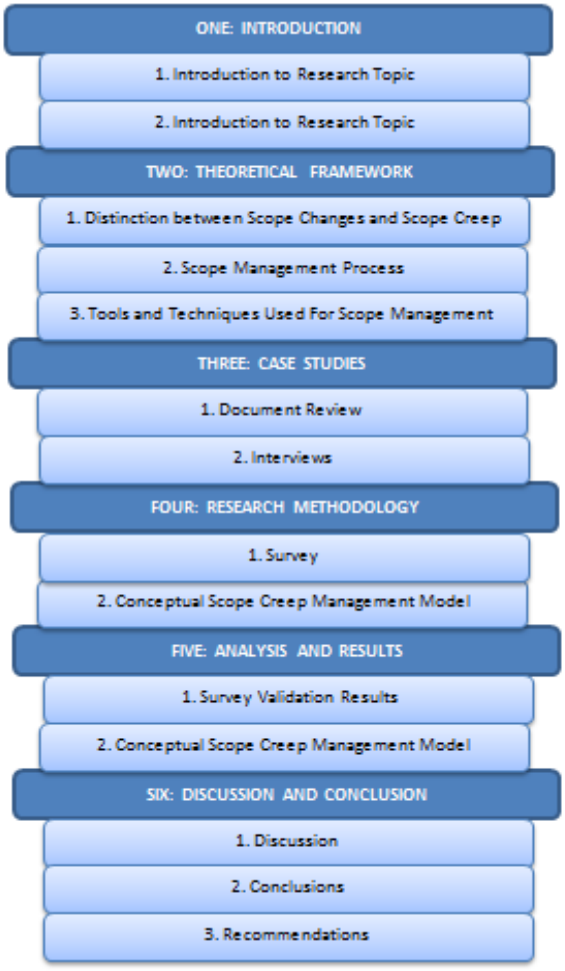


Figure 5 Research Outline

CHAPTER TWO

Theoretical Framework

2. THEORETICAL FRAMEWORK

Introduction

In this chapter an extensive literature review will be conducted under three sections. Section one will focus on making a distinction between scope change and scope creep using their respective definitions, causes and consequences. Section two will focus on scope management process suggested by leading project management manuals and on problems faced in managing project scope. While, section three will focus on describing tools and techniques which will be used in developing conceptual uncontrolled scope change management model.

2.1 DISTINCTION BETWEEN SCOPE CHANGE AND SCOPE CREEP

It is important to make a clear distinction between the problem of scope change and scope creep occurring in construction project. As Hussain, (2012) states that it is not unusual for construction projects to witness major scope changes however, scope change and scope creep are completely different. This aspect makes distinction vital for having a better understanding of the two different problems faced by the projects. A good understanding of a problem can only guide the industry to a fruitful solution. Until now most of the research focuses on the problem of scope changes and scope creeps together or only few research describes one of these problem exclusively. In this part of the literature study, an analysis will be done on the definitions, causes and consequence of the two problems exclusively. As already mentioned there are very few researches that focus exclusively on these two problems. Acknowledging this limitation, research papers focusing on causes of delays, cost overruns and changes in construction industry will also be used.

2.1.1 SCOPE CHANGE DEFINITION

There are only two definitions of scope changes found while going through various project management literatures. On the basis of these two definitions an argument is made on the problem of scope changes in construction industry. Correspondingly, a new definition is developed covering all the aspect of scope changes which are missing in either of these two definitions which are as following.

“Scope Change is an official decision made by the project manager and the client to change a feature X to expand or reduce its functionality. Generally, scope change involves making adjustments to the cost, budget, other features, or the timeline. ” (O. Hussain, 2012)

“Scope Change is defined as any change to the project scope. A scope change almost always requires an adjustment to the project cost or schedule. ” (PMBOK 4th edition)

The two definitions described above are correct but incomplete in essence of covering all the aspects of scope changes. The first definition by Hussain, (2012) talks about expanding or reducing functionality but the function of the utility can remain the same and the specification can be changed. Furthermore, it only talks about making adjustments in cost, budget, timeline or the other features which are not clear enough which also implies to the second definition by PMBOK. In order to have a scope change definition with a holistic view of this phenomenon, a new definition is derived by studying the process of scope change. This new definition which is described below will be validated in the design and engineering consultancy firm.

"Scope change is an official decision taken by the project manager and the client to change, expand or reduce originally defined scope of work. A scope change always results in making adjustment to all the activities, resources and contractual agreement affected by the change."

After analysing the scope change definition the phenomenon of its occurrence is clear. However, it is also important to note the reasons that lead to the occurrence of scope change in design and engineering construction projects along with its consequences. In order to list all the possible reasons that lead to official changes in predefined scope of work, research papers focusing on causes of delays, cost overruns and project changes were studied. All the reasons which are in line with the scope changes definition mentioned above are short listed below.

Causes of scope change

The main reasons that lead to scope changes in a project are listed in table 1. These changes are compensable as they are usually initiated by the client or approved by the client. In addition this complete list of scope change causes, individual author wise can be seen in appendix A.1.

S.NO	Causes of Scope Change	(Bröchner & Badenfelt, 2011)	(Alnuaimi et al., 2009)	(Sun & Meng, 2009)	(Le-Hoai et al., 2008)	(Hanna & Swanson, 2007)	(Hsieh et al., 2004)	(Chang, 2002)	(Chan & Kumaraswamy, 1997)
1.	The original contract documentation from the owner may contain errors, omissions and contradictions in specifications.	✓			✓			✓	✓
2.	Change in client business case.	✓							
3.	Owners instruction to execute additional work		✓	✓	✓	✓	✓	✓	✓
4.	Owners instruction to modify design specifications		✓	✓	✓	✓	✓	✓	✓
5.	Shortage of funding			✓					
6.	Inexperienced clients are particular prone to causing late changes due to delays in review and approvals; as well as inappropriate interference in design and project execution.			✓					
7.	Abnormal site & ground conditions discovered during site investigation.			✓					

8.	Owner failure to provide complete project information							✓	
9.	Incomplete or Incorrect project information provided by the owner							✓	
10.	Consultants for other related projects fail to provide necessary information on time.							✓	
11.	Change initiated by Stakeholders.							✓	
12.	Changes in Law & Standards.							✓	
13.	Slow decision making			✓					

Table 1 List of causes of scope changes

Consequences of scope change

The phenomenon of scope change and its causes as described in the previous sub-section of this chapter, which helps in understanding the basic principle behind this type of change. Project scope change is an official decision to change originally defined project scope which makes adjustment to all the project variables affected by it. Therefore, it can be said that the consequences of scope change are not significant for the design and engineering firm. However, it is not the same for the client as scope change can significantly increase the time of completion and budget that is required to conclude the project.

Most of the time scope changes are required to be initiated for successful completion of the project which satisfies the stakeholders and the client expectations. Changes are initiated in a project scope of work to compensate for requirements which were not fully anticipated in the initiation phase of the project by the client or all the stakeholders were not taken on board while planning for the project. Acknowledging this aspect of scope change, it can be said that scope change usually add value to the project. But the level of value added differs depending upon the project phase in which change is initiated and executed. That is why, it was important to note all the relevant consequences of scope changes which are listed in table 2. Furthermore, scope changes consequences from the client perspective will not be confirmed in this research, which is one of the research limitations.

S.NO	Consequences of scope change	(Arun, 2007)	(Assaf & Al-Hejji, 2006)	(Peter Love, Irani, & Edwards, 2003)	(Olsson, 2006)	(Dvir & Lechler, 2004)	(Wu, Hsieh, & Cheng, 2005)	(Sun & Meng, 2009)	(Chang, 2002)	(Alnuaimi et al., 2009)	(Acharya, Dai Lee, & Man Im, 2006)	(Taylor, Uddin, Goodrum, McCoy, & Shan, 2012)	(William Ibbs, 2007)
1.	Increase in cost	✓		✓	✓		✓	✓	✓	✓		✓	✓
2.	Increase in schedule	✓	✓	✓			✓	✓	✓	✓		✓	✓
3.	Quality						✓	✓					✓
4.	Customer dissatisfaction			✓		✓		✓				✓	
5.	Low morale of project team						✓	✓				✓	
6.	Legal dispute						✓	✓		✓	✓		
7.	Damage to reputation							✓					
8.	Rework							✓	✓			✓	

Table 2 List of scope changes consequence

2.1.2 SCOPE CREEP DEFINITION

There are various definitions of scope creep which were found while going through project management literature in construction industry. An argument is made on this problem by acknowledging the definitions and the process of scope creep. Firstly, all the scope creep definitions will be listed followed by a concluding paragraph describing the flaws in these definitions. Finally, a new definition is developed as done for scope change to give a holistic view of the problem.

“Scope Creep is generally referred to as the phenomenon where the original project scope to build a product with feature X, Y, and Z slowly grows outside of the scope originally defined in the statement of work. ” (O. Hussain, 2012)

“Scope creep refers to scope change which happens slowly and unofficially, without changing due dates or otherwise making adjustments to the budget.” (O. Hussain, 2012)

“Scope creep is the “the tendency for a project to extend beyond its initial boundaries.” (O. Hussain, 2012)

“Scope Creep occurs by adding features and functionality (project scope) without addressing the effects on time, costs, and resources, or without customer approval.” (PMBOK 4th edition)

“Uncontrolled changes are often referred to as project scope creep.” (ISO 4th edition, Prince2 5th edition)

“The accumulation of changes to the scope is called scope creep.” (Shane et al., 2009)

“Scope creep is a term used to describe unauthorized scope changes.” (Asadullah Khan, 2006)

All the scope creep definitions mentioned above in totality agree with the phenomenon of unofficial increase in officially defined scope of work. However, none of the definition completely describes all the aspects of scope creep problem i.e. the process along with its impact. The definitions only narrows down the effect of scope creep to time, cost, resources, budget and customer approval. But none of the definitions talks about scope creep effect on the activities. In order to have a holistic clear view of the scope creep problem a new definition is developed which will be validated in a design and engineering firm.

“Scope creep is an uncontrolled scope change which occurs slowly/gradually and unofficially without addressing its impact on project activities and resources. These are the changes which occur without an official agreement between the client and the project manager.”

Post having a clear understanding of the scope creep problem after going through various definitions developed by different authors and project management manuals. It is important to acknowledge all the reasons that lead to the occurrence of scope creep in the construction design projects. The list of reasons that facilitate scope creep will help in developing a better understanding of the problem. This better understanding will pave way to develop a coherent solution. In order to list all the possible reasons that lead to unofficial changes in predefined scope of work, research papers focusing on causes of delays, cost overruns, project changes and scope creeps were studied. All the reasons which are in line with the scope creep definition mentioned above are short listed in table 3.

Causes of scope creep

The main reasons that lead to scope creep in construction projects are illustrated in table 3. In addition this complete list of scope creep causes, individual author wise can be seen in appendix A.2.

S.NO	Causes of Scope Creep	(Alp & Stack, 2012)	(O. A. Hussain, 2012)	(Sun & Meng, 2009)	(Le-Hoai et al., 2008)	(Assaf & Al-Hejji, 2006)	(Hsieh et al., 2004)	(Wu et al., 2005)	(Chang, 2002)	(Chan & Kumaraswamy, 1997)
1.	Misappraisal of the original scope of work	✓	✓	✓		✓	✓		✓	
2.	Unforeseen conditions	✓								
3.	Client requirements	✓								
4.	Ignorance of key stakeholders until the project is underway.		✓							
5.	The project is executed after years of completion of study and scope definition.		✓							
6.	Scope definition is done by the wrong people.		✓							
7.	Government officials are always "ambitious" and unrealistic regarding the outcome of projects.		✓							
8.	Intervention by politicians and senior government officials.		✓							

9.	The data was not enough when the scope was defined.		✓			✓		✓	✓	✓
10.	Bad management of project changes, and absence of scope management and control systems.		✓							
11.	Most managers focus on major scope changes and ignore small changes that could lead to bigger scope creep problems.		✓							
12.	Conflict in different government agencies interests		✓							
13.	Design change due to poor design brief, errors and omissions			✓				✓		✓
14.	Poor communication between the key partners is a main cause for design changes and rework.			✓						
15.	Design errors and omissions			✓	✓		✓	✓	✓	✓
16.	Inconsistency between drawing and site conditions			✓			✓	✓		
17.	Poor interdisciplinary communication			✓		✓				
18.	Team instability i.e. disputes, bankruptcy etc.			✓						
19.	Inappropriate project organizational structure			✓						
20.	Delays in producing design documents					✓				

21.	Insufficient data collection and survey before design		✓	✓		✓	✓	✓		
22.	Inadequate design team experience					✓				✓
23.	Errors and omissions in quantity estimation						✓			
24.	Inadequate arrangement of contract interface						✓			
25.	In government projects, it is not easy to differentiate between what is included in the project and what is not included.		✓							
26.	Citations of inadequate specification						✓			
27.	Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework						✓			
28.	Necessary variation of work									✓
29.	Delay in design information									✓
30.	Long waiting time for approval of drawing									✓

Table 3 List of causes of scope creep

Consequences of scope creep

The phenomenon of occurrence of scope creeps and their respective causes as described in the previous sub-section of this chapter helps in developing better understanding of this particular problem. As the definition of scope creep states that it is a change which is initiated without an official decision between the project manager and the client. This aspect implies that the client is not liable for any consequence that evolves out of such a change. Leaving design and engineering consultancy firm vulnerable to bear the impact of scope creeps, as they have to accommodate these changes in the available resources. However, it would be wrong to state that the client is not impacted by scope creeps at all. Scope creeps add on additional work or specification in the project, which means it, will also increase construction cost which has to be fully payed by the client. Furthermore, all the relevant consequences of scope creep are listed in table 4 on the basis of which an observation can be made between the scope creep impacts noted in practice and in theory. These consequences of scope creep will be further validated in design and engineering consultancy firm, with the limitation of its validation from the client perspective.

S.NO	Consequences of scope creep	(Alp & Stack, 2012)	(Firesmith, 2007)	(O. A. Hussain, 2012)	(Wiegers, 2000)	(Arun, 2007)	(Dvir & Lechler, 2004	(Wu et al., 2005)	(Sun & Meng, 2009)	Alnuaimi et al., 2009)	(Acharya et al., 2006)	(William Ibbs, 2007)	(Mirza, Pourzolfaghar, & Shahnazari, 2013)
1.	Increase in cost i.e. decreased profitability	✓	✓	✓		✓		✓	✓	✓		✓	✓
2.	Increase in schedule	✓	✓		✓	✓		✓	✓	✓		✓	
3.	Quality	✓						✓	✓			✓	
4.	Customer dissatisfaction						✓		✓				
5.	Low morale of project team							✓	✓				
6.	Legal dispute							✓	✓	✓	✓		
7.	Damage to reputation								✓				
8.	Rework								✓				

Table 4 Consequences of scope creep

2.1.3 PROJECT SUCCESS CRITERION

Post conducting an analysis on causes and consequences of scope changes and scope creeps on project deliverables and resources. It is also important to acknowledge whether these problems do have any impact on design and engineering consultancy firms project success criteria's. There are many different ways in which several researches in past have listed project success criteria's. However, in this research all the scientific papers regarding project success criteria's with different approaches will not be explicitly investigated. But this research will only use two success criteria scientific papers in which the authors have compared most of the papers published in the past and have come to a conclusion with all the relevant success criteria's for a project.

In order to analyse impacts of scope changes and scope creeps on a project success, a list of project success criteria's is being used from a recent graduation research conducted by Jorge, (2016) at TU Delft. Jorge, (2016) came up with a list of 20 success criteria's based upon the most cited studies in literature which can be seen in figure 6. He further divided these 20 success criteria's into four categories namely project efficiency, stakeholders satisfaction, organizational benefits and future preparation.

The argument made by Jorge, (2016) to make such a distinction is that, first two categories are acknowledged in literature as critical in determining project success, particularly because they contemplate the traditional iron triangle and the satisfaction level of the stakeholders. However, the remaining two criteria's focuses on direct and indirect impacts of a project. Jorge, (2016) quotes Atkinson, (1999) describing the organizational benefits as the criteria to measure the direct contribution of a project to an organization's profit, goal etc. Furthermore, he states that the knowledge and motivation maintained in a project helps in preparing the organization for future projects.

			Atkinson (1999)	Chan et al (2002)	Collins & Baccarini (2004)	Pinto & Slevin (1988c)	Shenhar et al. (2001)	Westerveld (2003)	TOTAL CITATIONS	RELATIVE OCCURRENCE	COEFFICIENT OF IMPORTANCE
SUCCESS CRITERIA		CITATIONS	1358	254	114	700	687	388	3501		
PROJECT EFFICIENCY	C01	Meeting schedule	■	■	■	■	■	■	3501	100%	1,00
	C02	Meeting budget	■	■	■	■	■	■	3501	100%	1,00
	C03	Meeting technical specifications	■	■	■		■		2413	69%	0,69
	C04	Meeting functional performance		■	■	■	■		1755	50%	0,50
	C05	Reliability and safety	■	■	■				1726	49%	0,49
	C06	Project management efficiency			■	■		■	1202	34%	0,34
STAKEHOLDERS SATISFACTION	C07	End-user satisfaction	■	■	■	■	■	■	3501	100%	1,00
	C08	Client satisfaction		■	■	■	■	■	2143	61%	0,61
	C09	Project team satisfaction	■	■	■			■	2114	60%	0,60
	C10	Supplier satisfaction	■					■	1746	50%	0,50
	C11	Investors satisfaction	■					■	1746	50%	0,50
	C12	Personal development	■		■				1472	42%	0,42
ORGANISATION BENEFITS	C13	Profit increase	■	■	■		■		2413	69%	0,69
	C14	Contribution to organisation's goals	■		■	■			2172	62%	0,62
	C15	Waste reduction	■		■				1472	42%	0,42
	C16	Knowledge acquisition	■						1358	39%	0,39
FUTURE PREPARATION	C17	Contribution to organisation's future	■				■		2045	58%	0,58
	C18	Economical and technological impact	■				■		2045	58%	0,58
	C19	Social and environmental impact	■	■					1612	46%	0,46
	C20	Public reputation		■	■		■		1055	30%	0,30

Figure 6 List of project success criteria by (Jorge, 2016)

In addition to Jorge's research an additional research paper is being used to explicitly acknowledge success criteria from a company perspective. Al-Tmeemy, Abdul-Rahman, & Harun, (2011) in their research proposed a framework to categorize project success for building projects in Malaysia from contractor's perspective. They initiated there research by making a list of all the success criteria mentioned in scientific papers published between years 1992 to 2009. Thereafter they validated all the identified success criteria's by conducting a survey with 151 participants and came up with a framework enlisting all the validated success criteria's under three categories that are project management success, product success and market success which can be seen figure 7.

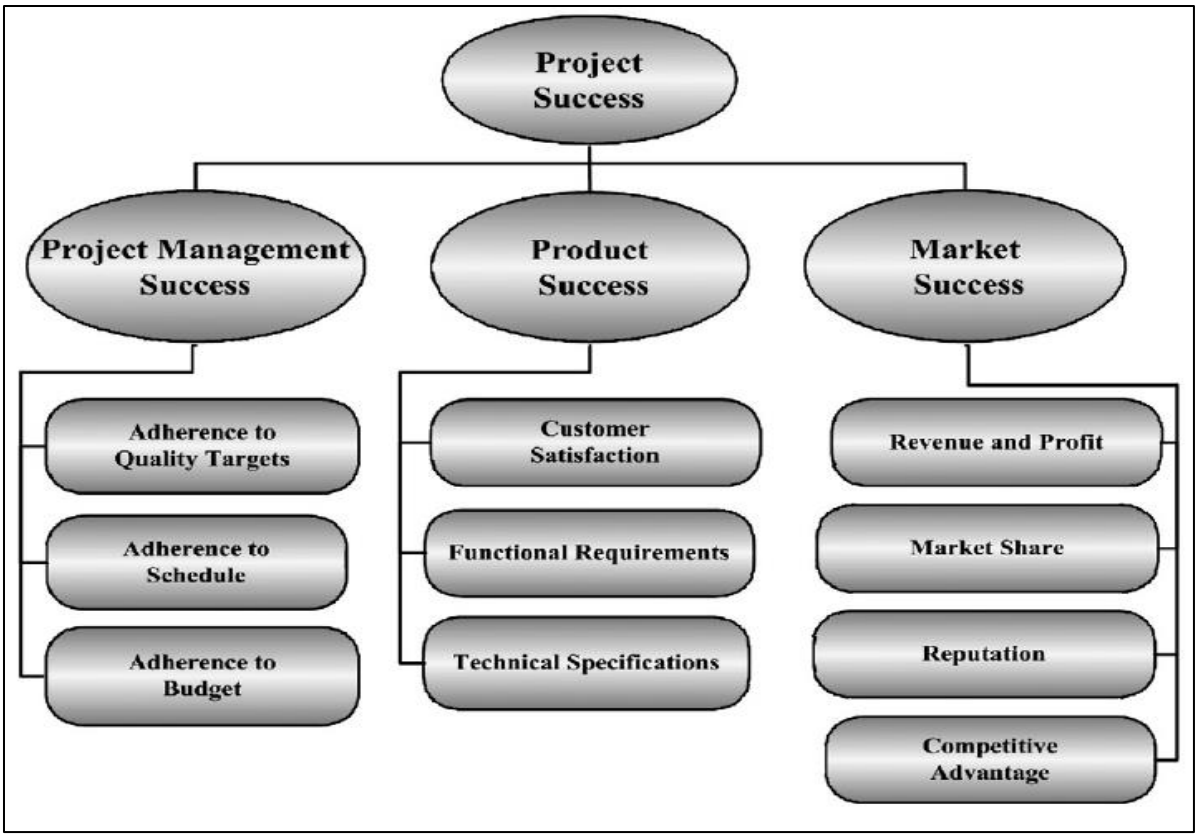


Figure 7 Distinction of project success criteria by (Al-Tmeemy et al., 2011)

The argument made by Al-Tmeemy et al., (2011) for making such a distinction in success criteria is that. Firstly, Project management success concerns with achieving management targets in terms of completing project within the contracted period and allotted budget as well as conformance to the requirements. Secondly, product success relates to the end product's (building's) targets in terms of functionality and fulfilling the technical requirements, as well as customer's satisfaction. Lastly, the market success relates to the project's potential in contributing to company's success in long terms of gaining a competitive advantage, enhancing company's reputation, increasing the market share and reaching specified revenues and profits.

Acknowledging success criteria's mentioned in both the research described above a conclusion can be drawn over success criteria's which are relevant to be considered in this research. All the success criteria that will be considered in this research will be from design and engineering consultancy firm's perspective. This is the reason behind using a scientific paper from contractor's perspective as there was no literature found that exclusively focused on success criteria from design and engineering consultancy firm's perspective. Furthermore, it is also important to note that most of the success criteria for a contractor

and consultant would be similar as both of these parties are working for the client with their own business interest.

Moreover, the line of reasoning used in the research papers used for choosing success criteria's is almost in line with each other for the points which are common is both. This makes it easier to choose success criteria's that will be used in this research to check whether they are affected by scope changes and scope creeps. All the success criteria which are common in both the papers described in this section will be used in this research as a measure of project success criteria for design and engineering consultancy firms. The selected list of success criteria can be seen below.

1. Adherence to project schedule
2. Adherence to project budget
3. Adherence to technical specification
4. Adherence to functional requirements
5. Client and stakeholder satisfaction
6. Project profit
7. Company reputation
8. Market share

In the end, it is vital make a brief observation on the project variables which are negatively affected by scope changes and scope creeps and the success criteria's of a project. The variables which are negatively affected can be seen in table 2 and table 4 under the consequences sub-sections of this chapter. It can be easily realized while comparing the consequences table with the list of success criteria's, that there are quite some commonalities in the two. The project schedule, budget, technical specification, functional requirements, profit and reputation are negatively affected by the changes. This observation leaves some room to further investigate this subjective relation between project success criteria's and scope changes & scope creeps consequences. Based on the findings of the case studies and the literature study a survey questionnaire will be developed.

2.2 SCOPE MANAGEMENT PROCESS

This section initiates by comparing scope management approaches suggested by PMBOK, PRINCE2, ISO 21500 and APM manual. The objective behind making a comparison between these approaches is to acknowledge where these management standard converge or diverge from one another in managing project scope. This comparison will make sure that all the aspects of project scope management are considered with in this research.

In the beginning when one starts to go through the approaches suggested by all these four standards. It is easily realized that, on one hand scope management approach suggested by PMBOK and ISO 21500 have some similarities. This aspect can be easily understood as PMBOK and ISO 21500 explicitly suggests to manage project scope of work under planning and monitoring & controlling process groups as can be seen in figure 8 & 9.

Knowledge Areas	Project Management Process Groups				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring & 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 Execution	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 Collect Requirements 5.2 Define Scope 5.3 Create WBS		5.4 Verify Scope 5.5 Control Scope	

Figure 8 Scope management process retrieved from PMBOK 4th edition

Subject groups	Process groups				
	Initiating	Planning	Implementing	Controlling	Closing
Integration	4.3.2 Develop project charter	4.3.3 Develop project plans	4.3.4 Direct project work	4.3.5 Control project work 4.3.6 Control changes	4.3.7 Close project phase or project 4.3.8 Collect lessons learned
Stakeholder	4.3.9 Identify stakeholders		4.3.10 Manage stakeholders		
Scope		4.3.11 Define scope 4.3.12 Create work breakdown structure 4.3.13 Define activities		4.3.14 Control scope	

Figure 9 Scope management process retrieved from ISO21500 1st Edition 2012

On the other hand, scope management approaches suggested by PRINCE2 and APM manual have some similarities. These two project management manuals, do not suggest to explicitly manage project scope of work under planning and monitoring & controlling process groups. However, PRINCE2 and APM manuals suggest defining and understanding the scope of work while starting a project and later

controlling the project deliverables in delivery stage of the project. Figure 10 & 11 portrays how PRINCE2 and APM manual start a project

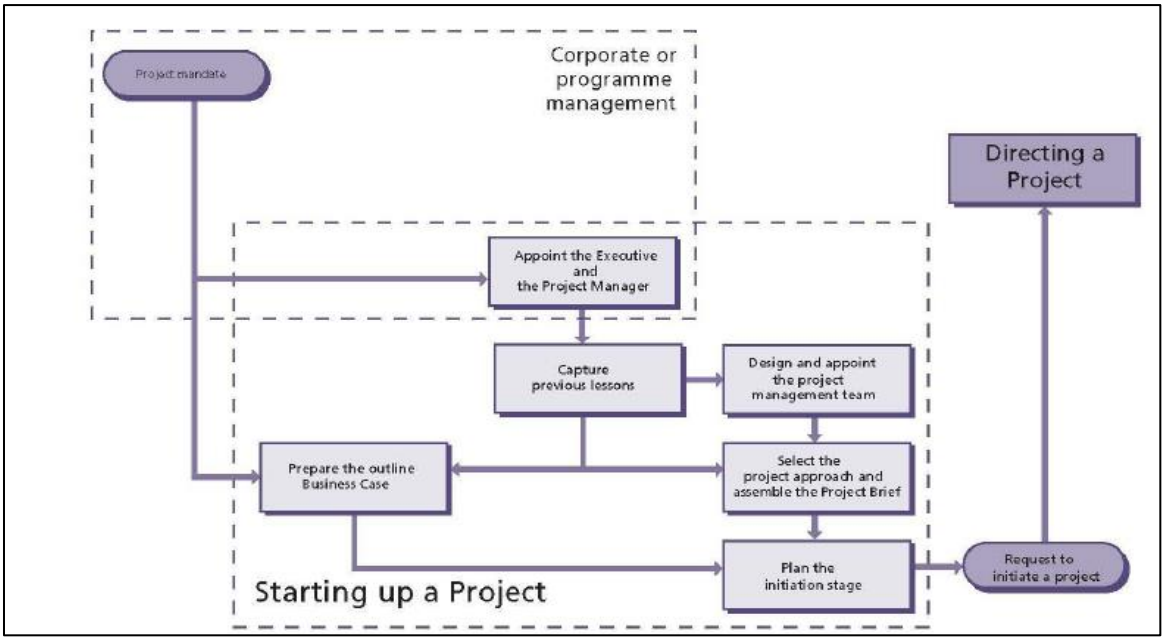


Figure 10 Scope management approach retrieved from PRINCE2 5th edition

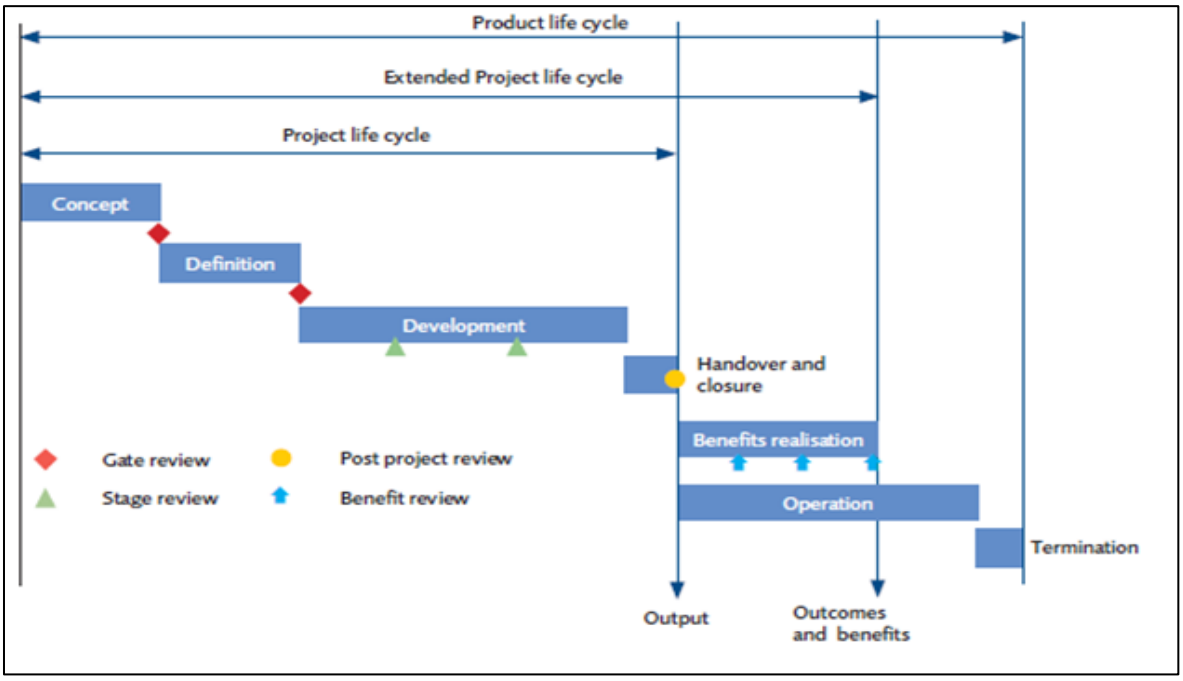


Figure 11 Scope management approach retrieved from (APM, 2006)

Furthermore, this research looks at scope management approaches proposed by these four standards holistically without going into minute details. While making a holistic observation it can be realized that approaches suggested by all these standards are very much alike but expressed in different terms. The

only major difference can be seen in the scope definition approach suggested by these standards. PMBOK along with ISO 21500 only talks about defining scope of work in Work Breakdown Structure (WBS) as can be seen in figure 9 & 10 under planning process group. While, PRINCE2 and APM manual suggests to define project scope of work first using Product Breakdown Structure (PBS) and then using Work Breakdown Structure (WBS). As there were no figures found explaining how scope is to be defined using PRINCE2 and APM manual, it has been decide to quote.

The following quotes are from (PRINCE2 5th edition) and (APM, 2006) project management manuals.

"In well-defined projects the approved breakdown structures are baselined at the end of the definition phase of the project life cycle. The products in the product breakdown structure will become the configuration items for the use in configuration management and any proposed changes of scope will go through a formal change control procedure."

The 'product focus' supports almost every aspect of PRINCE2: planning, responsibilities, status reporting, quality, change control, scope, configuration management, product acceptance and risk management. Without a product focus, projects are exposed to several major risks such as acceptance disputes, rework, uncontrolled change (i.e. scope creep), user dissatisfaction and underestimation of acceptance activities.

"There are several ways to identify activities, including

- *Making a separate list of the activities, while still using the product flow diagram as the source of the information*
- *Taking the products from the product breakdown structure and creating a work breakdown structure to define the activities required (PRINCE2 5th edition).*

Once a solution has been identified which meets the stakeholders requirements, the scope of work can be illustrated using a product breakdown structure (PBS) and a work breakdown structure (WBS)" (PRINCE2 5th edition).

"Identifying both product and the work involved in building them is an iterative activity. Where uncertainty about the end products exists, provisions must be made for revisiting the PBS and WBS during the project life cycle" (APM, 2006).

As can be acknowledged while going through the quotes above, that PRINCE2 and APM manuals talks about defining scope of work first in terms of products in Product Breakdown Structure (PBS). Thereafter, they suggest using Work Breakdown Structure to schedule activities to realize scope of defined products, along with allocation of resources to these activities as quoted above. The argument that is used for using PBS is to have a better configuration management of defined scope of work. Additionally, for more information on the use of PBS, it is suggested to refer PRINCE2 project management manual.

Change control process key words			
PMBOK	ISO 21500	PRINCE2	APM Manual
1. Tracking 2. Reviewing 3. Regulating the process to meet PMP objectives. (PMBOK 4th edition)	1. Record change request 2. Evaluate 3. Assess the impact 4. Approval 5. Implementation (ISO21500 1st Edition 2012)	1. Capture 2. Examine 3. Propose 4. Decide 5. Implement (PRINCE2 5th edition)	1. Request 2. Review 3. Assessment 4. Decision 5. Implementation (APM body of knowledge 6th edition)

Table 5 Change control processes suggested by project management manual

However, all these four standards in totality converge on initiating the project by first understanding the business case and thereafter collecting the stakeholder requirements (i.e. identification of scope of work). After the scope of work has been identified they all suggest defining scope of work along with the activities, but with the difference in approach of scope definition explained in the previous paragraphs. The same applies to the control of changes in predefined scope of work but expressed using different terms having the same meaning. Moreover, these standards don't constrict change control process to changes in project scope of work only, but tends to apply it to all the changes that take place in originally defined project management plan. The very basic change control methodology that is used by all the four starts with the request to change followed by analysing its impact. After assessment of the change request they all suggest to make a decision on the change and thereafter implementation of the decision along with configuration management. The change control process proposed by all these four standards can be seen in table 5. Furthermore, it is important to note that change management approach scheme suggested by PRINCE2 5th edition will be used in developing a scope management model in this research.

In addition to all the points made in this section, a scope management approach will also be selected, which will be followed by this research. The scope management approach that is selected covers all the aspects proposed by all these standards. As explained above the approaches suggested by these standards are very similar to each other and only largely differs in scope definition techniques. Keeping in mind this subtle distinction in scope definition, the scope management approach in this research will use scope definition approach suggested by PRINCE2 and APM manual. This decision has been made as PRINCE2 and APM manual does not reject WBS but adds PBS to have a better configuration management of activities. Similarly, like PMBOK and ISO 21500 this research will make a distinction in scope management process between planning and monitoring & controlling process groups. Making such a distinction helps in developing better understanding about the problems in scope management process. The processes that project teams have to go through while controlling project scope becomes very evident by using this distinction. A flow diagram of scope management process that will be followed in this research can be seen be in figure 12.

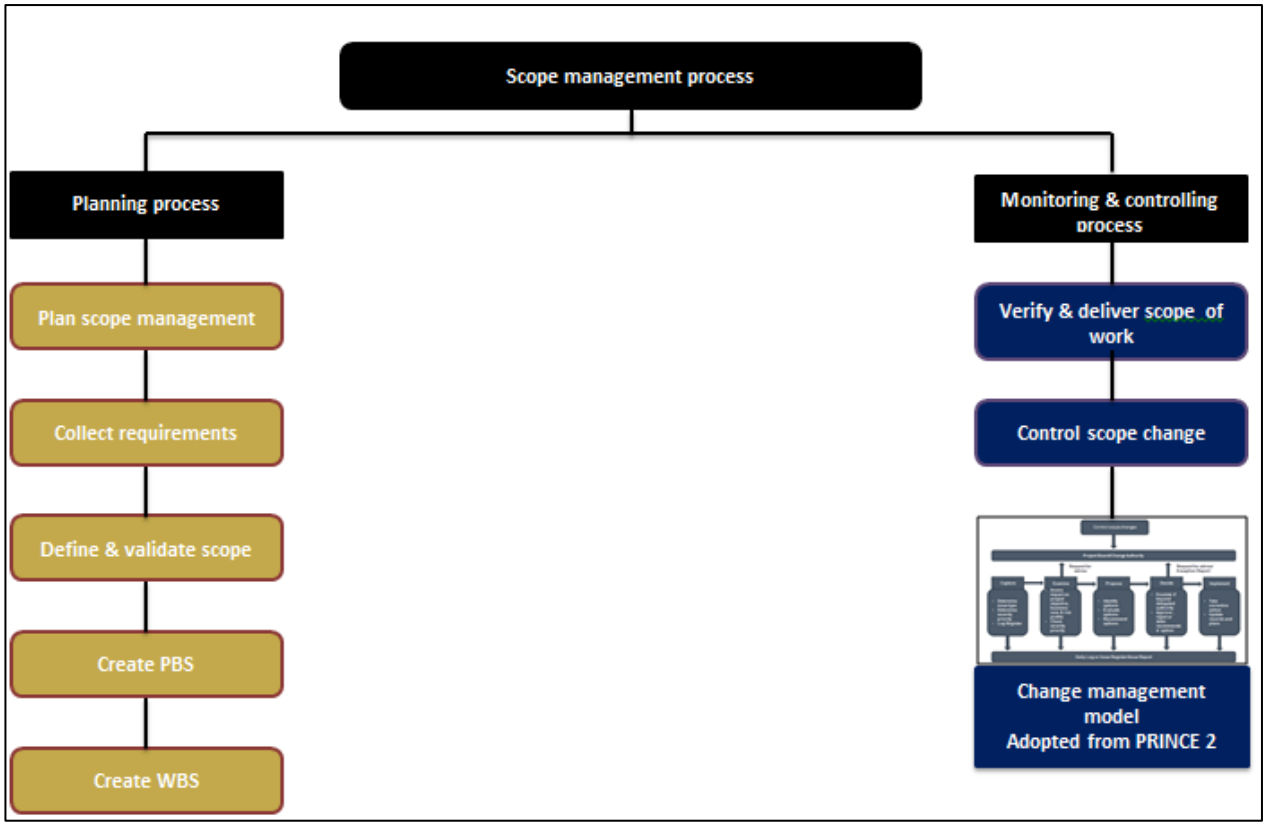


Figure 12 Scope management approach to be followed in this research

Figure 12 portrays scope management process suggested by PMBOK and ISO 21500 with an addition of scope definition approach suggested by PRINCE2 and APM manual. Furthermore, appendix A will elaborate further on the flaws in scope management process illustrated in figure12. Appendix A.3 will focus on all the aspects of planning process group whereas, Appendix A.4 will focus on all the aspects of monitoring and controlling process group.

2.3 TOOLS AND TECHNIQUES USED FOR SCOPE MANAGEMENT

The range of project management tools is growing, while the attention is paid to the tools that help implement the basic project parameters effectively, i.e. the project objective, quality, period and budget, and minimize the related risks (Kostalova & Tetrevova, 2014).During the last few decades, numerous planning and control techniques, such as Gantt bar chart, program evaluation and review technique (PERT), earned value analysis, and critical path method (CPM) have been developed. A variety of software packages are also available to support application of these project control methods; for example, Microsoft Project, Asta Power Project, Primavera, and so on.

The problem is that these techniques, although beneficial, would always be used as part of a project control process and do not constitute a control process on their own. In practice, project control is a complex and iterative process that is usually achieved in three phases: setting performance standards, comparing actual performance with these standards, and then taking necessary corrective actions (Olawale & Sun, 2012). Alshawi & Hassan, (1999) developed the CONPLAN model in the argument that the planning process will not fulfil its potential role as a control and decision making tool without proper integration. The detailed and elaborate model was developed primarily to aid planning rather than overall project control (Olawale & Sun, 2012).

Barraza and Bueno, (2007) noted that standard control methods, such as the earned value method, apply a deterministic approach which may be insufficient, given that they ignore the variable nature of projects. A probabilistic project control model that uses performance control limit curves and stochastic S-curves was developed, but it will be more effective for projects with uncertain performance behaviour (Olawale & Sun, 2012). The process-based control models, such as PDCA and its variations, only describe what, not how.

Although a number of studies describe what an ideal project control process should look like diagrammatically, mathematically or with isolation of a project management control success factor, there is not much research on how they can be utilized in practice (Olawale & Sun, 2012). It is considered the last logical step in management and during the control stage the level of performance is compared with the planned objectives to find any deviation and, consequently, act on it (Pellicer, 2005).

Acknowledging the availability of tools and techniques for efficient project management, and their inability to address the problem of specifically scope management will be addressed in this research. The following tools will be taken into consideration to acknowledge whether they can be used for, efficiently addressing scope management problem. Furthermore, the tools and techniques which are chosen to be studied in this research are either strongly recommended by the literature or have been suggested by interviewed project managers.

1. Documentation and implementation of Lessons learned: Recommended by PRINCE 2
2. Benchmarking techniques: Recommended by interviewed project managers
3. Work breakdown structure: Recommended by interviewed project managers
4. Stage- Gate- Model: Recommended by interviewed project managers
5. Project Health Check Model: Recommended by RH (DHV)
6. Responsibility assignment matrix (RACI): Recommended by PMBOK 4th edition
7. Formalized project communication plan Scrum Model: Recommended by interviewed project managers

This section will elaborate on literature of all the chosen tools and techniques which are capable of facilitating, efficient management of project scope.

2.3.1 LESSONS LEARNED

Lessons –learned (LL) are elements of both organizational learning and knowledge management (Carrillo, 2005). A lessons learned is defined as knowledge gained from experience, success or otherwise, for the purpose of improving future performance (Construction Industry Institute, 2007). Harrison, (2002) defines lessons learned as "a good work practice or innovative approach that is captured and shared to promote repeat application, or an adverse work practice or experience that is captured and shared to avoid recurrence." The European Space Agency 2006 describes it as "A knowledge or understanding gained by experience. The experience may be positive, as in a successful test or mission, or negative, as in a mishap or failure (Caldas, Gibson Jr, Weerasooriya, & Yohe, 2009).

In today's knowledge-based economy, effective Knowledge Management can reduce project time and cost, improve quality, and provide a major source of competitive advantage for the construction organizations (Shelbourn et al., 2006). Knowledge is a critical resource, not only for carrying out projects successfully, but also for choosing the right projects and preparing winning bids (Ferrada, Núñez, Neyem, Serpell, & Sepúlveda, 2016). In fact, as construction is a project-based industry, most of its knowledge is generated in projects (Tan, Carrillo, & Anumba, 2011). Then, capturing, sharing, and utilizing the combined knowledge of the current workforce is essential to avoid losing vital corporate knowledge assets (Caldas et al., 2009). This means construction companies need to capitalize what it is learned in each project to continuously improve organizational performance (Almeida & Soares, 2014). Every construction organization should have a proper lessons learned database, because using it, project team individuals can acquire and assimilate more knowledge through organizations and, further, organizations should also not rely heavily on individuals (Senaratne & Malewana, 2011).

It is commonly accepted that construction companies have been successful at collecting and storing explicit knowledge. However, it has also been recognized that they are poor at knowledge retrieval and sharing (Woo, Clayton, Johnson, Flores, & Ellis, 2004). When considering that much knowledge during the construction phase of projects resides in individual's heads, managing this type of tacit knowledge becomes more crucial for the construction organizations in order to be competitive and sustainable in the long run. However, problems such as insufficient time for knowledge sharing and the difficulty in converting tacit knowledge into explicit knowledge makes it difficult to fully benefit from this valuable asset (Stenmark, 2000; Woo et al., 2004). Tacit knowledge is highly personal and context specific; therefore, it is hard to formalize and communicate. It is stored in humans' minds, and is difficult to see, share, copy, and manage. On the other hand, explicit knowledge can readily be codified in words and numbers, easily shared in manuals, and is easy to distribute (Payne & Sheehan, 2004). It can be stored as written documents or procedures and made available to others. Specifications, textbooks, and design codes are some examples of explicit knowledge (Kivrak, Arslan, Dikmen, & Birgonul, 2008).

Correspondingly, multinational engineering consultants, contractors, and real estate developers work on projects in various countries, encountering many challenges that arise from cross-national differences. These projects frequently bring together diverse participants in an unfamiliar environment. In these situations, firms are exposed to different "institutions" regulations, norms, and cognitive cultural beliefs that can increase misunderstandings, delays, and costs. Knowledge of these institutional elements is critical to create a project that is both locally sustainable and profitable for the firm. International firms continue to globalize to work on projects, encountering unexpected differences that result from working with diverse participants in unfamiliar locations. Virtually most of the research on international firms and

projects has focused on these differences, which add risks and thus costs when doing business abroad (A. Javernick-Will & Levitt, 2009).

In fact, many scholars have indicated that acquiring and maintaining institutional knowledge for each country in which global firms operate is critical Lord & Ranft, (2000), to help firms reduce knowledge gaps Petersen et al., (2008) and decrease their "liability of foreignness" (Zaheer, 1995). Recognizing the importance of this local knowledge on global project outcomes, the issue of how firms mobilize knowledge of a local project area's institutions becomes paramount for working successfully in a foreign environment. (A. Javernick-Will & Levitt, 2009)

Moreover, organizations in the construction industry cannot afford to make repetitive mistakes on major projects. Conversely, there are great benefits to repeating positive experiences from past projects. This need for institutional memory is amplified by the reality that in the course of normal turnover and retirement, people with years of experience leave their organizations. An effective lessons learned program is a critical element in the management of institutional knowledge; it will facilitate the continuous improvement of processes and procedures and provide a direct advantage in an even more competitive industry (Caldas et al., 2009).

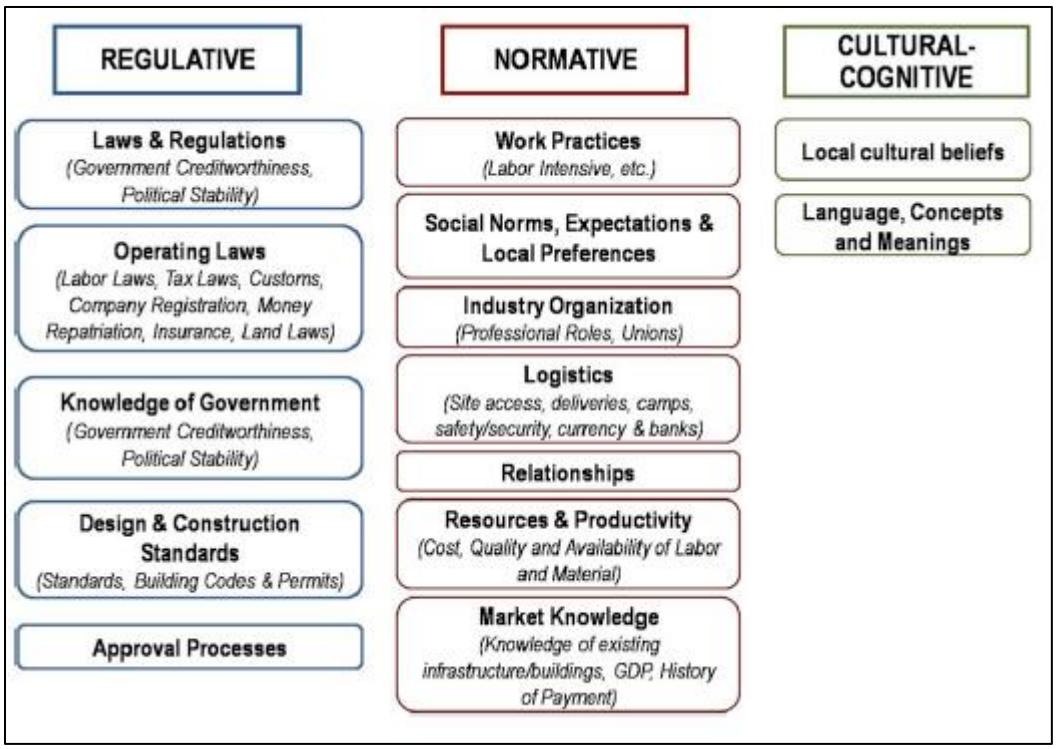


Figure 13 Distinction between types of lessons learned by (A. Javernick-Will & Levitt, 2009)

Besides acknowledging the importance of lessons learned in a construction organization it is also important to note what type of knowledge management is requires for successful execution of a project. A. Javernick-Will & Levitt, (2009) in their research categorized documentations of lessons learned important for firms engaged in International projects into three separate categories which are regulative, normative and cultural cognitive lessons portrayed in figure 13. These three categories helps in making a distinction between lessons learnt by an organization in a structured way aimed at solving project specific problems. A brief introduction to these three categories proposed by A. Javernick-Will & Levitt, (2009)

will be elaborated below, as this research also proposes to document lessons learned is these three categories.

- *Regulative elements*, stressed particularly by economists, include the formal machinery of governance: laws, rules, surveillance machinery, sanctions, and incentives. These tend to be more easily observed and explicit. Important regulative knowledge categories for architecture engineering construction (AEC) firms include laws and regulations, operating laws, knowledge of government, design and construction standards, and approval processes (A. N. Javernick-Will & Scott, 2010).

- *Normative elements*, emphasized particularly by sociologists and historical institutionalists, focus primarily on the prescriptive, evaluative, and obligatory dimensions of social life. This category stresses shared values and norms, interpersonal expectations, and valued identities. On international projects, important normative knowledge includes work practices, social norms, expectations and local preferences, industry organization, logistics, relationships, available resources, productivity norms, and market knowledge (A. N. Javernick-Will & Scott, 2010).

- *Cultural-cognitive elements*, a focus of cultural anthropologists, cross-cultural psychologists, and organization scholars, tap into a deeper layer that includes widely shared beliefs about the nature of the world cultural frames and scripts (Schank & Abelson, 2013) and cause-effect relations (social logics). The beliefs are "cultural" because they are socially constructed symbolic representations; they are "cognitive" because they provide vital templates for framing individual perceptions and decisions. Hofstede, Hofstede, & Minkov, (1991) identified a useful set of dimensions for assessing values, one but only one of the key cognitive-cultural elements of institutions. Important cultural cognitive knowledge includes local cultural beliefs, concepts and meanings, and cross-cultural disputes (A. N. Javernick-Will & Scott, 2010).

In general, the prevailing argument is that the greater the emphasis a firm places on acquiring the knowledge of institutions, the less uncertainty the firm will face regarding problems and opportunities in a foreign market (Johanson & Vahlne, 1977). The reduced uncertainty regarding a foreign market allows an international firm to have a more accurate view of the foreign market, thereby reducing unexpected difficulties and costs.

Furthermore, a theory of knowledge conversion Nonaka, (1994) assumes that an organization creates, converts, and transfers knowledge through a spiral process involving four steps

1. Socialization: the transfer of tacit knowledge through shared experiences such as mentoring and on-the-job training.
2. Combination: the transfer of explicit knowledge through mechanisms such as meetings, information processing, and technology.
3. Externalization: the conversion and transfer of tacit knowledge to explicit knowledge through questioning and reconstruction of perspectives and decisions.
4. Internalization: the conversion and transfer of explicit knowledge to tacit knowledge through learning and the awareness of knowledge (A. Javernick-Will & Levitt, 2009).

In the end it can be concluded that, lessons learned involves two parts one is collection and documentation of lessons and the other is sharing of lessons learned in an organization. Because without implementation, the best information collection system and the best data analysis process will merely result in the best-kept secrets. Therefore, it is equally important to document lessons learned in a way proposed by A. Javernick-Will & Levitt, (2009) and knowledge transferring method proposed by Nonaka, (1994).

Benefits of lessons learned by (A. Javernick-Will & Levitt, 2009)

Formal process

1. Employees focus on realizing, capturing, and writing down their individual and group knowledge to make it available to the entire organization.
2. The externalized and written nature of formal transfer methods also enables companies to better compare data, and in some cases, statistics, across multiple projects and regions.
3. Companies that consciously collect, compare, and analyse this data are likely able to better to learn from their past histories.

Social process

1. This lesson learned transfer method allows all types of knowledge to be shared.
2. In contrast to formal methods, socialization allows employees to contextualize their knowledge to the requestor's specific situation and personal experience, allowing the knowledge to have richer meaning and applicability.
3. Social methods, such as the movement of people, meetings and reviews, also enable employees to gain intimate knowledge of "who knows what" in the organization. E.g. Decathlon at RHDHV
4. Employees are able to meet, interact, and work with peers to gain an understanding of other's past experiences and areas of expertise to later call upon the person when they need knowledge that this person might possess.

Limitations of lessons learned by (A. Javernick-Will & Levitt, 2009)

Formal process

1. If the written material is not updated on a regular basis, the knowledge may become outdated and irrelevant.
2. If employees continue to find outdated information in published knowledge sources, they will be dissuaded from using them. This requires companies to continually monitor and maintain this knowledge to ensure that it is usable and up-to-date.
3. If the knowledge does not contain a personal contact for additional follow up, the knowledge cannot be contextualized to the situation facing the person requesting the knowledge.
4. Lessons learned have a sort of political dimension to them. Not everybody wants to be scrupulously honest about what went wrong.

Social process

1. Reach of knowledge is limited to each individual's knowledge and the known experiences of the peers they have encountered through social interactions in meetings, reviews, etc.
2. Multinational firms tend to have many employees who work across the globe, increasing both the cost of providing social interactions and amplifying the complexity of knowledge transfer.

2.3.2 BENCHMARKING TECHNIQUE

The comparison of methods and practices for performing business processes is based on the process of benchmarking so as to learn from the best and to improve one's own processes. Whereas strategic benchmarking is the comparison of the strategic choices and dispositions which is made by other organizations for the purpose of collecting information so that they would be able to improve their own strategic planning and positioning (Išoraite, 2004). Luu, Kim, & Huynh, (2008) classifies benchmarking technique into two perspective i.e. internal and external benchmarking. With internal benchmarking, an organization collects data on its own performance and assessment so as to make improvements through comparing to past years (Kozak, 2006).Whereas the comparison between one organization and competitors in the same industry is external benchmarking (Kozak & Rimmington, 1998).When dealing

with external benchmarking, organizations focus on the identification of performance gaps and learn the best practice of competitors. (Luu et al., 2008)

In addition to internal and external evaluation, benchmarking has been classified into three categories i.e. product, performance or process benchmarking. Product benchmarking concentrates on understanding how one product compares with another. Performance benchmarking compares one company performance with another. Process benchmarking offers additional benefits over product or performance benchmarking by enabling work to be viewed as a series of holistic transformation events with identifiable inputs and outputs (Garnett & Pickrell, 2000).

As described in the paragraphs above that benchmarking technique can be used to compare various project related factors. However, this research will only focus on using benchmarking technique for estimating commercial bid of a large infrastructure project along with its schedule and required resources. In line with Fisher benchmarking model which considered three parameters: cost (actual versus authorized), schedule (actual versus target) and construction labour (actual versus estimated) to benchmark the projects. This research will also propose to use benchmarking technique in front end loading phase of the project, to exclusively acknowledge the difference between the estimated and authorized commercial bid for the project. The objective behind using such a tunnel vision approach is to pin point under bidding anomalies in competitive bidding procurement process.

The idea for using benchmarking technique in front end loading phase of the project to detect underbidding anomalies was suggested by project managers, while they were being interviewed. The project managers themselves use this technique to estimate approximate commercial bid of the project. The project manager interviewed from UK uses an exponential project price chart developed by Association of consultant engineers (ACE) to benchmark project commercial bid. However, the project manager interviewed from South Africa uses standard rates for various kind works given by engineering council of South Africa to benchmark project commercial bid.

Benefits of benchmarking technique

1. The benefits arise from focusing on core areas of business and identifying inefficiencies in the way processes are carried out. The proof of its benefit comes from understanding and illustrating the change in processes (Garnett & Pickrell, 2000).
2. By benchmarking leading companies, firms have experienced significant success in upgrading their organizational capabilities (Barber, 2004).
3. Identify key performance indicators to which a project manager might aspire (Barber, 2004).
4. It is a systematic and structured approach to searching for the best way to choose and then measure chosen skills and competencies(Barber, 2004).

Limitation of benchmarking technique

1. Time constraints
2. Competitive barriers
3. Lack of both management commitment and professional human resources
4. Resistance to change
5. Poor planning and short-term expectation (Kozak, 2006).
6. Insufficient resources, time, money, staff.
7. Difficulty in identifying and obtaining partners
8. Difficulty in obtaining data (Garnett & Pickrell, 2000).

9. One has to be careful not to make the apples-and-oranges error when comparing cost figures for one system with those for another while benchmarking one system with data from others (Flyvbjerg, Bruzelius, & Van Wee, 2008).
10. Not only should a comparison be made between like with like (apples and apples) but what is often missed is the quality of the apples being benchmarked (Barber, 2004).

2.3.3 RESPONSIBILITY ASSIGNMENT MATRIX

To begin with, a project team is a temporary organization and the product (or end-goal) is unique. The project team is formed at the start of the project and then dismissed at the completion. For instance a matrix organization is the most commonly used organization structure for project execution. A team may include full-time or part-time staff from different functional departments. In a conventional incentive system, invariably evaluated by fixed-time interval, such as annual or quarterly evaluation, cannot provide responsive incentives to motivate the project team (Yang & Chen, 2009).

Furthermore, consistent with good business practice, it is well established that people perform better when they know what is expected of them. In addition, in a collaborative venture it is important for all to know what they can and should expect from each other. This provides an opportunity to match responsibilities with authority, something that can be lacking within an organization with projects carried out in cross-functional or multi-company teams (Bouchlaghem, 2012).

Bouchlaghem, (2012) further states that trust between team members is enhanced if there is transparency in roles and responsibilities, and particularly if each member of the team can understand what the others are doing and whether they have the authority for such task. Efficiency and economy of effort is essential for all members of a collaborative team and by relating the clarity of roles and responsibilities to the collaborative team's processes one can eliminate gaps and avoid duplication.

Roles and responsibilities for the execution of various work package activities need to be defined and assigned accordingly to the project team. This process can be achieved by the use of Responsibility Assignment Matrix (RAM). It describes the association between the work package activities and the project team. The most popular type of RAM is the RACI chart. RACI is an acronym for the four types of interaction: Responsible, Accountable, Consulted and Informed which are explained in table 6 (Wende & Otto, 2007) (Ali Khan, Khamidi, & Idrus, 2010).

(R) Responsible	The person is assigned to get the work done. May delegate work or may be supported by others. Only one person is responsible, think of the lead or manager
(A) Accountable	The person who will sign off on work-package/deliverables. Ultimately only one person but often includes others (e.g. sign-off document requiring signatures of multiple approvers)
(C) Consult	Those people who contribute to the work by providing information (consultancy), either by providing information or directly working at the direction of the person responsible.
(I) Informed	Those people who need to be informed, but not contributing (i.e. do not have active role).

Table 6 Explanation of RACI matrix acronyms

Moreover, Hartman & Ashrafi, (2004) modifies RACI by adding three elements and term it as SMART RACI+ chart. The first element added is a short term schedule, usually in the form of a Gantt chart spanning about six weeks. The second is the work hour budget for each deliverable in the Gantt chart. Note that project managers schedule production of deliverables, not ''activities''. Thus a product is

delivered at the end of each bar in the Gantt chart. The third addition is the budget associated with the deliverables. In addition to these three elements he also suggests to develop Communication maps for project implementation using RACI+ charts.

RACI Chart	Person				
Activity	Ann	Ben	Carlos	Dina	Ed
Define	A	R	I	I	I
Design	I	A	R	C	C
Develop	I	A	R	C	C
Test	A	I	I	R	I

R = Responsible A = Accountable C = Consult I = Inform

Figure 14 RACI matrix table retrieved from PMBOK 4th edition

RACI matrix is also suggested by PMBOK 4th edition for human resource management. According to PMBOK 4th edition RACI illustrate connection between work packages or activities and project team members. The responsibility matrix according to PMBOK can be used at two levels. High level RACI can define what project team group or unit is responsible for within each component of WBS. While lower level RACI can be used within the group to designate roles, responsibilities and level authority for specific activities. The matrix format shows all activities associated with one person accountable for any one task to avoid confusion an example of such a matrix can be seen in figure 14.

Benefits of using RACI matrix by (P. Khan & Quraishi, 2014)

1. If the work environment is volatile and people involved in the project keep moving in and out, role-based RACI is better.
2. If the resources are stable, then name based RACI is good to be employed.
3. Identification of roles anticipated for each of the deliverables and work-packages (right during planning phase itself).
4. When RACI is shared with all the stakeholders, it also adds value by spotting out any missing work-packages, missing roles, missing stakeholders, thus providing an opportunity for early correction.
5. RACI can be helpful as a checklist or reference when assigning resources, duration and cost estimates, to ensure that everyone who has a role in tasks has been properly accounted for.

Limitations of using RACI matrix by (P. Khan & Quraishi, 2014)

1. Benefits of RACI can only be realized fully if the project management team understands and employs it by tailoring it to the organizational context.
2. There is a high possibility of human error on RACI-Matrix deployment decision. Different team members had differing opinion and understanding of RACI-Matrix deployment process.

2.3.4 SCRUM PROCESS

Scrum is a communication approach used in agile project management, which will be used in this research to strengthen communication within a project. It is a new approach that is being slowly implemented in construction industry, but has been used in software developing industry for a decade. In this section the author will first use Cervone, (2011) research to explicitly explain scrum approach used in projects execution and there after use other research to elaborate on its benefits and limitations.

Exploring Scrum in depth by (Cervone, 2011)

The Scrum model is built on three major components: roles, process, and artefacts. The Scrum Master is the role traditionally assumed by a project manager of team leader. This person is responsible for several things, perhaps the most important of which are enacting the Scrum values and practices and removing impediments. The Scrum team typically is a cross-functional team which consists of five to ten people who work on the project full time. The team is self-organizing, which has been interpreted in various ways, but most often means that the leadership role within the team is not fixed and changes depending on the needs of the specific iteration (known as a sprint) in process at the time. It is important to note that membership of the team only changes between sprints.

The product owner is typically a functional unit manager who knows what needs to be built to enable the project and how the sequence of builds should progress. The Scrum process has five major activities: the kick-off, the sprint planning meeting, the sprint, the daily Scrum, and the sprint review meeting. The sprint planning meeting is a meeting of the Scrum team, the Scrum master, and the product owner at the beginning of each sprint (iteration). These meetings, which may take up to a day, consist of two parts. In the first part of the meeting, two major activities occur.

First, the group defines the product backlog, which is basically a list of the project requirements. After this, the group determines the sprint goal, which is the formal outcome(s) from this particular sprint. In the second part of the meeting, the focus of work is on creating the sprint backlog. The kick-off meeting is structured similarly to the sprint planning meeting with the major difference being that the group define the high-level backlog for the project and the major project goals. Once the sprint planning meeting has been held, the sprint can begin. Sprints differ from phases in a traditional project in that sprints are limited to a month-long iteration cycle in which time the functionality of the product is further developed. Another differentiating factor is that during a sprint, no outside influence should be allowed to interfere with the work of the Scrum team. This has several potential implications with the most important being that project requirements cannot be changed during a sprint.

In many projects, but not all, each sprint begins with a daily Scrum meeting. This meeting, typically lasting no more than 15 minutes, is held every day between the Scrum master (who chairs the meeting) and the Scrum team. In this meeting, every team member briefly answers three questions:

1. What did you do since the last Scrum?
2. What are you doing until the next Scrum?
3. What is stopping you getting on with your work?

While it might not be evident, the daily Scrum is not a problem solving session and is not really designed to be a way of collecting information about who (or what) is behind schedule. Instead, the purpose of the daily Scrum is to both track the progress of the team as well as allow team members to make commitments to each other and the Scrum master so that work can proceed in the most expedient and unimpeded manner.

The sprint review meeting is held at the end of each sprint. During the meeting, the functionality that was created during the sprint is demonstrated to the product owner. Perhaps what most differentiates this meeting from a meeting in traditional project management is that this meeting should be informal and not be a distraction for the team members.

The last major component of the Scrum model is the Scrum artefacts that include the product backlog, the sprint backlog, and burn down charts. The product backlog is the requirements for the project expressed as a prioritized list of backlog items. Unlike a traditional project, this list is managed and owned by the product owner. In most projects, the product backlog is a major deliverable of the kick-off or spring planning meetings. As is the case with sprints, the product backlog cannot be changed until the next sprint planning meeting.

During the sprint planning meeting, the team performs an estimation of each product backlog item. The estimates are specifically intended to be forecasts and not exact measurements. Regardless of method of estimation chosen, the estimation includes placing the backlog item into a size category, discussing the story points and using that to estimate the amount of hours or days of work that will be involved to complete the item. Based on this estimation, a collective decision can be made that establishes the team's velocity or amount of effort that can be reasonably handled during one sprint.

Similarly, the sprint backlog is the subset of product backlog items that are defined as part of the work for a particular sprint. However, unlike the project backlog, the sprint backlog is created only by the Scrum team members. Ideally the sprint backlog is updated every day and contains no more than 300 tasks. The team may need to break down a task if it is determined that it will take more than 16 hours. Furthermore, the team may determine that items may need to be added or subtracted from the sprint but this is the team's decision, it is not something that is directed by the product owner.

Unlike traditional project management, Scrum intentionally focuses on work done through the use of burn down charts. Three types of burn down charts are commonly used: the sprint burn down chart documenting the progress of the sprint, the release burn down chart documenting the progress of the release, and the product burn down chart documenting the overall project progress. A goal of a burn down chart is to provide information in an easy to comprehend manner. As such, each task is typically represented in terms of time (the x-axis of the display grid) and duration (the y-axis).

The scrum model description by Cervone, (2011) gives a clear picture about how project is to be managed using scrum. However, it is important to note here that everything proposed to be done in a project while using scrum is not rigid. The model should be adapted according to the organizational or project requirements. Furthermore, certain terms used in the model are different than what is usually used while executing a project such as.

1. Scrum master = project manager
2. Product owner = design leads
3. Kick off = Project kick off meeting
4. Product back log = product breakdown structure
5. Burn down chart = completed work

However, scrum simplifies project execution by first making the entire project team aware of the project end goal in the kick off meeting. Thereafter, it suggests breaking project goals in parts by setting small goals in sprint meeting known as sprint goals, which are supposed to be achieved by the end of each sprint without any variation. The most advantageous aspect of using scrum is its obligation of having the entire project team aware of the project status. This awareness is achieved by having rigorous project

team meeting which is usually obligatory for everyone working on the project to attend. There are various researches which have been conducted exclusively to test communication efficiency in scrum which are briefly elaborated in the following paragraph.

An Integrated Scrums model has all teams fully distributed and each team has members at multiple locations. While, this appears to create communication and coordination burdens, the daily Scrum meetings help to break down cultural barriers and disparities in work styles.(Sutherland, Viktorov, Blount, & Puntikov, 2007).According to Danait, 2005; Holmstrom, Conchúir, Agerfalk, & Fitzgerald, (2006) sprint planning and retrospective meetings improve communication, coordination and team cohesion in a distributed project. Usually the whole team participates in a planning meeting. Furthermore, Paasivaara, Durasiewicz, & Lassenius, (2008) quotes one of the interviewees comment on how efficiently scrum communication works when working in a globally distribute project team.

"So actually a lot of opportunities opened up. That means during the daily scrum you can just tell your counterpart ''I want this assistance. So shall we meet on another meeting or shall we stay on the phone after this?'' You can choose, so there were a lot of opportunities in place to make sure the communication between Malaysia and Norway was there, so Scrum made it possible.''

Paasivaara et al., (2008) in their research concluding remarks goes on to state that, all our interviewees stated that according to their experience, an agile method like scrum, is well suited to distributed settings. It actually helps to mitigate the biggest problem of globally distributed project team, communication, by giving frequent possibilities to communicate across distributed sites. It could be even said that scrum practices almost force distributed team members to communicate frequently and really learn to communicate, which can be seen as very positive.

Benefits of using scrum

1. Provides frequent structured way of communication.
2. Improved communication between the teams.
3. Help teams to be aware of what the other teams were doing.
4. Help to teams know in advance whether the work in some other team was going to have an impact on their own.
5. Improves trust and motivation between the team.
6. Helps improving perceived quality (Paasivaara et al., 2008).

Limitations of using scrum

1. Misunderstood requirements.
2. Lack of videoconferencing possibilities.
3. Awkward communication in distributed meetings due to cultural and geographical distance (Paasivaara et al., 2008).

2.3.5 PROJECT HEALTH CHECK (PHC)

In order to improve the potential for a project to achieve the outcomes expected, a construction project health check model was developed. This model allowed immediate assessment of current project health, identify the root causes of the reasons why the project is not performing as expected and suggest a means of returning the project to better health. The model evolved from a human health care model using symptoms to evaluate project health, detailed investigation of key symptoms to diagnose cause of problem and proposition of a remedy to return the project to good health (Mian, Humphreys, & Sidwell, 2004).

Mian et al., (2004) proposed that human physical health can broadly be thought of as the condition of the body. When physical health is poor, performance or quality of life can be compromised. Poor physical health often has associated symptoms that can be used to help pinpoint the cause of ill health quickly and accurately. Once the cause has been identified, a remedy can be implemented to return the body to good health. But, if symptoms are left unchecked, they can develop into critical situations and become much worse (Mian et al., 2004). Here project health is synonymous with project performance, if a project or any particular aspect of a project is not performing as expected by the stakeholders it would be perceived as unhealthy or failing. On the other hand if it is fulfilling the expectation of the stakeholders it would be perceived as healthy or successful.

The use of performance indicators to assess the state of the contributing factors allows remedies to be prescribed, based on the condition of the contributing factors investigated (Mian et al., 2004). These are thus called Critical Success Factors (CSFs) and used as the basis for a broadly inclusive fundamental health check to gauge project health in terms of specific success factors that are critical to the interested stakeholders (Rockart, 1979). In short Rockart, (1979) suggest that CSFs are the ingredients that give the greatest chance of a successful outcome. In the health model these are areas that are critical to all the stakeholders and need to be investigated in order to ascertain project health.

From the start no matter how exciting a project is, it should have an evaluation system that tells the members of the team how the project is progressing at each stage of the development. Royer, (2003) suggests that the chances of bringing a failing project back on track are better if the problem is identified at an early stage. If a project does not have an efficient early warning system or if the warning signs are not seen with scepticism, a point might come when it would be impossible to recover from the damage caused by the persisting problem. In comparison the cost associated with identifying and remedying a problem at an early stage is much lesser. This is analogous to human health, where the chances of remedying a disease are better if it is diagnosed at an earlier stage rather than neglected and permitted to spread (Mian et al., 2004).

Therefore, it is argued that the PHC tool needs to be linked to project performance indicators (results) so that the managers understand the whole picture of the project performance. Jaafari, (2007) noted that "the information obtained from the PH-Check and progress reports should be combined and used to judge which of the enabling factors need to be attended to and in what way to address any performance shortcoming". Thus, defining the success and failure processes within the project will help to ensure that the success is repeated and failure is avoided (Almahmoud, Doloi, & Panuwatwanich, 2012).

The aim of the PHC tool is to systematically define how the project variables are being managed in order to determine whether a project is managed systemically (in case of a healthy project) or haphazardly (in case of an ill project). The system approach reflects the critical success factors and proven project management principles (Jaafari, 2007). There are indirect links that may affect the project performance as well. As identified in the research, project managerial functions as well as the project outcomes are integrated and can affect each other. For example: client satisfaction is always influenced by project time and cost; and governance and leadership may affect the way information and communication is managed (Almahmoud et al., 2012).

In order to have a robust PHC approach Mian et al., (2004) proposed, accurate and immediate assessment of current health of a construction project in terms of the seven broad themes, certain characteristics were chosen that need to be possessed by the critical success factors. The six critical CSF characteristics were identified as:

1. Easily measurable– must be able to be measured quickly, directly and accurately with as little effort as possible.
2. Broadly applicable – must be able to be measured at any stage of a project or at least a combination of indicators across a CSF should be able to represent all stages of a project. The indicators should also be able to represent different procurement methods.
3. Assessable– once measured, the indicator must be able to be compared to a known value to allow correct judgment of health to be made.
4. Independent (not duplicate) – independence from other project variables is desirable to provide clarity in assessment of a specific CSF by avoiding interference which can give misleading results.
5. Reflect reality – the measured variable must encourage a description of reality rather than 'ideal' or perceived situations.
6. Sensitivity–the indicator must be tuned to project health to allow accurate health assessment.

Lean Management Philosophy used in Project Health Check Model

Projects are temporary production systems. When those systems are structured to deliver the product while maximizing value and minimizing waste, they are said to be 'lean' projects (Ballard & Howell, 2003). The primary rules or principles for production control are drop activities from the project schedule into a 6-week (typical) look ahead window, screen for constraints and advance only if constraints can be removed in time. Try to make only quality assignments which require defective assignments to be rejected.

Note the analogy with Toyota's requirement that workers stop the production line rather than allow defective products past their workstation. In directives-driven production systems like construction projects, it is possible to intervene in the planning process before direct production Track the percentage of assignments completed each plan period (PPC or 'per cent plan complete') and act on reasons for plan failure(Ballard & Howell, 2003; Samset, 2010). Production is defined as designing and making things. Designing and making something for the first time is done through a project, which is, for that reason, arguably the fundamental form of production system (Ballard & Howell, 2003).

Ballard, Koskela, Howell, & Zabelle, (2001) states that production systems are designed to achieve three fundamental goals that is delivering the product by maximizing the value and minimizing the waste. Constraints analysis is done by examining each activity that is scheduled to start within the period chosen as the project look ahead window. The constraints that prevent the activity from being a sound assignment are identified and actions are taken to remove those constraints. The rule governing constraints analysis is that no activity is allowed to retain its scheduled date unless the planners are confident that constraints can be removed in time. Following this rule assures that problems will be surfaced earlier and that problems that cannot be resolved in the look ahead process will not be imposed on the production level of the project, whether that be design, fabrication or construction (Ballard & Howell, 2003). Operating is conceived in terms of planning, controlling and correcting. In this context, to plan is to set specific goals for the system. To control is to advance towards those goals. To correct is to change the means being used or the goals being pursued (Ballard et al., 2001).

Project health check at RHDHV

Project health check tool adopted by Royal HaskoningDHV works on the same principle as proposed by the literature. Project health check tool developed by RHDHV has been modified as per their business requirements. The objective behind using this tool is to achieve project outcomes which are in line with the expected outcome. The key performance indicator which has been suggested in literature to be used in health check is termed as health check indicators in RHDHV tool.

In Royal HaskoningDHV health check reporting process, project risks are being assessed based on 9 Health Check Indicators with aim of eliminating any risky surprises

1. Client Relationship : Complaint or serious dissatisfaction
2. Budget/Finance : Cost overrun or non-payment
3. Time Schedule : Missed deadlines
4. Scope : Baseline or change management issue
5. Quality Assurance : Excessive defect levels
6. Employees/Staffing : Morale, attrition, key positions
7. Other Risks and Issues: Technical or Subcontractor related
8. Communication: Issues/risks associated to communication
9. Procurement: Issues/risks associated to sub-contracting of third parties

Furthermore, each indicator in health check tool should have supporting comments to communicate the following

1. Status
2. Major issues/action plan
3. Key risks/mitigation strategy
4. Any additional key information

RHDHV tool requires project managers to submit project health check report on the monthly basis to the project excellence managers. The report represents status of the health check indicators by using three colour indicators inspired by traffic light concept. The report uses three colours to represent how project key indicators are behaving. The three colours used are listed below with their respective meaning.

1. **Green**
    1. None of the other indicators (which may be flagged yellow or red) is serious enough to jeopardize overall success.
    2. The Project is progressing normally and is on track for success.
    3. Risks or issues that could impact success are known and continuously re-assessed.
    4. Mitigation/Action plans to address risks and issues are working effectively and are being actively managed.
2. **Yellow**
    1. One or more risks or issues threaten Project success and need close monitoring.

2. Mitigation/Action plans to address key risks and issues have been defined, but are either challenging to implement or might be insufficient to stay on track for success.

3. Requires appropriate/continued management oversight to ensure mitigation/action plans are working effectively.

3. Red

1. One or more risks or issues significantly threaten or have already impacted Project success.

2. Mitigation/Action plans to address risks and issues have either not been defined/ implemented or have a low chance of being effective exposure remains high.

3. Additional and urgent senior management attention is required to correct the situation.

The project health check process involves monthly, open, complete, correct and consistent risk oriented project reporting. This process facilitate active involvement of all management levels i.e. consolidated reporting to business line project excellence managers, calls on critical projects between business line directors and chief executing officers. While, the line managers have supportive role towards the project managers. Furthermore, the project manager is fully accountable for their project on all aspects which requires them to look forward to anticipate plausible risks.

The project health check provides a common and consistent approach for reporting across the company. It also summarizes end to end status of the project by providing early warnings.

Benefits of health check tool

1. It provides a formal mechanism to ensure review of project risk and mitigations on a regular basis.
2. It provides an opportunity to project managers to gain insight and knowledge from others on unseen challenges and suggested mitigations.
3. It provides a platform to escalate concerns and issues within the company higher managerial chain. This aspect will be beneficial for project managers who feel their concerns are not being heard.
4. It also provides an opportunity to the project manager to keep the senior management aware of the project status and there by avoid surprises.

Limitations of Health check tool

1. The quality of data in the health check report is dependent on the quality of data inputted i.e. garbage in garbage out. There no simpler way to track improper information but the accountability assigned to the project manager minimizes this risk.
2. There is not enough space in the health check tool dashboard to elaborate on all the aspects of a large multidisciplinary project.

2.3.6 STAGE GATE MODEL

A Stage Gate process is a conceptual and operational map for moving new product projects from idea to launch and beyond a blueprint for managing the new product development (NPD) process to improve effectiveness and efficiency. Stage Gate is a system or process not unlike a playbook for a football team. It maps out what needs to be done, play by play, huddle by huddle as well as how to do it in order to win the game. The process begins with an ideation stage, called discovery, and ends with the post launch review. Note that there are three stages discovery plus two homework phases before serious financial commitments are made at the go to development gate (Cooper, 2008).

The innovation process can be visualized as a series of stages, with each stage composed of a set of required or recommended best practice activities needed to progress the project to the next gate or decision point. Think of the stages as plays in a football game well defined and mapped out, clear goals and purpose, and proficiently executed:

1. Each stage is designed to gather information to reduce key project uncertainties and risks; the information requirements thus define the purpose of each of the stages in the process.
2. Each stage costs more than the preceding one: The process is an incremental commitment one a series of increasing bets, much like a game of Texas casino. But with each stage and step increase in project cost, the unknowns and uncertainties are driven down so that risk is effectively managed.
3. The activities within stages are undertaken in parallel and by a team of people from different functional areas within the firm; that is, tasks within a stage are done concurrently, much like a team of football players executing a play.
4. Each stage is cross-functional: There is no research and development (R&D) stage or marketing stage; rather, every stage is marketing, R&D, production, or engineering. No department owns any one stage (Cooper, 2008).

Following each stage is a gate or a go/kill decision point, as in. The gates are like the huddles on the football field: Gates serve as quality control check points, go/kill and prioritization decisions points, and points where the path forward for the next play or stage of the project is agreed to. The structure of each gate is similar. Gates consist of the following:

1. Deliverables: what the project leader and team bring to the decision point (e.g. the results of a set of completed activities). These deliverables are visible, are based on a standard menu for each gate, and are decided at the output of the previous gate.
2. Criteria against which the project is judged: These include must-meet criteria or knock-out questions (a checklist) designed to weed out misfit projects quickly; and should-meet criteria that are scored and added (a point count system), which are used to prioritize projects.
3. Outputs: a decision (Go/Kill/Hold/Recycle), along with an approved action plan for the next stage (an agreed-to timeline and resources committed), and a list of deliverables and date for the next gate (Cooper, 2008).

The stages are cross-functional and not dominated by a single functional area. This is a business process, not an R&D or marketing process. The play is rapid, with activities occurring in parallel rather than in series. The governance process is clear, with defined gates and criteria for efficient, timely decision making. And the project is executed by a dedicated and empowered team of players and led by an entrepreneurial team leader or team captain (Cooper, 2008).

Benefits of stage gate model

1. Sets clear objectives that a project team can focus and work diligently to achieve.
2. Sets clear expectations.
3. If the team misses the target, causes are sought and improvements to the process are made so as to prevent a recurrence of the cause closed loop feedback and learning.
4. Facilitates in estimating realistic time and budget for each stage (Cooper, 2008).

Limitation of stage gate model

1. Missing stage gate steps and activities.
2. Poor organizational design and leadership.
3. Inadequate quality of execution.
4. Unreliable data.
5. Gates have no teeth once a project is approved, it never gets killed.
6. Hollow decisions at gate: gate review meeting is held and a go decision is made, but resources are not committed.
7. Missed timelines (Cooper, 2008).

Conclusion

An explicit literature study is conducted in this chapter covering all the aspects of project scope management. This chapter initiated by making an explicit distinction between scope change and scope creep using literature. Section one of this chapter presents all the definitions of scope change and scope creep, which were found in the available literature. Furthermore, the author formulates his own definitions of scope changes and scope creep in section one, as no universal definition was identified in the literature. Section one also answers research sub-question one by presenting all the scope change and scope creep definitions which were available in literature. In addition, it also identifies all the causes and the consequences of scope changes and scope creeps. Thereafter section two highlights scope management approaches suggested by leading project management manuals, which will be used in the final scope management model that will be developed to answer the research main question. In section two, using scope management process suggested by PMBOK 4th edition scope management process is split into two groups namely, planning process group and monitoring & controlling process group. The problems faced in these two scope management groups are then explained in the proceeding sub-sections, which provide insight into root causes behind occurrence of scope creep. Lastly, section three of this chapter focuses on literature review on chosen tools and techniques retrospectively. Although the tools and techniques were chosen after steps taken in chapter three of this research, the literature had to be explained under the theoretical framework chapter. Section three highlights why a certain tool or technique is chosen to be used in conceptual scope creep management model. Correspondingly, it also explains the workability of tools and techniques with their respective benefits and limitations. On the basis of the findings of this chapter, all the proceeding steps in this research are executed.

CHAPTER THREE

Case Studies

3. CASE STUDIES

3.1 INTRODUCTION

Apart from explicit literature study on aspects of scope change, scope creep and scope management it is also important to investigate how these aspects are being dealt in practice. Hence, document review of four large infrastructure projects was conducted along with nine interviews in context to the studied projects. This chapter initiates with the explanation of document review of four on going large infrastructure projects at RHDHV. Thereafter, this chapter explains how scope is being managed at RHDHV, by evaluating interviews conducted in context to the studied projects. In the end this chapter is concluded by briefly reflecting on how scope is being managed at design and engineering consultancy firm and by coming up with the list of scope creeps and scope changes causes encountered in practice.

3.2 DOCUMENT REVIEW

This section describes four shortlisted large infrastructure projects which were selected by the author. The projects were selected on the conditions that they should have been troubled with the problem of scope creeps and scope changes. All these four projects are large infrastructure projects undertaken by Royal HaskoningDHV on lump sum price contracts. Furthermore, in order to have a clear understanding of the problem it was decided to study at least one project from each of the four business lines at RHDHV. But, due to inability in getting access to projects from Industry and Building business line, the number of projects was reduced to three. The four business lines at RHDHV are as following:

1. Transportation and Planning
2. Maritime and Aviation
3. Industry and Buildings
4. Water

However, according to the number of business lines the number of projects that are supposed to be studied should be three. But due to introduction of a project which faced extraordinary scope change and scope creep problem, it was also included in the scope of this research. At the end their will be four projects in total that will be studied with two of them coming from Transportation and Planning business line.

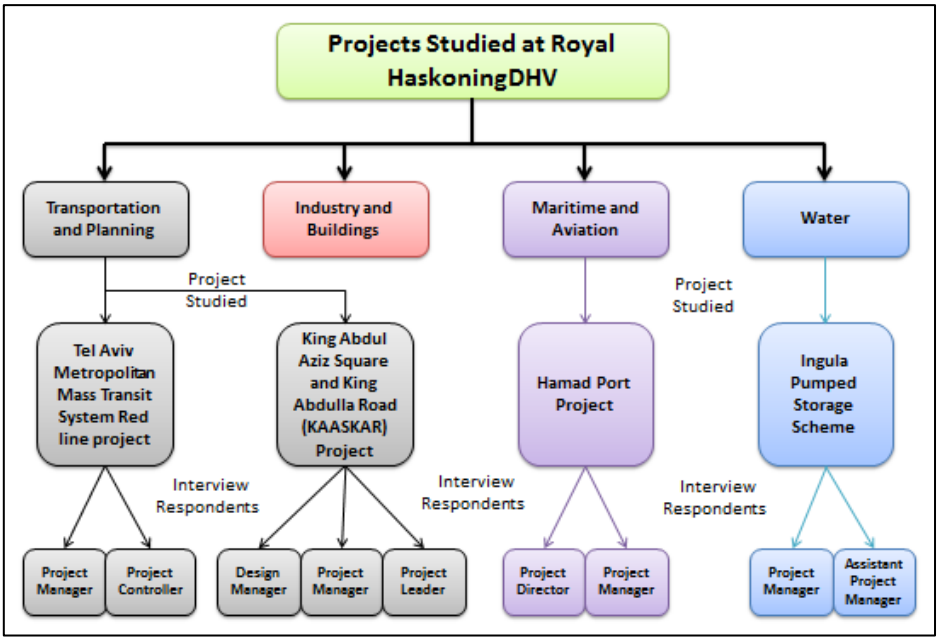


Figure 15 Case studies structure

Additionally, it is also important to note that first document review of the projects was conducted. Thereafter, the author verified all the observation that he made while reviewing the documents through interviews of project managers. The idea was to avoid any misinterpretation of facts which are being explained under each studied projects. All the projects are introduced by combining the document review observations and project insight obtained from interviews. The structure of case studies conducted at RHDHV can be seen in figure 15.

3.2.1 TEL AVIV METROPOLITAN MASS TRANSIT SYSTEM RED LINE PROJECT

This is an on-going project from Transportation and Planning business line which was initiated in 2011. The client is NTA a government owned company from Israel. Royal HaskoningDHV is working on this project in collaboration with its lead consultant (IBI group). IBI group has been selected by the client in a competitive procurement process to deliver preliminary and final design for 10 underground stations and tunnel services. Thereafter, IBI group outsourced structural, mechanical, electrical and plumbing design of five stations to RHDHV. Moreover, RHDHV remuneration scheme for completed work is directly dealt with the NTA and not by IBI group.

RHDHV project undertaking is to provide design and consultancy services on lump sum basis for the structural, electrical, mechanical and plumbing design of 5 underground light rail stations along with construction supervision. The project was initiated by going into legal agreement with NTA for a design build contract where everything to be delivered was explicitly detailed. According to this contract the contractors were supposed to be provided with a reference design by the engineering and design consultants. The left over part of the design was to be completed by the contractor i.e. part of issued for construction (IFC) documents along with some quantities of material. However, after two years of project initiation the contract type was changed by NTA. This step was taken after the client acknowledged that the impact of design was very complex on the city, which hardly left any design freedom for the contractor to deal with.

The contractors didn't even have any freedom to decide how the construction site would be managed along with the methods of construction to be used. Everything was predetermined making it essential to change the contractual agreement to traditional design bid build contract. The point that is important to be highlighted for such a change in agreement is about the negotiation process. The consultant and the client set an expectation on the pot of money that will be paid for such a change a year before the final contract was signed i.e. in 2013. The problem with such an expectation agreement was that, until that point in time the final scope which was supposed to be delivered as per the new contract was not clear. This situation led to re-negotiation in 2014 before the final contract was signed as the client came up with few more appendices attached to the previous scope of work, which the consultant didn't realize unless they were presented.

Correspondingly, the contractual agreement in this project is open to wide interpretation, which is making it difficult for both the parties to align themselves on a common understanding of agreement. The formulation of such an agreement has facilitated development of mistrust between the two parties i.e. consultant as whole and the client on several issues. The consultant has filed 274 CORs (change order request) post initiation of new contractual agreement. However, the research specifically focused on the CORs rejected by the client by studying the reasons of rejection. This helped in identifying basic reasons that led to scope creep in this project which was later used while interviewing the project manager for making references to the generic questions asked.

The most evident reasons which led to scope creep in this project are as following

1. **Contractual agreement open to wide interpretation**

   Some of the contract clauses are so loosely defined such as "3% of additional work per milestone will be carried out by the consultant for no additional fee" is open to wide interpretation. The client is interpreting this clause to get a larger discount, however if the discount is done correctly as per new milestones the discount would be very less. The other example can be acknowledged when going through the detailing of scope of work. One of the important deliverable (i.e. bill of quantities (BOQ)) was only mentioned in the preamble of scope of work however, BOQ deliverable was not at all mentioned in the detailing of scope of work. There is still conflict between the client and the consultant on how detailed bill of quantities is to be delivered for each work package.

2. **Inability to identify knock on effects of scope changes in time**

   The main reason behind inability in identifying the knock on effect is absence of a structure that shows interdependencies between several activities and work packages. Whenever, there is a change the entire project teams comes together and discuss the change in context to agreed scope of work. But this process is vulnerable in missing some items which are interrelated. The other reason is that members of project team working on work packages are not aware of the final negotiated budget. This situation leads to gold plating of service to be delivered.

3. **Contractual agreement to provide generic design services in totality**

   This is a major problem that obliges a consultant to do additional work without getting paid for it. These services are considered by the client as normal service of work as they are agreed on general terms and conditions for the entire design assignment. For instance RHDHV agreed on contractual agreement to assure stability of all the structures in the vicinity of underground stations construction site. The stability calculations were completed for the underground stations design, however a new survey report was introduced by the client on the basis of which stability calculation are to be re done. There is a law in Israel that a survey result is only valid for a period of 2 years, hence the previous design is in violation of law, which was not acknowledged while signing the new contractual agreement.

4. **Some of the CORs claimed with generic information which was not objective and quantifiable**

   Some of the CORs which are related to work packages where there are fewer changes when compared to the other. The COR related to these work packages were send with very generic information on which the client could not fully rely upon and hence got rejected. For instance IBI&RHDHV filed a COR for removal of bridge connection and its implication on the stations design and landscaping. The client rejected this COR stating that this work is within their scope of work and NTA has not instructed consultant to make any such modification. However, later when an explicitly detailed COR was filed, the client right away accepted.

5. **Agreeing to provide design services without fully understanding its requirements and availability of resources**

   RHDHV came up with construction schedule for all the structures of underground stations. Thereafter, NTA asked RHDHV that is it possible to have a training operation session without the structure being fully completed i.e. when it is under construction. RHDHV accepted the additional work to plan training operation without fully understanding what client is actually asking for. This decision which RHDHV perceived as a small scope of work gradually became, bigger and bigger as they started aligning themselves with the clients expectations. This additional work is finally resulting in large scope creep as RHDHV is not able to meet client specified milestones due to lack of in house resources.

6. **Progress on work without receiving all the information from the client to meet the deadlines**

   There was a COR in which the consultant said that they would progress with the development of monitoring plan independent of the conditions of survey. If there will be any discrepancy between the survey and the plan, then a COR will be filed for any amendments, if required. This was suggested to meet the deadline specified by the client, however the client replied that consultant would not be paid for any amendments as it is with in their scope of work.

7. **Change in Environment ministry requirements due to change in its officials as well as delay in permitting due employee issue at government organization**

   This particular reason of scope creep also has links with agreeing to general terms in a contractual agreement. There is an instance where the requirements of environment ministry changes due to change in its official. Initially officials from environment ministry allowed design of temporary at grade work for construction by removing trees. However, later when there was a change in environment ministry official, he instructed to redesign at grade temporary work for construction by not removing the trees. This change in requirements led to un-approval of completed work. The client has rejected the COR filed by the IBI group stating that it is part of their scope of work as per contractual agreement. There is still a dispute between the two parties on this issue.

8. **The client team does not have decision making power which leads to significant delays**

   There is usually delay in progressing with the big CORs as the members from client team who are present for commercial meeting are not empowered to take decision. So meeting is not a commercial meeting it's just an information meeting. These situations lead to missing of milestones deadline which sometime cause scope creep due to knock on effect.

3.2.2 HAMAD PORT PROJECT

Hamad Port Project is an on-going project from Maritime and Aviation business line which was initiated in 2008. The client is government of the state of Qatar represented by new Doha port project steering committee (NDPPSC). Royal HaskoningDHV is working on this project under a lead consultant (Worley Parsons). A part of this project assignment was undertaken from lead consultant with remuneration scheme for completed work also being dealt by Worley Parsons and not by NDPPSC. In this case all the claims for a change request had to be filed through Worley Parsons leaving final negotiation terms and conditions on them as well to a greater extent.

Worley Parsons have a back to back contractual agreement with Royal HaskoningDHV. RHDHV along with Worley Parsons is responsible to advice and provide design services to NDPPSC for planning and construction of commercial, naval and cruise port project. Both the consultants are also responsible to supervise contractor construction document. Furthermore, NDPPSC and Worley Parsons went into a lump sum contractual agreement based on modified FIDIC (Fédération Internationale Des Ingénieurs-Conseils) red book contract template. Some of the clauses in this contract heavily swing in client favour which obliges consultants to carry out additional work at risk making them vulnerable to scope creeps. According to the contractual agreement, a lump sum pot of money was agreed when the entire scope of work was not clear to have a better understanding of the deliverables. For instance quoting from the contract "*The engineering design services to be provided by the consultant shall include, but not be limited to the following services mentioned below*". The contract always mentioned this statement while describing the project deliverables, but it did not state anything, anywhere about the limit of deliverables. The scope of several work packages was later freezed while developing the master plans.

Furthermore, this project faced significant losses majorly due to lack of support network by the RHDHV organization i.e. no one working on the project was fully accountable. There were no cordial relations between Worley Parsons and RHDHV due to poor delivery of service by RHDHV. This issue propped in dispute between the two organizations which was in no one's commercial interest. There were two security design packages which were significantly underbid by RHDHV due to underestimation of deliverables as a result of lack of in house expertise. It was also the time when incompetent sub-consultants were hired by RHDHV to deliver some of the services due to lack of knowledge in those disciplines. All these big issues along with some of the small ones related to work completed at risk led to finishing the entire contingency budget in half way of the project completion.

The most evident reasons which led to scope creep in this project are as following

1. **Lack of support from RHDHV organization network which led to unaccountability**

   The main reason behind, things' going wrong on this project was a result of not having an appropriate RHDHV support structure, as no was clearly given responsibility. RHDHV senior management was not giving enough attention to this project when compared to the attention it deserved. There was no project manager assigned at that point in time and the project director assigned to the project was not interested in this project, who later left.

2. **The electrical design teams of container terminal was unware of clear scope of work and type of contractual agreement**

   In essence electrical design team did not understand the scope of work that they were contracted to prepare. The design team prepared the design in rush without putting enough due diligence in it and passed it on to Worley Parsons. They were not aware that RHDHV contract included a detailed design of the electrical works. Furthermore, they were also not aware that the works would be tendered as a FIDIC red book construction contract. Consequently they were not aware that WP was using RHDHV electrical lay out design of the substations as an input for the detailed design of the utility buildings. The main reason behind such an incident is unclear communication within RHDHV project team and between the Worley Parsons and RHDHV.

3. **No clear written agreement on the deliverables of certain services with the Worley Parsons**

   RHDHV electrical team had discussed the design scope with Worley Parsons (WP). There was however not a clear written agreement with WP on the deliverables. RHDHV understanding was that they needed to prepare a Design Intent and tender documents for a Design & Built Tender. This was discussed and agreed with the lead electrical engineer of WP in a telephone conference but never really recorded. It was also discussed in a meeting at the start of the tender design but the minutes of meeting seem never have been confirmed by WP. A clear understanding was also not established and documented of which party was taking the lead electrical role in the project. During the construction phase problems start occurring with the level of detail provided in the design. By then the staffing of WP and the client had already changed.

4. **Insufficient document control by WP document controller, led RHDHV engineers to face difficulty in tracking the status and comments incorporated in the submitted documents**

   For this project the document control system of WP was used. A document controller of WP carried out the document control. Not all documents, submitted by RHDHV to WP, were submitted by WP to the project management consultant (PMC)/ client. This resulted in certain issues as it was difficult for different engineers of RHDHV to know the status of documents and whether comments were incorporated or not.

5. **Difficulty to negotiate with the lead consultant and the client team on surfaced problems due to change in their team staffing**

   The container terminal was the first terminal design for Hamad port project. Afterwards WP prepared the design of the other terminals. The design approach for the other terminals was not consistent with the Container Terminal. There were a lot of changes required during the construction process to align design of the container terminal with the other terminals. By then the staffing of WP had already changed. This cause of scope creep is a consequence of knock on effect due to undocumented and unapproved agreements between RHDHV, the lead consultant and the client.

6. **Lack of clear understanding of the client requirements and expectations about several deliverables**

   Sizes of electrical equipment (transformer) procured in the Middle East tend to vary from sizes of equipment elsewhere in the world due to local standards. Also the regulations on free space margins in / around substations are in some cases completely different when compared to European design practices. The client did not want to commit himself to certain preferred electrical equipment suppliers. Due to budget and time restrictions the electrical team could not check the dimensions of the electrical equipment inside the

substations with electrical equipment manufacturers. The electrical team tried to prepare a design with realistic equipment dimensions, but that was incorrect as per client expectation.

7. **Unclear communication lines between WP and RHDHV led to interface design errors leading to rework**

   There was no clear communication between RHDHV design team and WP. This situation resulted in rework of WP design work as RHDHV design team was unaware of the fact, that the WP was using RHDHV design as the basis for their design. Due to lack of understanding about the deliverables within RHDHV design team, the design provided to WP was incorrect. This resulted, Worley Parsons to redesign the substation buildings for which they have claimed against RHDHV for their costs.

8. **Budget and time pressure led to delivery of a design based on estimation rather than proper calculations**

   Due to budget and time restrictions the electrical team did not calculate but only estimate the electrical panel sizes in the substations. For the sizing of electrical light voltage (LV) and high voltage (HV) panels a calculation of the sizing of the feeders has to be made. Based on the calculated size of the feeders a calculation can be made of the length of the panels. These calculations had not been made by the electrical team, but were estimated. Due to which the HV & LV panels had to be re designed, as the delivered design was rejected by the PMC.

9. **A design work package delivered without realizing that it is in violation of local standards**

   The electrical team had foreseen to locate the batteries in the corner of one of the rooms in each substation. The client preferred to locate them in a separate room. There is furthermore a requirement from local 'Kharamaa' standard to locate batteries in a separate room. The electrical team indicated that they generally design according to IEC standards and the local standards they are aware of. However it is often difficult to know the contents of all the local standards. WP also had not identified these issues during their check of the documents. While, the contractual agreement exclusively stated to use 'Kharamaa' standard for the design, considering this fact the delivered design was rejected.

10. **Contractual agreement swinging in client favour**

    There is a clause in the contractual agreement which obliges consultant to carry out additional work instructed by the client even if there is no commercial agreement on it. This was one of the main reasons why RHDHV had large losses, as work completed under risk, as per this clause in the contract. Furthermore, there is another clause which states that, for construction support service consultant is not due any additional fee even if the contractor takes longer time than planned.

11. **Unforeseen circumstance due to constantly changing stakeholder requirements**

    This project is faced with a lot of unforeseen condition as the client and stakeholders are very unpredictable. In this project there are situations in which an agreement is made with the client in a negotiation meeting. But after few days the client reopens already negotiated agreements as they come up with new changed requirement which is another cause of scope creep. The main reason behind such a working culture is inexperienced people working in client project team who are inefficient in managing the stakeholder's requirements.

12. **Lack of decision making power leading to lack of feedback, sign off or reply to multiple request for confirmation of requirements**

    The members of client project team and stakeholder were not taking decision neither they were providing any feedback to the consultants. There was no-reply received after multiple requests for confirmation of requirements. This situation resulted in spending excess time on agreeing on scope of work when compared to the anticipated time in the proposal. The reason was that no one from client team wanted to take responsibility of the solution, which would always allow them to have a way-out. They were masters in not approving as per the project manager. This cause of scope creep is related to the working culture of the client.

13. **Significant underestimation of commercial bid for port security work package, due to lack of full knowledge**
    RHDHV bided for design of two port security work package in which they had no experience. Due to lack of experience the level of bid was massively misunderstood. RHDHV did not have right expertise to put together right man-hours and other deliverables for this task. The members of design team working on these work package thought that the proposed amount is reasonable. However it was completely different than what it should have been.

14. **Improper selection and control on sub-consultants selected to deliver port security work package**
    Port security work package sub-consultants were not selected correctly, which resulted in poor delivery of work. The sub-consultants not only delivered poor quality of work but the delivery of work was late. The primary problem in appointing these sub-consultants was that RHDHV project team did not had right expertise to manage them and their work. The company was wholly relying on the sub-constants to provide quality design. RHDHV was unable to identify some obvious flaws in the quality of their technical design, because they didn't had right expertise and skill in their team to assess what the sub-constants were doing.

3.2.3 KING ABDUL AZIZ SQUARE AND KING ABDULLA ROAD (KAASKAR) PROJECT

This is an on-going at grade intersection and road improvement project from Transportation and Planning business line which was initiated in concluding months of 2013. RHDHV in 2013 won four public projects from Saudi Arabia which were initiated concurrently. KAASKAR project which is being described in this section is one of those four projects. It is also important to note here, that all four projects faced significant scope creeps and the reason behind there occurrence were quite similar to the one being elaborated in this research.

Royal HaskoningDHV was procured on lump sum contract basis for providing design and engineering consultancy service through a competitive tendering procurement procedure chosen by the client. Moreover, it is also interesting to acknowledge that, undertaking these projects was a strategic move taken by RHDHV for its expansion in the international market and in particular in Saudi Arabia. This particular project highlights how there are certain project risks which are associated with a typical client and the country where the project is being initiated. The reason behind making such an argument is the procedure which was chosen by the client for procurement of consultant service of which RHDHV was unfortunately unaware off.

The client requested competing firms to submit a proposal for the project on the basis of request for proposal (RFP) set out, as usually done for competitive procurement. Thereafter, client chose a consultant on the basis of minimum price offered and then signed a contract only on the requirements specified under request for proposal (RFP). Interestingly RHDHV proposal was not allowed to be part of contractual agreement, which means the firm basis for proposal was rejected. RHDHV agreed to execute this project only on the basis of RFP which compromised their planning and strategy. This aspect can be seen as mother of all the problems in this project which are elaborated below.

The most evident reasons which led to scope creep in this project are as following

1. **Underbid due to underestimation of efforts required to execute the project**
   The commercial bid for this project was significantly under bided. The main reason which led to under bidding was underestimation of level of efforts required to conclude the project. Proposal team at RHDHV assumed requirements of detailed design as the same as it is done in the Netherlands. However, there is a big difference in the level of details which is usually expected of a designer in an international project. The level of details which are used in the US or the UK are similar to the one used globally. In which everything is completed by the designer in detail such as reinforcement drawings, bending schedule etc. and nothing is left for the contractor to complete.

2. **The project manager and design manager were inexperienced**

   The project manager as well the design manager assigned to this project was inexperienced in handling technical structural process. Neither of the two had any experience in working on an infrastructure project like this one. So they had to wholly rely on their design team leads such as structural, highway, geotechnical etc. for any technical understanding and technical process to be executed. Furthermore, the technical scope wasn't clear enough to the Design manager which led different disciplines have different level of details in their design. This issue led several discipline to work with in their own group which created interface problems.

3. **Insufficient control due to which budget and planning gave major problem**

   This project is executed in three phases which are conceptual, preliminary and detailed design phases. All these three phases were strongly interdependent on the outcome of their predecessor project phase. The design team from the start went off track as they solely approached this project from architectural design point of view without thinking about the end goal. Most of the discipline in the initiation phase worked independently as no one was in position to have a sufficient control over them due to reason elaborated in point 2.

4. **Misappraisal of client request for proposal**

   KAASKAR project proposal and execution team wrongly understood the scope of deliverables. While going through the RFP it can be acknowledged that the client only talks about architectural aspects in the preamble. But while detailing of project deliverables there is not a single instance where client mention about the architectural design. However, the project team only focused on delivering an eye catching architectural design and spend large amount of money and time on it. The details of scope of work in RFP explicitly focused on engineering problems, which was the reason behind initiating this project by the client.

5. **RHDHV subsidiary company SADECO in Saudi Arabia was not utilized in the proposal stage to gather procurement information**

   RHDHV did not use any guidance from its subsidiary company (SADECO) operating in Saudi Arabia for last couple of decades. However, it is important to note that SADECO is a very small company unit consisting of not more than 6 employees who had never done this type of projects. But irrespective of not having any experience in a certain field, does not mean that SADECO don't even have any knowledge about the procurement procedures and conditions being practiced in Saudi Arabia.

6. **Agreeing to project management consultant (PMC) request on additional work without a written confirmation**

   The PMC (HYDER consultancy) requested RHDHV to collect traffic flow information. While, the traffic flow information was supposed to be provided by the client as per the contractual agreement. RHDHV did collect traffic flow data without getting any formal written request from the client. However, the client did not pay RHDHV for collecting this information, but is said to be adjusted in the penalties filed against RHDHV by the client.

7. **Communication lag between RHDHV and Municipality of Jeddah in the initial phase of project execution**

   There was not enough time spend on having a direct communication with the client (i.e. Municipality of Jeddah) in the initial phase of the project. The project team only interacted with the project management consultant (HYDER). This situation led RHDHV to execute certain services requested by HYDER about which Municipality of Jeddah was not bothered about.

8. **Impossible planning**

   RHDHV accepted all the conditions mentioned in the contract when they realized that there proposal was not going to be part of contractual agreement being risk averse. The RFP clearly stated that out of 64 weeks of project duration 46 weeks will be used for design and the left over 18 weeks would be used by client for assessment. Out of 46 weeks 20 weeks were assigned to conceptual design, 15.5 weeks for preliminary

design and 11 weeks for detailed design. Being aware of these unachievable deadlines the project team should have planned project execution in line with these milestones which they didn't.

9. KAASKAR project executed with too many management layers

There were too many management layers in the project execution team starting from the project director, project manager, design manager, design leads and then design team. The employees working on the project didn't have good interaction with their counterpart from project management consultant. This is due to the fact that most of the interaction was done by the senior management. At this point we should again recall statement made in point 2 which is a facilitator of this issue.

10. Lack of internal communication

Lack of communication within RHDHV project team made situation mentioned in point 9 even worse. As there was lack of concrete quantifiable information being transferred to RHDHV design teams by the senior managers. Furthermore, it weakened the ability of several disciplines to track their dependencies on their counterpart disciplines work.

11. Insufficient control on completeness

There was insufficient control on completeness which can be understood by the fact, that employees working on certain deliverables didn't really understand, what they are supposed to deliver. There are two reasons for such an incident.

1. The employees working on certain deliverables were not experienced enough.
2. The mentor (design manager) of these employees had no experience on these kinds of projects, who would have helped bridging this gap.

12. Tasks and responsibility of several members of the management team not clear

It was not clearly set out in the project execution plan that who is responsible for what. Here we can see how complex responsibility assignment can get. The project director of this project was also the project manager of an adjoining project. Thereafter, this project itself had three managers i.e. project manager (PM), design manager (DM) and the project leader. Out of which two managers were exclusively focusing on process. Furthermore, the design leads were not having a discussion between themselves on technical difficulties, rather than that they were only having discussion with the PM and DM. This led to overlap creating confusion, between the team who is responsible for what.

13. Too much expected of the structural engineer

As stated earlier the roles of project team members were not clearly defined. The design manager spends too much time on the process, therefore leaving too much responsibility of technical decision on the structural engineer. Too much was expected of the structural engineer because management had too little structural experience. Quoting

"Design leaders / design management were insufficient in control of this technical process. For instance blue printing, conceptual engineering and interacting of roads and structures were no priority."

14. No common responsibility for budget and planning control within the project team

A very critical point is made in the project evaluation document. Quoting

"There was no common responsibility for the budget and planning within the team. It was for the review team very difficult to find information about the state of budget and planning within the project. A common question like "what's already been done and what remains to be done (within the contract) and what will that cost?" needed a lot of energy and discussions with several persons to get an answer".

Furthermore, there was no organizational support from the manager of advisory group i.e. the line manager, as he was not interested in the project until the project team spend exceedingly.

15. **Very late intervention by the project manager on budget overspend , due to lack of accurate information on project expenditure**

    It is important to acknowledge how the project was executed in first 12 months; everything was very relaxed due to which project team overspend. But when it was realized it was too late to control budget which made project team insecure about the project status. The fault again lies in the project planning which was not done phase wise. Moreover, it is also important to acknowledge a project which is under bided is being troubled by overspending. The reason behind occurrence of such an issue is, project team being unaware of the actual situation of under bid, otherwise people would have been conservative.

16. **New unknown design guidelines and software**

    This aspect can again be linked back to poor planning as all the requirements concerning design guidelines were specifically mentioned in the RPF. For instance, the contract exclusively mentioned that for design of services local 'Manmarra' standards are to be used. However, the project evaluation reports states that the project team was unaware of the guidelines in those standards.

    Furthermore, the structural design team decided to use new structural analysis software 'Sofistik', which had not been used at the company before. This means people working on the structural design were not fully familiar with the use of Sofistik software, which caused problems while executing the project.

17. **In experienced geotechnical team assigned to the project**

    This point is again made in context to the competence and experience of employees assigned to this project. Later an experienced geotechnical engineer was assigned who solved all the issues in a very short period of time.

18. **A good proposal is one, but getting a good contract is a different issue**

    The RHDHV project proposal looked very good from all the aspects. But in this case it was value less as only the RFP was effective of which the RHDHV was not aware off.

19. **Poor project management and inadequate collaboration between disciplines**

    It was more of consequence of over spends in the initial phase of the project. When it was realized that the project is going to lose allot of money. Thereafter, the project came under control mode to minimize time due to which everyone on the project was not kept informed. The communications were very task specific rather than working together as a team.

20. **No team spirit**

    There were a lot of efforts made by the project manager to develop team spirit. He invited team members for social activities, weekly update etc. One of the reasons for lack of team spirit was employees working from different locations. The other reason was poor communication within the entire project team.

21. **Frequent flights to Jeddah instead of local presence**

    There was a lack of local presence exclusively dedicated to these four projects. It was a set back from strategic point of view to gather local working cultural information, which could have helped in growing a dedicated office in Saudi Arabia. Moreover, it would have further facilitated in having a better communication with Municipality of Jeddah and HYDER.

22. **Generic terms in request for proposal created confusion within the design team**

    There are generic terms like landmark and iconic in the contract which was being interpreted by the client and the project management consultant in the way they liked at different occasions.

23. **Outsourcing work to other country (India) to cut cost**

    Some of the design services were outsourced to the RHDHV office in India. The motive behind outsourcing work was to cut cost and to make the deliverables cheaper. The other reason was to quickly finish the work in due time. So every time when there was a request made to the line manager in India to ask him if it is possible to deliver certain service. The answer received was always yes without eventually realizing if there

are adequate resources available to execute that work. There were not enough resources available along with some of the resource which were allocated to the project were not experienced, which further caused delays.

24. Basic facilities on the project location office were insufficient

When the project initiated the basic facilities such as plotters, printers etc. at RHDHV Jeddah office were not available. This is another good example of going into a project without sufficiently planning in advance. The project team worked without these services for about first 10 months. An interesting point to be acknowledged here is that the project team did buy cars, smart screens, and coffee machines in the beginning of the project. So it can be assumed, that if plotters and printers were so important for the project they should have bought them as well.

25. Several discipline did their job too much independently

The project was not started as an integrated project. Several disciplines in the initial phase of the project had done too much work independently. The road and structures were not optimized in the early stage of the project, as the road design team was working from India and the structural design team from the Netherlands. While the road package manager was most of the times working from India or from Saudi Arabia, hence he had no time for communication when he was travelling. The consequence of working independently resulted in inability in optimizing structures design and calculation in the later stage.

26. The geotechnical engineers were not integrated in the design team of structures

In the later phase of the project in order to have strong collaboration between several disciplines it was decided to make them work in a common office at Amersfoort. It was a great effort made by the project management officials. However, this approach didn't end up fully integrating geotechnical team. The reason behind this issue was an effort to cut cost, so the geotechnical team was brought into the project for certain period of time and then moved out. It was easier to practice as geotechnical work have to be done in some parts of the project. It was more like bringing them in and sending them out couple of times.

27. Penalties due to RHDHV project team inability in meeting project milestones

RHDHV project team had to pay penalties on this project due to their inability in delivering services in due time. This point is especially made in context to detailed design delivery.

28. Contractual agreement issues in context to terms and conditions

There are some terms and conditions in the contract which could have been negotiated before initiating the project. One of the clauses in the contract states that only 10% of additional work on the project will be compensated, anything above will have to be adjusted by the consultant. A consequence of such clause can be seen in a modification request which was filed in mid-2014 and is still under process.

The other crucial condition in contract obliges consultant to assign separate teams for each of the four projects. However, some of the specialist which were required for all the four projects had to do similar work which could have been executed by one team only. For instance, separate structural engineering team were working on these four projects designing bearings, expansion joints, bridges etc. The conditions for design were the same for all the projects, which could have been easily done by one team.

29. Absence of scope management control system

The project evaluation document clearly states that "there was no working management system (earned value on weekly base) within the project available to measure such important information".

3.2.4 INGULA PUMPED STORAGE SCHEME

This is an on-going pumped storage construction design project from Water business line initiated in 2007. The INGULA project is realized in South Africa. The project consist of three design phases along which detailed design will be delivered starting from basic design thereafter tender design followed by construction design. RHDHV is executing this project as one of the member of joint venture which has been procured by a public client (i.e. Eskom a South African electricity public utility) to deliver detail construction design on lump sum price contract. The construction design of pumped storage project consists of following deliverables:

1. Access roads
2. Infrastructure
3. Underground works
4. Main access tunnel
5. Quarry
6. Dams and
7. Building works

It is important to note that there were no occasions on this project where scope creep occurred. Moreover, this project is a perfect example of scope changes which takes place due to wrong decisions made by the client. Interestingly this project had a 95% increase in the original budget allocated to the joint venture for providing construction design. The project management on this project was being done by Eskom, which is the root cause of all the scope changes, cost and time overruns. Furthermore, there were three major compensation events with 54.2%, 16.4% and 22.1% increase in original cost of consultancy service with one small compensation event with 2.4% increase in cost. All the compensation events were follow-up of several early warning notifications send to the client to make him acknowledge about the situations if not acted upon would lead to scope change of consultancy service.

The major reasons which led to scope changes in this project are listed below

1. Eskom was not able to achieve milestones specified in the project program which were the basis for joint venture proposal.
2. Financial constraints faced by Eskom.
3. Eskom had capacity issues in terms of right people to execute this project.
4. Large public client executing a multibillion project had to go through a lot of red tapes, procedures and bureaucracy to make decision.

It is difficult to quantify specific scope changes which led to compensation events under these four scope change causes. That is why the author will try to generalize argument made by joint venture in the following compensation events.

1. **Compensation event with total increase of 54.2% on original cost of consultancy service**

   The joint venture design deliverables heavily relied on the following which were delayed by Eskom

   1. on contractor interaction
   2. on contractor provided information
   3. on adaptation to actual conditions and
   4. on integration to suit the offering range of contractors

   The above program changes resulted in an extension of the design duration which raises costs and inputs not only through extension per se, but also through reduced efficiency and productivity.

Furthermore, there were longer working hours implemented by the contractor which required consultant design and monitoring service to be enhanced by additional staffing.

2. **Compensation event with total increase 16.4% on original cost of consultancy service**

This compensation event was filed within a period of 9 months since the previous compensation event had been accepted by Eskom. The reasoning given for this compensation is absolutely in line with the reasoning given in the compensation event 1.Quoting

"*The consultant has regularly pointed out that the design process relies on contractor interaction, on contractor provided information, on adaptation to actual conditions and on integration to suite the offerings of the range of contractors. It was for this reason that the consultant developed a detailed list containing dates on which it required specific approved information from others so as to enable it to meet its contracted obligations, both in terms of construction program demands as well as the consultant's planned program of work on which its lump sum price for the design service was based*."

3. **Compensation event with total increase 22.1% on original cost of consultancy service**

This compensation event took place after 2 years of its predecessor compensation event. The reasons stated by the consultant for this particular compensation are no different than its predecessors. The only difference between this compensation event and the previous ones was the financial constraints faced by the client at this occasion. Moreover, at this point the lump sum contract was changed to cost and time contract.

4. **Compensation event with total increase 2.4% on original cost of consultancy service**

This was the last compensation which was in line with the extra time that was being spent by the consultant on this project. The extra time was spent on making adjustments to drawings on contractors request to make them simpler or to amend defects.

3.3 INTERVIEWS

3.3.1 INTERVIEW QUESTIONNAIRE DESCRIPTION

The interview questionnaire was developed as an outcome of phase 1 of this research. In the phase 1 an explicit literature review was done on the problem of scope change and scope creep faced by the construction industry along with the scope management approaches suggested by leading project management standards. Additionally, the interview questionnaire is also equipped with some of the questions which are not at all addressed in the literature, but will be highlighted in this section. The sources of these questions are four exploratory interviews which were conducted by the author at RHDHV to get better insight into what was being discovered in literature study.

There are four sections in the interview questionnaire with an extra introduction section exclusively dedicated to questions related to scope change and scope creep occurrences in projects. The reason behind dividing interview questionnaire into several sections was to pinpoint specific problems of uncontrolled scope changes associated to different stages of a project. A brief explanation is given below on the reasons of asking particular type of questions under these sections along with the sources associated to them. Furthermore, the interview questionnaire can be seen under appendix B.1.

1. **Introduction section with definitions and questions related to scope creep, scope change and scope baseline**
   This section of interview questionnaire first focuses on introducing interviewee's to the research topic along with the definitions of scope change and scope creep. Thereafter, the interviewee is introduced to basic questions attributed to scope change, scope creep and scope baseline. These questions are framed using literature review done in chapter 2 of this research in section 2.1.

2. **Questions covering all the relevant aspects of frontend loading**
   In this section of the questionnaire the interviewees are asked questions related to frontend loading phase of the project. The questions asked in this section are concerned with the planning process group described in chapter 2 appendix A.3. However, it is important to note that most of the questions asked in this section come from exploratory interviews conducted at RHDHV such as (question 1, 3, 4 & 5).

3. **Questions covering all the relevant aspects of client requirement elicitation as well on communication within the project**
   The interviewees under this section are asked questions, which leads to uncontrolled scope changes due to poor client requirement elicitation, due to poor communication within the project execution teams and with other stakeholders. The questions in this section are formulated from the literature study described in chapter 2 appendixes A.3 & A.4. However, question number 2 sub-questions a, b, c and f comes from exploratory interviews.

4. **Questions covering all the relevant aspects of change management**
   In this section the interviewees are asked questions, which are associated to change management and have not yet been covered in the previous sections. Correspondingly, this section also focuses on configuration management which also facilitates occurrence uncontrolled scope changes. All the questions in this section comes from literature study done in chapter 2 appendix A.4 except question 1 sub-question d and question 2 sub-question d which comes from exploratory interview.

5. **Open unstructured questions**
   This section focuses on questions which also facilitates occurrence of uncontrolled scope changes in projects. Questions such as 2, 3 and 5 come from project management lecture given at Technical university of Delft. While, question 1, 4, 6 and 8 comes from exploratory interviews as well as from the authors RHDHV supervisor recommendations.

3.3.2 INTERVIEWS EVALUATION

This section will illustrate how scope is being managed at design and engineering consultancy firm i.e. (RHDHV). Two practitioners from each of the four projects studied above were selected for interviews. The objective behind interviewing project officials was to avoid any chance of misinterpretation of facts gathered during document review and to understand how projects are being managed. Therefore, it was decided to interview project managers along with one more practitioner suggested by the project manager from each project. The project managers were requested to suggest a name of their colleague who is aware of most of the project management processes. According to the number of projects the total number of interviews should be eight, however as from KAASKAR project three practitioners were interviewed the total number of interviews became nine. The interview answers given by the practitioners, per topic, per question are summarized under appendix B.2.

3.4 LIST OF SCOPE CHANGE AND SCOPE CREEP CAUSES ENCOUNTERED IN PRACTICE

This section will establish a link between causes of scope creep and scope change found in chapter 2 using theoretical framework and in chapter 3 by conducting documents review and interviews at RHDHV. This section consist of two tables 7 and 8 out of which first tables establish a link between causes of scope creep found in literature and in practice. While the second table establishes a link between scope change causes found in literature and in practice. Lastly, it is important to note that causes presented in the end of the table 7 are not addressed in literature hence they are an addition from case studies.

Causes of scope creep found in literature and in practice

S.NO	Causes of scope creep found in literature	Causes of scope creep found in practice
1.	Misappraisal of the original scope of work	Project C points: 4
2.	Unforeseen conditions	Was not found in the projects
3.	Owner requirements	Was not found in the projects
4.	Ignorance of key stakeholders until the project is underway.	Was not found in the projects
5.	The project is executed after years of completion of study and scope definition.	Was not found in the projects
6.	Scope definition is done by the wrong people.	Was not found in the projects
7.	Government officials are always "ambitious" and unrealistic regarding the outcome of projects.	Was not found in the projects
8.	Intervention by politicians and senior government officials.	Was not found in the projects
9.	The data was not enough when the scope was defined.	Was not found in the projects
10.	Bad management of project changes, and absence of scope management and control systems.	Project A points: 4 Project C points:11
11.	Most managers focus on major scope changes and ignore small changes that could lead to bigger scope creep problems.	Project A points: 5
12.	Conflict in different government agencies interests	Was not found in the projects
13.	Design change due to poor brief.	Was not found in the projects
14.	Poor communication between the key partners is a main cause for design changes and rework.	Project B points: 8 Project C points: 6
15.	Design errors and omissions	Project B points: 8
16.	Inconsistency between drawing and site conditions	Project B points: 7
17.	Poor interdisciplinary communication	Project C points: 7
18.	Team instability i.e. disputes, bankruptcy etc.	Was not found in the projects
19.	Inappropriate project organisational structure	Was not found in the projects
20.	Delays in producing design documents	Project C points: 27
21.	Insufficient data collection and survey before design	Project B points: 6
22.	Inadequate design team experience	Project C points: 2,17
23.	Errors and omissions in quantity estimation	Was not found in the projects
24.	Inadequate arrangement of contract interface	Project B points: 7
25.	In government projects, it is not easy to differentiate between what is included in the project and what is not included.	Was not found in the projects

26.	Citations of inadequate specification	Project B points: 9
27.	Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework	Was not found in the projects
28.	Necessary variation of work	Was not found in the projects
29.	Delay in design information	Project A points: 7
30.	Long waiting time for approval of drawing	Project A points: 3 Project B points: 2
31.		Project managers too eager get additional work. Project A points: 5
32.		Lack of organizational support Project B points: 1
33.		Poor documents of agreements with key partners. Project B points: 3,4,5 Project C points: 6
34.		Wrong selection of Sub-consultant Project B points: 14 Project C points: 23
35.		Unrealistic budget Project B points: 11 Project C points: 2
36.		Lack of accountability in project team Project B points: 1 Project C points: 3,11,12,13,14,15
37.		Lack of presence at project site Project C points:21
38.		Project team working from different offices Project C points: 20, 23
39.		Not utilizing available resources Project C points: 5
40.		Push to use new technology Project C points: 16
41.		Contractual agreement open to wide interpretation Project A: 1

Table 7 Linking causes of scope creep found in literature and practice

Causes of scope change found in literature and in practice

S.NO	Causes of scope change literature	Causes of scope change literature
1	Shortage of funding	Project D: 2…financial constraints faced by the client
2	Change in client business case.	Not found in the case studies But was mentioned in the interview
3	Change initiated by Stakeholders.	Not found in case studies
4	Changes in Law & Standards.	Project A: Change in environment ministry requirements after the design was initiated.
5	Slow decision making	Project D: Slow decision making by the client to procure contractors
6	Owner failure to provide complete project information	Project D: The design consultant was
7	Owners instruction to execute additional work	Project A: Client requested the consultant to do extra work, which they accepted without understanding the entire scope of work.
8	Owners instruction to modify design specifications	Project A: Client instructed the partner consultant of RHDHV to modify design due to change in environment ministry requirements. Still under disputable discussion with the client.
9	Abnormal site & ground conditions discovered during site investigation.	Project A: Due to new ground survey report the design had to be amended. The impact of new survey on design evolved a dispute between the parties, which is still under discussion.
10	Consultants for other related projects fail to provide necessary information on time.	Not found in case studies
11	Incomplete or Incorrect project information provided by the owner	Not found in case studies
12	The original contract documentation from the owner may contain errors, omissions and contradictions in specifications	Project A: The client had to switch from initially signed design build contract to design bid build contract due to project complexity. Project D: The client had to change contractual agreement from lump sum to cost time contract due allot of scope changes.
13	Inexperienced clients are particular prone to causing late changes due to delays in review and approvals; as well as inappropriate interference in design and project execution.	Project D: The client had capacity issues in terms of right people to execute project.

Table 8 Linking causes of scope change found in literature and practice

Conclusion

The steps taken under this chapter, has helped in developing better understanding of scope change and scope creep occurrence in practice. After, reviewing the documents of four projects and conducting nine interviews in context to the studied projects at Royal HaskoningDHV. It became clear to the author that occurrence of scope creep and scope changes are common in practice. There were number of causes of scope creep and scope changes which were identified in practice in different cases studies. These causes of scope creep and scope changes were first identified while reviewing the documents and then were verified from interviews of senior managers working on the studied projects. Thereafter, the causes obtained from case studies were compared with the one obtained from literature study. It can be acknowledged while going through tables 7 and 8 that the causes of scope creep and scope changes obtained from case studies are quite similar to the ones stated in literature except some. Furthermore, while reviewing the documents and conducting interviews at RHDHV it was observed that there was no structured scope management process being followed. In all the projects studied, it was observed that all the project managers were managing projects on the basis of their experience and knowledge. It was also observed that the official scope changes were managed as it was specified in the contractual agreement. Acknowledging the arguments made above, it can be stated that there is no standard procedure which all the projects, executed by RHDHV follow to control and manage project scope. The points made above in context to scope management at RHDHV answers research sub-question three: How is scope management practiced, in design and engineering consultancy firm?

Additionally, this chapter also answers research sub-question two i.e. what are the causes of scope change and scope creep for projects executed on lump sum price contracts? (Mentioned in literature and found in practice).This question is answered in table 7 and 8 by establishing a link between scope change and scope creep causes found in literature and in practice respectively. Lastly, this chapter through interviews of senior managers working on the studied projects selected five tools /techniques to be used in developing conceptual scope creep management model. These tools & techniques are retrospectively explained in chapter two (section 2.3) to answer research sub-question four.

CHAPTER FOUR

Research Methodology

4. RESEARCH METHODOLOGY

4.1 INTRODUCTION

This chapter first elaborates on the proposed research methodology described in chapter one. Thereafter, in separate sections survey research and conceptual scope creep management model validation strategy will be elaborated.

The elaboration of research methodology will be done in line with the flow chart proposed in figure 1. Furthermore, research methodology explained in chapter one focuses on why case study approach is used and why does the author opt for survey methodology. However, this chapter will elaborate on how the chosen mixed methodology will be executed.

This combination of methodology is chosen as the research initiates its first phase with an extensive qualitative analysis on available literature on scope change and scope creep. Thereafter, using the findings of the qualitative literature study along with unstructured exploratory interviews at the design and engineering consultancy firm a semi-structured interview questionnaire is developed.

In the second phase of this research again a qualitative case study research approach is used. In which semi-structured interviews of project managers is conducted to investigate causes of scope change and scope creep in practice along with scope management approaches being practiced at RHDHV. Both the phase 1 and 2 research approaches satisfy requirements of case study methodology as suggested by (Yin, 2013).

In the third phase of this research the author came up with a list of causes and consequences of scope changes and scope creep along with design and engineering consultancy firm project success criteria's based upon the findings of phase 1&2. In addition to the above mentioned lists, a conceptual uncontrolled scope change management model will also be developed in this phase. This model will be developed using combination of project management tools, techniques and approaches that are being used in the industry and are suggested in literature. A survey questionnaire will be developed based on the outcomes of phase three to answer research sub-questions.

Thereafter, in the fourth phase of this research a survey will conducted at design and engineering consultancy firm (i.e. RHDHV) to get experts opinion. The expert's opinion that will be collected using survey will be subjected to quantitative analysis to get answers to the following points.

1. Rank causes and consequence of scope change and scope creep.
2. Clustering of causes and consequence of scope change and scope creep using factor analysis.
3. Correlation between causes and consequence of scope creep.
4. Correlation between causes and consequence of scope change (with the absence of client perspective).

In addition, to correlation the survey outcome will also be used to rank causes of scope creep in context to their respective occurrence in projects executed on lump sum price contracts. The research approach used in phase four satisfies requirements of survey methodology as suggested by (Yin, 2013).

Furthermore, there are three types of mixed methodologies suggested by (Tashakkori & Teddlie, 1998) which are as following

1. Equivalent status design: Sequential (QUAN/QUAL and QUAL/QUAN) and Parallel/Simultaneous (QUAN+QUAL and QUAL+QUAN)
2. Dominant-less dominant design: Sequential (QUAN/qual and QUAL/quan) and Parallel/Simultaneous (QUAN+qual and QUAL+quan)
3. Designs with multilevel use of approaches

Mixed methodology with Sequential dominant- less dominant design (QUAL/quan) will be used in this research as portrayed in figure 16.

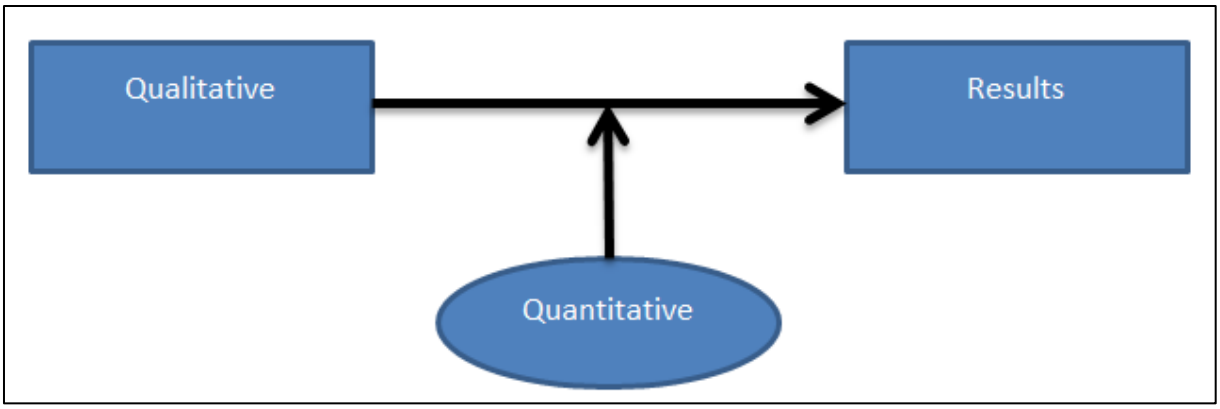


Figure 16 Quantitative methods to enlarge on Qualitative study (Ulin, Waszak, & Pfannenschmidt, 1996)

Finally, in the fifth phase of this research, conceptual uncontrolled scope change management model will be validated by using expert's opinion in a focus group. Thereafter, a qualitative analysis will be done on the outcome of quantitative analysis of the survey and on the outcome focus group validation process to conclude this research finding.

4.2 SURVEY

This section will elaborate on preparatory activities that will be used to conduct survey at design and engineering consultancy firm i.e. (RHDHV). The objective behind conducting a survey is to first, satisfy the requirements of research methodology to answer research sub-questions. Second, to validate and rank causes of scope changes and scope creeps found in theory and in practice exclusively in context to design and engineering consultancy firm projects executed on lump sum price contracts. Third, to validate scope change and scope creep definitions developed by the author. Fourth, to cluster causes and consequences of scope change and scope creep through factor analysis. Fifth, to find relationship between causes and consequences of scope change and scope creep by using correlation analysis.

The sub-section under this section will explain data gathering strategy chosen for survey research. Thereafter, following sub-sections will highlight how survey questionnaire was defined and how survey respondents were chosen.

4.2.1 DATA GATHERING AND ANALYSIS STRATEGY

Data gathering for validation, ranking, factor and correlation analysis was done by means of online and manual survey. The choice of using both online and manual survey was made for targeting different groups of respondents and to get survey response in specified period of time. The survey is conducted at RHDHV offices in three countries which are the Netherlands, South Africa and United Kingdom. An online digital version was developed to conduct survey at RHDHV offices in South Africa and United Kingdom, while pdf of the same digital version was used for manually conducting survey at RHDHV offices in the Netherlands.

The intention behind conducting a manual survey was to increase the number of respondents by touring all the big RHDHV offices in the Netherlands and get the survey manually filled. However, this strategy didn't work out as planned, as project managers who were supposed to fill the questionnaire were working from different locations. Thereafter, it was decided to send an online web link of the digital survey questionnaire to target respondents in the Netherlands as well. The digital survey questionnaire was developed using an online survey application i.e. Survey Monkey. This application was used as the company (RHDHV) for whom this research is being conducted have an access to this tool.

Furthermore, the data gathered using survey can be evaluated using several statistical analysis tools available in the market. The most commonly used tools are: Statistical Analysis System or SAS, as developed by SAS Institute, Inc.; S-PLUS, as developed by Insightful Inc.; Statistical Package for Social Sciences or SPSS, as developed by SPSS Inc. but now part of IBM and R, a programming language (Yan, 2009). The author in this research will use SPSS software, as it has been specifically applied to social science studies, for evaluating data gathered using survey.

Defining Survey questionnaire

The survey questionnaire for validation of definitions, causes and consequences of scope change and scope creep is set out under four sections. The first section of the questionnaire focuses on description of survey and on general question which are asked in context to respondent's personnel profile. Second section focuses on validation of developed scope change and scope creep definitions. While the third and fourth sections focuses on questions related to scope change and scope creep causes and consequences.

Correspondingly, it was acknowledged that the survey questionnaire needs to concise and to the point, so that sufficient number of response can be received. Keeping the length of survey in mind, it was

decided to have limited number of questions. However, if the survey is not very well structured or if it is very long then the number of response received are less. Hence, the survey questionnaire was sequentially structured with limited number of questions which were sufficient to satisfy completeness of the survey results. In the following sub-headings survey sections will be briefly explained and the question can be seen under appendix C.1.

General Questions

These questions were developed, in order to give some context to the survey analysis results. In addition to context these questions will help in understanding whether or not respondent's characteristics have any influence on validation of scope change and scope creep definitions, factor analysis and correlation analysis results. While developing general question it was kept in mind that the number of questions should be kept limited, to prevent respondents abandoning questionnaire without fully completing it. Furthermore, the survey questionnaire introduction explicitly states that the response will be treated anonymously; the name of the respondent is only required, to ask any clarification to the answers provided, if required.

Scope change and scope creep definition validation questions

In the second section of the survey questionnaire, two questions are asked to the respondents. The first question validates definition of scope change and the second validates definition of scope creep. Both the definitions are developed by the author, after having better understanding of scope change and scope creep problem by explicit literature review and case studies at RHDHV. Additionally, the respondents are asked to validate the definition, by responding to a five point Likert scale which ranges from strongly disagree=1 to strongly agree= 5.

Scope change causes and consequences validation questions

In the third section of the survey questionnaire, two questions are asked to the respondents. The first question focuses on validation of reasons which leads to scope changes in a project (i.e. causes). While, the second question focuses on validating scope changes consequences on a project. The reasons of scope change and consequences which are being validated in this section are obtained from explicit literature review and case study at RHDHV. Furthermore, the respondents are asked to validate causes and consequence of scope changes, by responding to a five point Likert scale which ranges from never=1 to most of the times= 5.

Scope creep causes and consequences validation questions

In the fourth section of the survey questionnaire, two questions are asked to the respondents. The first question focuses on validation of reasons which leads to scope creeps in a project (i.e. causes). While, the second question focuses on validating scope creeps consequences on a project. The reasons of scope creep and consequences which are being validated in this section are obtained from explicit literature review and case study at RHDHV. Additionally, the respondents are asked to validate causes and consequence of scope creep, by responding to a five point Likert scale which ranges from never=1 to most of the times= 5.

Choosing possible respondents

The respondents are selected on the basis of their working position at Royal HaskoningDHV. The first precondition for selecting respondents was to make sure that all of them are senior managers (for instance, project manager, consultants, directors etc.). The second precondition was that all the chosen

senior managers should be at least tier D manager or above. RHDHV has ranked project managers under tier system, based upon their experience and performance. The project managers below tier D were not included in the survey as senior managers at RHDHV suggested that they don't have enough exposure in managing large infrastructure projects. All the project managers working at RHDHV offices in the Netherlands, South Africa and United Kingdom were selected irrespective of the business line they are working in.

4.3 CONCEPTUAL SCOPE CREEP MANAGEMENT MODEL

A conceptual uncontrolled scope change (I.e. scope creep) management model was developed with an aim of minimizing/mitigating and tracking all the uncontrolled scope changes that takes places on a project. As per the definition, scope creep is an uncontrolled and unnoticed scope change that most of the time materializes on a project unofficially. That is why; the objective of developed uncontrolled scope change management model is to track all the trackable uncertainties associated to the project scope of work before it eventually materializes.

The uncontrolled scope change management model is divided into two phase's namely *front end loading phase* and *execution phase*. However, it is very important to note, that the developed model is designed exclusively for design and engineering consultancy projects executed on lump sum price contracts. Moreover, for an exclusive design and engineering project frontend loading and execution phases will differ from the same phases for a contractor who will eventually build the design. The designed conceptual scope creep management model is portrayed in figure 17.

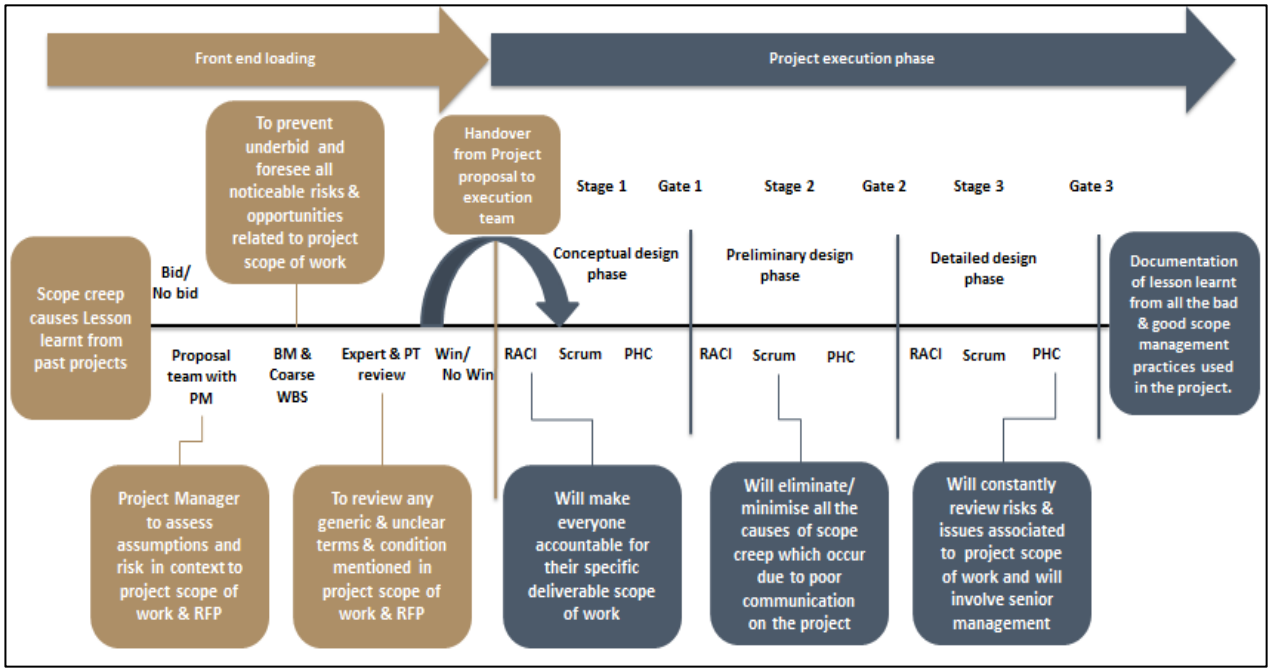


Figure 17 Fit for purpose uncontrolled scope change management model

Conceptual scope creep management model

The proposed conceptual model is developed by acknowledging root causes that lead to occurrence of scope creep in design and engineering projects. The root causes behind occurrence of scope creep in projects is identified while conducting an explicit literature review and while going through documents of 4 large infrastructure projects. Furthermore, the interviews conducted for each of the 4 studied projects helped in further understanding root causes of scope creep along with some possible solutions. The suggestions given by the interviewees for controlling scope creep were acknowledged and literature review was carried out on those suggestions. Based upon the findings of the literature review, the document review and the interviews a conceptual scope creep management model is developed. The designed conceptual scope creep management will efficiently work if the two conditions mentioned below are satisfied

1. The model is adjusted as per the project requirements (For instance: design project, maintenance project, refurbishment project etc.).
2. The proposed conceptual fit for purpose model can reduce occurrence of scope creep in a project, but at the end it strongly depends upon the project manager soft skills.

The tools, techniques and approaches used in the conceptual scope creep management model are briefly explained below phase wise. Correspondingly, while explaining each tool, technique and approach the author highlights on "Why" and "How" questions. The "Why" question focuses on highlighting target scope creep causes, which a certain tool, technique and approach is being used to minimize/mitigate. While, the "How" question focuses on how a chosen tool, technique and approach should be used to minimize/mitigate the target scope creep cause. Moreover, the yes/no questions asked in the model validation questionnaire are asked in context to the tools, techniques and approaches explanation given under this section.

4.3.1 FRONTEND LOADING PHASE

In design and engineering consultancy projects frontend loading phase is also called proposal development phase of a project. In this phase decision regarding bidding for a project is made. Thereafter, project proposal with its commercial price is developed for competitive procurement procedure chosen by the client. The developed conceptual model addresses all the issues concerning occurrence of scope creep due to mistakes made in frontend loading phase of the project. This project phase falls under planning process group in scope management process illustrated in figure 12. The steps proposed to be taken in frontend loading phase of the project to minimize occurrence of scope creep is explained below.

Lessons learned

Lessons learned should be used while initiating the project proposal phase, to acknowledge uncertainties which are associated to the project. The lessons learned will help the proposal team to consider all the risk concerning the client, country, working culture, laws and regulations etc. This approach will eliminate repeating the mistakes made in the past projects in future projects. An example of lessons learned documentation is portrayed in figure 18.

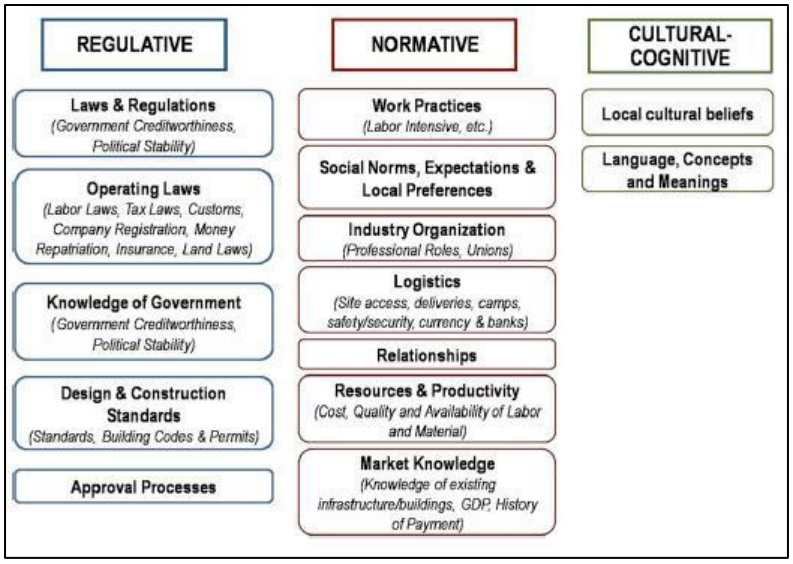


Figure 18 Categories under which lessons learned are to be documented and used

Bid/No Bid

At this step, the request for proposal (RFP) is reviewed by the senior management at the company to decide whether to progress on developing project proposal or not. This decision can be taken by acknowledging the scope of work, obligations, liabilities, terms & conditions and lessons learned.

Future project manager to be part of project proposal team

It is important to have future project manager in project proposal team, as he/she then has an opportunity to acknowledge all the assumptions made while developing the project proposal. The project manager going through this process becomes aware of all the uncertainties associated to scope of work, that he/she might come across while executing the project.

Benchmarking Technique (BM) and Coarse Work Breakdown Structure (WBS)

Why should we use these tools?

Use BM & Coarse WBS to minimize scope creep cause	
1. Unrealistic budget due to underbidding	2. Value risk, Identify Issues & Opportunities

These two tools are proposed to be used concurrently for estimation of project execution cost, along with the risk and the opportunities associated to the project scope of work. This approach will help in checking wrong price estimation, as the price is being estimated using two techniques rather than one. Furthermore, identification and valuing the risks using coarse WBS will ensure in having sufficient contingency. The Coarse WBS will also help in identifying opportunities in RFP, which can be leveraged while executing the project to make more profit.

How should we use them?

1. **Benchmarking Technique (BM)**
   BM technique should be used to estimate approximate project execution cost. This technique is being used in the UK & South Africa consultancies, which uses project price given by the following organizations

   1. Association of consultant engineers (UK).
   2. Engineering council of South Africa.

2. **Coarse Work Breakdown Structure (WBS)**
   Coarse WBS should be used to breakdown scope of work into several manageable work packages. These work packages can be further split into smaller work items. Thereafter, using a joint team approach resources, risk, opportunities and cost can be estimated for each work package.

   Lastly, for more insight into the workability and application of BM technique the reader can go through the explanation given in chapter 2 sub-section 2.3.2, while for WBS the reader can go through chapter 2 appendix A.3 for more information.

Experts and Project team review

The project proposal developed by the proposal team should be reviewed by selected/assigned specialist, risk managers and project design leads before it is submitted to the client. The reason behind getting the proposal reviewed is to mitigate scope creep causes mentioned in the table 9. Furthermore, it is also important to note, that usually the proposal is only reviewed by legal and financial experts who are not capable in checking the causes of scope creep which are mentioned in table 9.

Why should we incorporate this step?

Use Expert, PM and Design leads review to minimize the following	
1. Design change due to poor design brief	8. Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework
2. Misappraisal of the original scope of work	9. Project managers too eager to get additional work without fully understanding scope of work.
3. The data was not enough when the scope was defined.	10. Unrealistic budget due to underbidding
4. In government projects, it is not easy to differentiate between what is included in the project and what is not included.	11. Contractual agreement open to wide interpretation
5. Citations of inadequate specification	12. The project is executed after years of completion of study and scope definition.
6. Scope definition is done by the wrong people.	

Table 9 Causes of scope creep mitigated/minimized by expert review

How should we execute this step?

After the proposal and commercial bid has been developed by the proposal team. The proposal should, thereafter be reviewed by the selected/assigned specialist and risk managers. The review is important to understand generic terms and conditions mentioned in the RFP, which are not reviewed by the legal and financial experts. Furthermore, the review will help project design leads to detect any wrong assumptions made in the proposal, hence making them accountable for their respective scope of work.

Win/No Win

If the tender is awarded to the company, then we progress to the next steps.

Handover

This phase of the project is very crucial, especially when the project manager (PM) was not involved in the proposal development phase or when the proposal was not reviewed by the project execution team design leads. The causes of scope creep being targeted at this step are same as that of experts review step. The causes of scope creep being targeted at this step can be seen in table 10.

Why should we incorporate this step?

Use Expert, PM and Design leads review to minimize the following	
1. Design change due to poor design brief	8. Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework
2. Misappraisal of the original scope of work	9. Project managers too eager to get additional work without fully understanding scope of work.
3. The data was not enough when the scope was defined.	10. Unrealistic budget due to underbidding
4. In government projects, it is not easy to differentiate between what is included in the project and what is not included.	11. Contractual agreement open to wide interpretation
5. Citations of inadequate specification	12. The project is executed after years of completion of study and scope definition.
6. Scope definition is done by the wrong people.	

Table 10 Causes of scope creep mitigated/minimized by handover

How should we execute this step?

When either of the two situations mentioned above take place, then in the handover phase, the proposal team should handover the project details to execution team in such a way that all the key risks assumptions, conditions, liabilities, timelines and budget are made explicitly clear. Furthermore, the project manager (PM) and the design leads should evaluate the project scope of work along with the contractual agreement at this stage. The evaluation will help PM to acknowledge any uncertainties that he might foresee while executing the project. Moreover, any wrong assumption or condition made by the proposal team can be reported to the line management so that provisions can be made to taken care of these issues. This step will eliminate line manager putting pressure on PM to deal with these issues while executing the project.

4.3.2 EXECUTION PHASE

In design and engineering consultancy projects execution phase is the phase in which the project team delivers all the services promised in the contract. The services to be delivered in the contract can also include supervision of construction phase, and then in that case the execution phase will cover the entire construction phase of the project. The proposed conceptual model addresses all the issues concerning occurrence of scope creep in execution phase of a project. This project phase falls under monitoring and controlling process group in scope management process illustrated in figure 12. The steps proposed to be taken in execution phase of a project to minimize occurrence of scope creep is explained below.

Responsibility assignment matrix (RACI)

The RACI matrix will help project managers in making members of his/her project team accountable for their respective deliverables. Correspondingly, RACI matrix will also help in making the project team members aware about their colleague's deliverables. This approach will make it easy for project team members to identify whom they have to speak to, in case their deliverable has dependencies on others work. Furthermore, RACI matrix will also facilitate in following the legitimate scope change management protocol of a project. This means everyone working on the project will not be allowed to entertain scope changes irrespective of the size of the change. The decision about making a change will only be made by the person made responsible to do so. The use of RACI matrix targets the scope creep causes mentioned table 11.

Why should we use this tool?

Use RACI to minimize and manage the following	
1. Inadequate design team experience	6. Client requirements
2. Errors and omissions in quantity estimation	7. Ignorance of key stakeholders until the project is underway.
3. Delay in design information	8. Government officials are always "ambitious" and unrealistic regarding the outcome of projects
4. Lack of accountability on project team members	9. Intervention by politicians and senior government officials.
5. Unforeseen conditions	10. Conflict in different government agencies interests

Table 11 Causes of scope creep mitigated/minimized by RACI Matrix

How should we use this tool?

RACI matrix illustrates connection between work packages or activities and project team members. A project team may include full-time or part-time staff from different functional departments. Hence, in a collaborative venture, it is important for all the members of a project team to know what they can and should expect from each other.

The responsibility matrix according to PMBOK can be used at two levels.

1. High level RACI matrix can define what project team groups or units are responsible for within each component of WBS.
2. While lower level RACI can be used within the groups to designate roles, responsibilities and level of authorities for specific activities.

The matrix format shows all activities associated with one person accountable for any one task to avoid confusion. Lastly, for more insight into the workability and application of this tool the reader can go through the explanation given in chapter 2 sub-section 2.3.3.

Scrum process

The scrum process in this research is exclusively being used as a communication tool. However, it is important to note that scrum process can be used for other uses as well such as project execution planning etc. The scrum process is being used to minimize or mitigate the scope creep causes mentioned in table 12.

Why should we use this tool?

Use Scrum Process to minimize and manage the following	
1. Poor communication between the key partners is a main cause for design changes and rework.	10. Delay in design information
2. Poor interdisciplinary communication	11. Long waiting time for approval of drawing
3. Design errors and omissions	12. Project team working from different offices
4. Inconsistency between drawing and site conditions use of scrum with frequent project site visit	13. Unforeseen conditions
5. Team instability e.g. disputes, bankruptcy etc.	14. Client requirements
6. Delays in producing design documents	15. Ignorance of key stakeholders until the project is underway
7. Insufficient data collection and survey before design	16. Government officials are always “ambitious” and unrealistic regarding the outcome of projects.
8. Errors and omissions in quantity estimation	17. Intervention by politicians and senior government officials.
9. Necessary variation of work	18. Conflict in different government agencies interests

Table 12 Causes of scope creep mitigated/minimized by Scrum process

How should we use this tool?

This tool is being used to strengthen communication with in the project execution team. Additionally, this tool will stimulate project manager to have better communication with the client and other key partners.

In projects, each sprint begins with a daily Scrum meeting. This meeting, typically lasts no more than 15 minutes, and is theoretically held every day between the Scrum master (who chairs the meeting) and the Scrum team. In this meeting, every team member briefly answers three questions:

1. What did you do since the last Scrum?
2. What are you doing until the next Scrum?
3. What is stopping you getting on with your work?

NOTE: It is not obligatory to have scrum meeting every day, a PM can schedule the scrum meetings as per his/her project requirements.

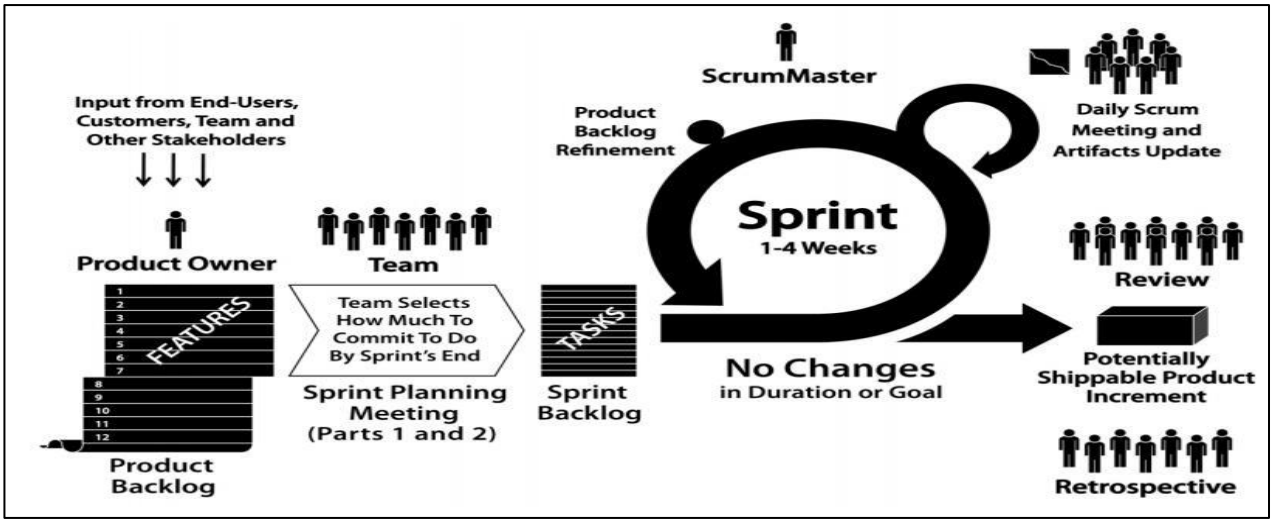


Figure 19 Scrum process (Verheul, 2015)

Lastly, the scrum process can be seen in figure 19, and for more insight into the workability and applicability of this tool the reader can go through the explanation given in chapter 2 sub-section 2.3.4.

Project Health Check (PHC)

The project health check is being used to check project execution status on the monthly basis. This tool obliges the project manager to reflect on project performance every month. The PHC report is than shared with the project excellence manager, who reviews the project report and see if the project requires any senior management assistance. Furthermore, this tool also helps in improving the project governance, as senior management is obliged to provide assistance to the project manager when he/she requires. The causes of scope creep which are being targeted by using PHC are listed in table 13.

Why should we use this tool?

Use Project Health check to minimize and manage the following	
1. Inadequate design team experience	5. Government officials are always "ambitious" and unrealistic regarding the outcome of projects.
2. Unforeseen conditions	6. Intervention by politicians and senior government officials.
3. Client requirements	7. Conflict in different government agencies interests
4. Ignorance of key stakeholders until the project is underway.	It also updates status of all key performance indicators keeping senior management in loop.

Table 13 Causes of scope creep mitigated/minimized by PHC

How should we use this tool?

A construction project health check model was developed for immediate assessment of current project health. It identifies the root causes of the reasons, why the project is not performing as expected and suggests a means of returning the project to a better health. The model evolved from a human health care model using symptoms to evaluate the project health, detailed investigation of key symptoms to diagnose cause of problem and proposition of a remedy to return the project to good health.

Furthermore, each indicator in health check tool should have supporting comments to communicate the following:

1. Status
2. Major issues/action plan

3. Key risks/mitigation strategy
4. Any additional key information

The report uses three colours to represent how project key indicators are behaving.

1. **Green:** Means an indicator is progressing normally and is on track for success.
2. **Yellow:** Means an indicator is threatened by one or more risk.
3. **Red:** Means an indicator is significantly threatened by one or more risk.

Based upon the status of an indicator, mitigation measures are planned and executed to mitigate risks or issues. Correspondingly, when the risk or issue is critical then senior management is involved. Lastly, for more insight into the workability and applicability of this tool the reader can go through the explanation given in chapter 2 sub-section 2.3.5.

Stage gate model

The stage gate model is being used in the proposed model to ensure efficient planning of project execution phase. Stage gate model facilitates in estimating resources required in different project stages. Moreover, it also helps in planning the amount of time and budget that should be spend in a specific project phase. The entire planning using stage gate model is done by keeping the project end goal in mind. The scope creep causes which are being targeted by using stage gate model can be seen in table 14.

Why should we use this tool?

Use Stage Gate Model to manage the following	
1. Delay in design information	2. Long waiting time for approval of drawing
3. Penalties due to missing milestones deliverables deadlines.	4. Budget overspend

Table 14 Causes of scope creep mitigated/minimized by Stage Gate model

How should we use this tool?

A Stage-Gate model is a conceptual and operational map for moving new product projects from idea to launch and beyond a blueprint for managing the new product development (NPD) process to improve effectiveness and efficiency.

It maps out what needs to be done, play by play, huddle by huddle as well as how to do it in order to win the game. Lastly, for more insight into the workability and applicability of this tool the reader can go through the explanation given in chapter 2 sub-section 2.3.6.

Documentation of lessons learned at the end of project completion

The lessons learned should be documented after project completion. The objective is to learn from the mistakes made in the past and to improve future project performance. Additionally, the lessons learned should not only be used to document and learn for the mistakes made in the past, but should also be used for documentation of best practices.

Why should we document lessons learned?

Lessons learned should be used to learn from the mistakes made in the past, so that repetition of same mistakes is mitigated.

How should we document lessons learned?

The lessons learned from the project should be documented at the end of the project preferably in the same categories as proposed in figure 18.

Lastly, for more insight into the workability and applicability of this tool the reader can go through the explanation given in chapter 2 sub-section 2.3.1.

Defining conceptual scope creep management model validation questionnaire

The conceptual model validation questionnaire is set out in three sections. The first section of the questionnaire focuses on general questions which are asked in context to respondent's personnel profile. Second section focuses on yes/no questions which are asked in context to the workability of tools and techniques used in conceptual scope creep management model. While the third section focuses on open questions, asked specifically in context to the conceptual scope creep management model.

Furthermore, it was acknowledged by the author that the questionnaire needs to concise and to the point, so that it easy for the expert to respond to the specific questions. In the following sub-heading conceptual scope creep management model questionnaire will be briefly explained and the question can be seen in appendix D.1.

1. **General Questions**

   These questions were developed, in order to give some context to the conceptual model evaluation results. In addition to context these questions will help in understanding whether or not respondent's characteristics have any influence on validation of conceptual scope creep management model results. While developing the general question it was kept in mind that the number of questions should be kept limited, to prevent respondents abandoning questionnaire without fully completing it. Moreover, before staring the conceptual model validation presentation it was explicitly stated that the response will be treated anonymously, the name of the respondent is only required, to ask any clarification to the answers provided, if required.

2. **Yes/No questions**

   In the second section of conceptual model validation questionnaire, nine questions are asked to the respondents. These questions are asked in a sequential order of tools, techniques and approaches application in the conceptual scope creep management model. The objective behind asking specific questions is to acknowledge whether the tools, techniques and approaches used in the model are effective in minimizing the target problems of scope creep exclusively. The author first strategy is to validate the application of specific tools, techniques and approach proposed in the model. Based upon the results it can be concluded whether a certain tool, technique or approach would benefit in reducing scope creep in projects or not.

3. **Open questions**

   In the third section of the conceptual scope creep management model validation questionnaire, five questions are asked to the respondents. All the five questions in this section are exclusively asked in context to the workability of conceptual scope creep management model. The questions in this section focus on workability, re-structuring, applicability and on recommendations to improve the proposed model. Similarly, an exclusively question is also asked on why available tools and techniques which are proposed in the model not used in practice. The answers to these questions will help in understanding all the important aspects related to the developed scope creep management model workability in practice.

Choosing possible respondents

The respondents are selected on the basis of their working position at Royal HaskoningDHV. The first precondition for selecting respondents was to make sure that all of them are senior managers (for instance, project manager, consultants, directors etc.). The second precondition was that all the chosen senior managers should be at least tier D manager or above. RHDHV has ranked project managers under tier system, based upon their experience and performance. The project managers below tier D were not

included in the survey as senior managers at RHDHV suggested that they don't have enough exposure in managing large infrastructure projects. Likewise, all the project managers working at RHDHV Amersfoort office in the Netherlands were selected for validation of conceptual scope creep management model. The decision to only include project managers from RHDHV Amersfoort office was taken considering the availability of project managers. Moreover, it was also acknowledged that it was not practical to invite project managers from other RHDHV offices as they would not come to Amersfoort office exclusively for a one hour meeting.

Conclusion

In this chapter the author extended the proposed research methodology of the research. Thereafter, section one survey, explains the consideration made to gather data by conducting survey at RHDHV offices. Additionally, this section also very briefly explains how different questions were formulated in the survey questionnaire. The section two of this chapter initiates by introducing the developed conceptual scope creep management model to the reader. Thereafter, the model is briefly explained along with the tools, techniques and approaches which are used in developing the model. It is also important to note that all the seven chosen tools/techniques are also very briefly explained under this section. The tools and techniques description highlights why and how these chosen tools, techniques and approaches are to being used in the model. The explanation given in this section will be used to validate the workability effectiveness of the chosen tools, techniques and approaches while validating the conceptual scope creep management model. The idea is to confirm whether the chosen tools, techniques and approaches will be efficient in controlling scope creep occurrence when applied in practice. As the applicability can be seen very good in theory but in practice it might not be good enough. Lastly section two of this chapter explains how the developed conceptual scope creep management model will be validated in the focus group of experts at RHDHV.

CHAPTER FIVE

Analysis and Results

5. ANALYSIS AND RESULTS

5.1 INTRODUCTION

In this chapter first, the data gathered using survey research will be evaluated by using factor analysis and correlation analysis. Thereafter, the data gathered from focus group validation process will be evaluated. Based upon the evaluation outcome results will be presented, these obtained results will then be used to conclude this research finding.

5.2 SURVEY

5.2.1 RESPONDENT'S CHARACTERISTICS

The criterion used for selection of respondents has already been discussed in chapter 4. The survey questionnaire was send to 199 respondents, out of which 114 were from the Netherlands, 64 from South Africa and 21 from United Kingdom. There were in total 126 response received, out of which only 120 responses were complete and 6 responses were partially completed. Hence, as per the pre-condition mentioned in the survey questionnaire of not including partially completed responses, hence only 120 complete responses will be evaluated.

Figure 20 portrays the number of responses received per day. The survey questionnaire was send to all the respondents on 18th of Sep late in the evening. As it was Sunday, it was presumed that if the questionnaire is send late that evening it would be one of the first mail that respondents would see on Monday morning. Furthermore, initially a manual version of questionnaire was send to all the respondents in the Netherlands. However, on the very first day when the author travelled to Amersfoort it was realized that manual response and collection of questionnaire was not feasible. Hence, on Monday i.e. 19th of Sep an online digital version of the survey questionnaire was send to all the respondents in the Netherlands.

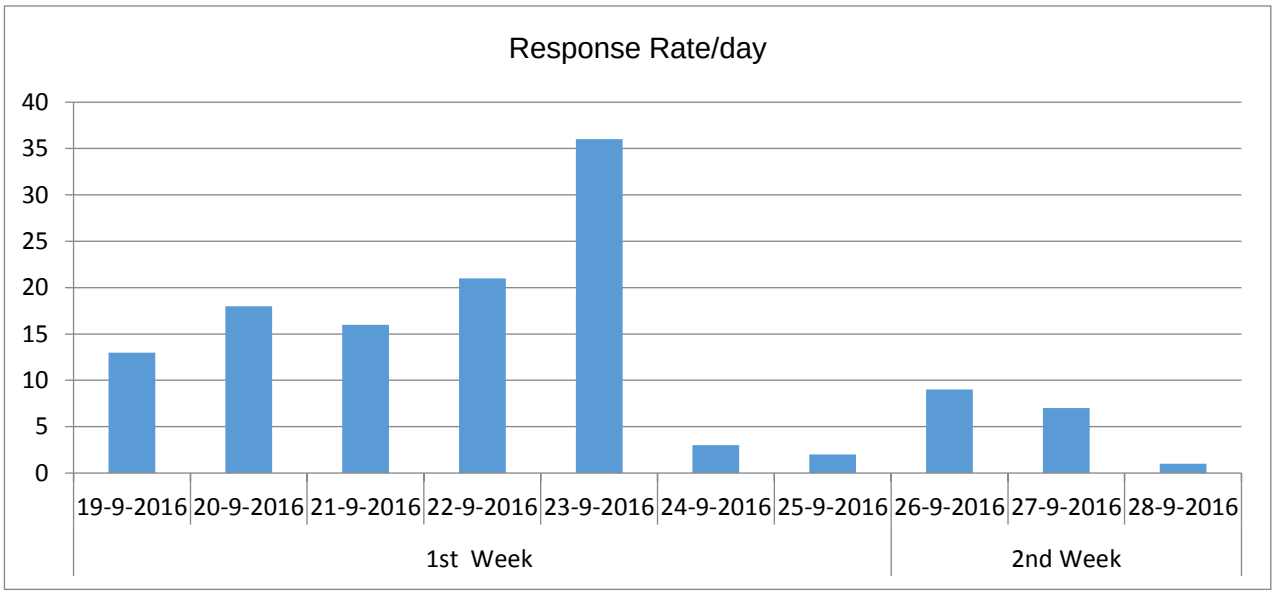


Figure 20 Survey response rate

The author kept track of all the responses received and was constantly in touch with the respondents through a communication tool Skype for business used at RHDHV. This tool helped in tracking which respondent was online, and when a possible respondent was online a personnel message was send to him/her. In addition to the personal messages reminder mails were send with survey web link enclosed after every three days. The idea of providing an exclusive web link in all the reminder mails was to make it easy for the possible respondents to access and complete the survey. Correspondingly, all the reminder mails send also included survey completion deadline, which also contributed in receiving early responses. In end it can be said, that the strategy used worked very well, as 63.03% of the response were received within 10 days, out of which 60.30% responses were complete. Figure 21 was developed to portray some of the important characteristics of the survey respondents.

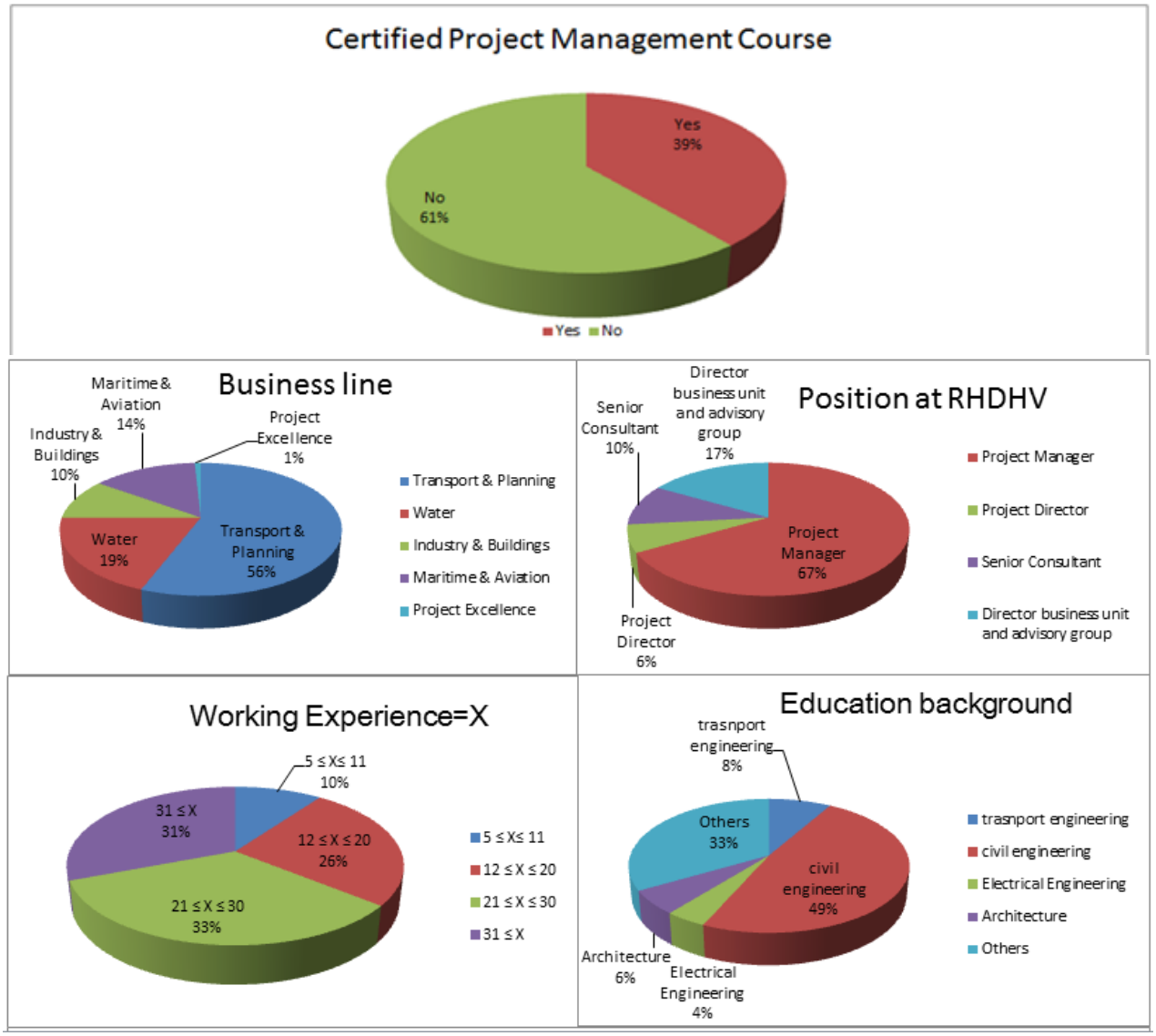


Figure 21 Survey respondents characteristics

5.2.2 DISCUSSION ON VALIDATION OF SCOPE CHANGE AND SCOPE CREEP DEFINITIONS

In this section survey results of scope change and scope creep definitions will be evaluated. As stated in chapter 4 the respondents were asked to score these two definitions on a Likert scale of 5 points ranging from strongly disagree to strongly agree. This section will first evaluate the survey results of scope change

definition followed by evaluation of scope creep definition. The evaluation will start by first making a discussion on Likert scale score results. Thereafter, the disagreement comments made by the respondents will be subjected to qualitative analysis. Finally this section will be concluded by considering the results of both the statistical data analysis and qualitative analysis of the disagreements comments.

Scope Change Definition

The statistical results obtained from the survey can be seen in figure 22. Figure 22 portrays both the % and the number of response obtained in favour of each option provided in the questionnaire. It can be seen that the majority (i.e. 49%) of the respondents agree with the proposed definition. While, only 25% of the respondents strongly agree along with a minority of respondents that disagree (i.e. 15%) or strongly disagree (i.e. 4%). Based upon the statistical results, the definition can be considered validated. However, it is also important to acknowledge that there is some room for improvement in the proposed definition as a big population of respondents do not strongly agree. The definition will be amended by making a qualitative analysis on the 39 comments made by the respondents. Additionally, the scope change definition proposed by the author in the survey questionnaire is stated below.

"Scope change is an official decision taken by the project manager and the client to change, expand or reduce originally defined scope of work. A scope change always results in making adjustment to all the activities, resources and contractual agreement affected by the change."

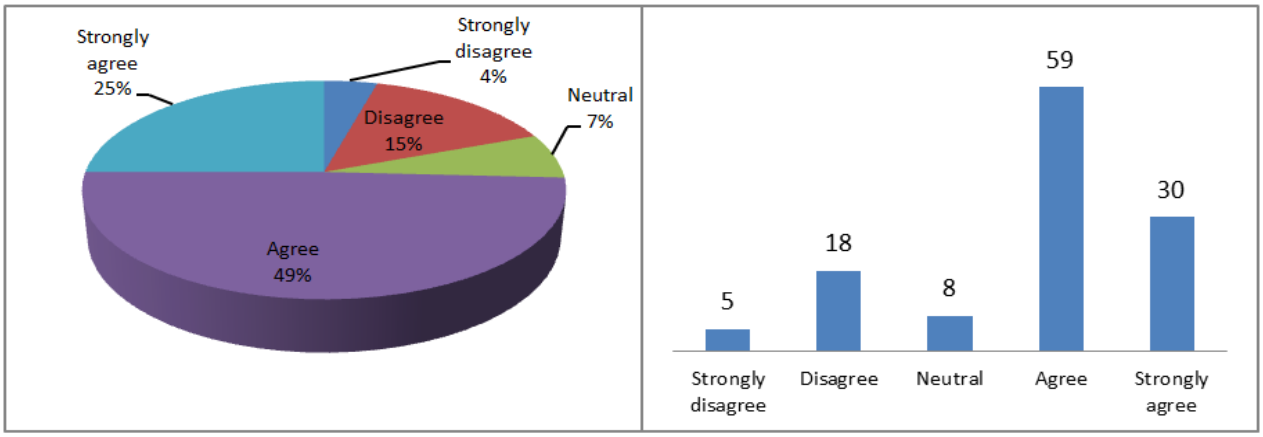


Figure 22 Scope Change definition survey response

S.NO	Key survey disagreement response on the proposed scope change definition
1	All the scope changes decisions are not always an official decision.
2	There are small scope changes, for which no official decision is made.
3	Scope changes also occur due different interpretation of scope of work made by the client and by the consultant.
4	Scope changes occur with a conflict between the client and the consultant, on deciding whether it is normal service of work or not.
5	It is an official decision but not always taken mutually by both client and project manager together. Client is the owner and he only has the decision making power.
6	Scope change does not require adjustment to activities and resources but requires amendments to the contractual agreements.
7	Scope change does not require amendments to the contract but does require amendments to resources and activities.
8	Scope change may also occur due to choosing alternative A instead of alternative B.
9	Scope changes does not require amendments to "all" the activities, the change might have to be made to few only.
10	The proposed definition describes an ideal situation.

Table 15 Key disagreement response to the proposed scope change definition

There were 39 comments made in context to proposed scope change definition. Despite that, it is also important to note that all the comments made were not disagreements. The key disagreements comments have been shortlisted in table 15. While, all the 39 comments can be seen in appendix E.1, for any clarification that a reader may require. Moreover, in the following paragraphs arguments will be made for or against the 10 shortlisted comments in table 15.

To begin with, the first four comments with which the author strongly disagrees as all of them are causes of scope creep, which can be traced in the list of scope creep developed in chapter 3 table 7. They are considered scope creep as the client does not reimburse consultant any additional fund for these change nor does he give consultant any extra time. Furthermore, the author partly agrees with point five, that the client being the owner has large power over project manager in decision making. But, the client may ask project manager to deliver something which can be against consultants interest, and unacceptable to the project manager. Therefore, author sticks to mutual agreement between the two parties for making a scope change.

Moreover point six and seven are contradicting each other hence the author would presume them to counter each other claims and stick to the proposed form. Point eight, is addressing the service that a design and engineering consultant usually provides to the client. However, if the client has chosen a certain alternative which later he/she wants to change, then the client has to pay for the completed work of that chosen alternative. If the client refuses to compensate for the completed work, then it would be a scope creep for the consultant. With regard to point ten the author agrees, that the proposed definition represents an ideal situation which should be the case in scientific research. As unideal situations are the problems that should be solved to achieve ideal situations, which in practice is not achievable.

Lastly point nine has been addressed, as this point has also been highlighted by the respondents who agree with the proposed definition. This is also the only major reason behind large number of respondents not strongly agreeing to the definition, as author personally checked it with some of respondents. Conversely, the problem is not with the definition, but the way it was presented made respondents miss read it. The definition explicitly states "*making adjustment to all the activities, resources and contractual agreement* ***affected by the change***", but most of the respondents overlooked the part represented in bold. Hence the only amendment that will made, is to remove "**all**" from the proposed definition to acknowledge the respondents concerns. In end the final validated and amended scope change definition is presented below

"*Scope change is an official decision taken by the project manager and the client to change, expand or reduce originally defined scope of work. A scope change always results in making adjustment to the activities, resources and contractual agreement affected by the change.*"

Scope Creep Definition

The statistical results obtained from survey response can be seen in figure 24. Figure 24 portrays both the % and the number of response obtained in favour of each option provided in the questionnaire. It can be seen that the majority (i.e. 62%) of the respondents agree with the proposed definition. While, only 22% of respondents strongly agree along with a minority of respondents that disagree (i.e. 6%) or strongly disagree (i.e. 2%). Based upon the statistical results the definition can be considered validated. However, it is also important to acknowledge that there is some room for improvement in the proposed definition as a big population of respondents do not strongly agree. The definition will be amended by making a

qualitative analysis on 17 comments made by the respondents. Additionally, the scope creep definition proposed by the author in the survey questionnaire is stated below.

"Scope creep is an uncontrolled scope change which occurs slowly/gradually and unofficially without addressing its impact on project activities and resources. These are the changes which occur without an official agreement between the client and the project manager."

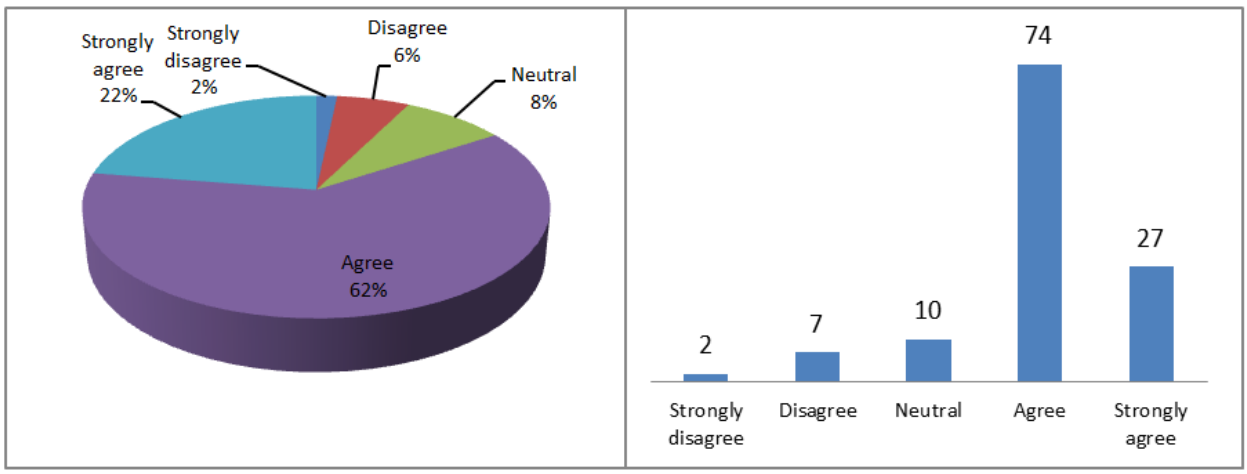


Figure 23 Scope Creep definition survey responses

S.NO	Key survey disagreement response on the proposed scope creep definition
1	It is a polar opposite definition. Scope creep can also occur, due extra time (e.g. 10 minutes extra on every occasion) spend meeting with the client for the meeting.
2	Scope creep can also happen due to poor scope definition.
3	Scope creep can happen due to poor design.
4	Accumulation of a lot of small scope changes.
5	Scope change may not have been brought to project manager knowledge by the project team members.
6	It is a moment when project manager takes no action.
7	Client may introduce scope creep intentionally in order to avoid payments.
8	May not happen slowly.
9	The key word is unnoticed.
10	Scope creep when accepted by consultant, it should be considered as official decision.
11	Not all scope creep in unofficial and without client and project manager agreement.
12	Changes are never uncontrolled

Table 16 Key disagreement response to the proposed scope creep definition

There were 17 comments made in context to the proposed scope creep definition. Despite that, it is also important to note that all the comments made were not disagreements. The key disagreements comments have been shortlisted in table 16. While, all the 17 comments can be seen in appendix E.2, for any clarification that a reader may require. Moreover, in the following paragraphs arguments will be made for or against the 12 shortlisted comments in table 16.

To begin with first seven comments, all of the reasons mentioned in these comments are causes of scope creep which can be traced in the list of scope creep developed in table 7. However, the author would elaborate briefly on point one as it is a bit exceptional. The point made is valid, but it's just poor

meeting planning on the project manager side, if this happens on every occasion. Correspondingly, the author disagrees with point ten as the definition considers a decision as official when it is mutually made by both the client and the consultant.

With respect to point eleven, the author partly agrees but we should not forget that the project manager never officially agrees to this decision. As, there is always financial implication of such decision on the project, but yes sometimes project manager makes the client aware of such extra work. But making aware of extra work is different from official agreement as no compensations are made for it. The project manager by making such gesture only tries to earn client confidence.

Furthermore, the author agrees with point eight and nine. Scope creep may not always happen slowly, but it is usually unnoticed. Both these points will be acknowledged and the proposed scope creep definition will be amended. Lastly, the author strongly disagrees with point twelve by making reference to point nine. When a change in unnoticed it is by default uncontrolled. In end the final validated and amended scope creep definition is presented below

"*Scope creep is an uncontrolled and unnoticed scope change which occurs unofficially without addressing its impact on project activities and resources. These are the changes which occur without an official agreement between the client and the project manager*."

5.2.3 FACTOR ANALYSIS

Factor analysis is a technique used for identifying groups or clusters of variables. This technique has three main uses (Field, 2009)

1. To understand the structure of a set of variables.
2. To construct a questionnaire to measure an underlying variable and
3. To reduce a data set to a more manageable size while retaining as much of the original information as possible (Field, 2009).

In this research factor analysis is being used to reduce the data set of scope change and scope creep causes and consequences into more manageable size while retaining their original information as much as possible. Factor analysis uses R-matrix (i.e. a correlation matrix) to cluster large set variables into subsets of variables which could be measuring the same underlying dimensions. These underlying dimensions are known as factors or latent variables (Field, 2009). In factor analysis data reduction is achieved by looking for variables that correlate highly with a group of other variables, but do not correlate with variables outside that group (Field, 2009).

Furthermore, this section will describe factor analysis results along with the steps taken for clustering scope change and scope creep variables. It is also important to note that all the steps taken in factor analysis are suggested in the book written by Field, (2009) "Discovering statistics using SPSS".

The clustering of the variables under investigation was done in four phases, each of the four phases exclusively focused on one set of variables namely

1. Scope changes causes
2. Scope changes consequences
3. Scope creep causes and
4. Scope creep consequences

The procedure followed and assumption made will be briefly explained in phase one only i.e. while subjecting causes of scope changes to factor analysis. In rest of the phases only the results will be presented.

To begin with, preconditions which are required to be satisfied before a set of data can be subjected to factor analysis using principal component extraction method. It is important to note, that all the four phases will be executed using principal component extraction method. Moreover, according to Field, (2009) clusters developed using this extraction method are not termed as factors but are termed as components.

It has been decided to use principal component analysis, as it is the most commonly used extraction method for clustering of variables in social science studies. Field, (2009) also only explain this method in his book for use in SPSS software. Lastly, the two major preconditions which are required to be satisfied for factor analysis are mentioned below

1. Sample size: The requirement for sufficient sample size is checked using "Kaiser-Meyer-Olkin measure of sampling adequacy (KMO)". Kaiser, (1974) recommends accepting (KMO) values greater than 0.5 as barely acceptable (values below this should lead to either collect more data or rethink which variables to include). Furthermore, values between 0.5 and 0.7 are mediocre, values between 0.7 and 0.8 are good, values between 0.8 and 0.9 are great and values above 0.9 are superb (Hutcheson & Sofroniou, 1999).

2. Significant correlation: The requirement for indicating that sufficient level of correlation exists between at-least two variables under investigation. This is checked using "Bartlett's test of sphericity checked by value of "p"". According to Field, (2009), in order to satisfy the requirements of this test the value of p< .001. When the value of p is less than .001, it means that significant correlation exists between the set of data under evaluation. Correspondingly, this requirement has to be satisfied before a set of variable can be subjected to reliable factor analysis.

Clustering of scope change causes

The scope change causes variables satisfies factor analysis preconditions as can be seen in figure 24. Despite that it is also important to note that the KMO test shows, sample size is mediocrely satisfactory for this specific case. However, the Bartlett's test satisfies the requirement of having significant correlation with "p" value being represented by Sig (.000) in figure 24.

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		,653
Bartlett's Test of Sphericity	Approx. Chi-Square	319,933
	df	78
	Sig.	,000

Figure 23 Factor analysis precondition test

All the causes of scope changes were subjected to factor analysis using principal component extraction method, by choosing Oblique promax rotation option in SPSS software. Factor analysis uses two types of rotation for interpretation of developed clusters of variables. The interpretation using rotation is done by maximizing the loading of variables under a particular factor. The two types of rotation used in factor analysis are briefly explained below

1. Orthogonal rotation: This is applied to set of variables when underlying variables are assumed to be independent of each other.
2. Oblique rotation: This is applied to set of variables when underlying variables are assumed to be dependent on each other.

In the first analysis the most common oblique rotation was applied (i.e. Direct Oblimin). Thereafter as per the rule, component correlation matrix was checked for the strength of relationship that exits between the possible factor groups. As can be seen in figure 25, that three groups (i.e. 1, 2 & 3) have a moderate relationship between them. This moderate relationship can be seen as .290, .323 & .323 respectively. The moderate relationship between these groups means that they are dependent on each other. It can also be seen that few groups have no relationship between them by correlations .090, .180 etc. As we have both dependence and independence oblique promax rotation is suitable for such type of data. The promax rotation first interprets result by finding dependence between the variables and then later interprets results by assuming independence between the left over variables. The same rotation will be applied in all the four clustering phases.

Component Correlation Matrix

Component	1	2	3	4	5
1	1,000	,290	,181	,090	,180
2	,290	1,000	,323	,155	,237
3	,181	,323	1,000	,143	,104
4	,090	,155	,143	1,000	,138
5	,180	,237	,104	,138	1,000

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

Figure 24 Correlation strength between the developed scope change components

The second step is to check how many groups of factors can be developed. This is first done using Kaiser criterion which cluster variables based upon Eigen value. Basically an Eigen value measures how much variance a factor can explain within the available set of data. If the Eigen value is big, that means the factor is explaining a lot of variance in the data under evaluation. Based upon Kaiser Criterion, all the component groups which have Eigen value above 1 can be used as an exclusive group to cluster variables. As can be seen table 17, according to which scope change variables can be clustered under five component groups. However, it is important to note that Kaiser criterion over estimates variances; hence it cannot be independently used to cluster variables.

Therefore, parallel analysis was run, using an online parallel analysis tool (i.e. parallel analysis engine). This tool develops Eigen values for random set of data, but with the same number of variable and number of responses. The Eigen values obtained from this analysis is compared with the one obtained using Kaiser criterion. The components which have Kaiser Criterion Eigen values less than that of parallel analysis Eigen values are discarded.

Based upon the two analysis mentioned above, one can decided to have a fixed number of factors in SPSS software. The two analyses only helps an analyst to decide upon a logical number of fixed factors, but this analysis does not obliges him/her to have specified number of factors.

Component	Initial Eigenvalues		
	Total	% of Variance	Cumulative %
1	3,212	24,705	24,705
2	1,472	11,321	36,026
3	1,357	10,437	46,462
4	1,150	8,843	55,305
5	1,111	8,547	63,852
6	,926	7,124	70,976
7	,816	6,276	77,252
8	,780	6,001	83,253
9	,645	4,965	88,218
10	,512	3,935	92,153
11	,392	3,017	95,170
12	,362	2,786	97,956
13	,266	2,044	100,000

Random Data Eigenvalues

Root	Means	Percentile
1.000000	1.578008	1.718809
2.000000	1.439860	1.531348
3.000000	1.331814	1.415161
4.000000	1.222938	1.293336
5.000000	1.126480	1.186848
6.000000	1.042940	1.103095
7.000000	0.971838	1.031849
8.000000	0.895837	0.949129
9.000000	0.824299	0.890854
10.000000	0.753660	0.820023
11.000000	0.682089	0.735410
12.000000	0.606578	0.666035
13.000000	0.523659	0.601070

Table 17 Kaiser Criterion Eigen value and parallel analysis Eigen value table

After comparing the results obtained from the two Eigen value analyses done above, fixed the total number variables to three. The factor analysis was run again in SPSS, by specifying three fixed factors for clustering causes of scope changes. The scope change variables were clustered under three component groups, which can be seen in pattern matrix in table 18. The variables loaded under each component were assigned to each of the three fixed factors depending upon the strength of their respective correlations. The three developed component groups were then subjected to reliability test, to check whether these set of components are reliable or not. The reliability is checked by checking the value of "Cronbach's Alpha" under the reliability test results in SPSS. A component with a loaded set of variables can only be considered reliable if the value of Cronbach's Alpha is ≤ .70, while some researcher uses value of Cronbach's Alpha ≤ .60.

The three components were subjected to reliability test and the results are portrayed in figure 26. As can be seen in figure 26 that only component 1 is reliable and the other two are not. The clustering procedure was again repeated by fixing number of components to two. But only one component was found reliable. Hence, it can be stated that causes of scope changes cannot be clustered in more than one component using the available data.

Pattern Matrix[a]

	Component		
	1	2	3
12. Slow decision making process by the client.	,891	-,215	-,171
13. Late changes due to delays in review and approvals caused by an inexperienced clients	,862		
11. Consultants for other related project work fail to provide necessary information on time. (interface problem).	,598	,163	,122
8.Client request to modify design specifications	,502		,147
6. Incomplete project information provided by the client.	,452	,448	
2. Change in client business case.	-,122	,638	-,124
4. Changes in government Law & Standards.		,624	
5. The original contract documentation from the client may contain errors, omissions and contradictions in specifications		,513	,365
7. Incorrect project information provided by the client	,330	,480	,118
9.Abnormal site & ground conditions discovered during site investigation.	-,166	,200	,730
3. Change initiated by Stakeholders.		,524	-,655
1. Financial constraints on the client	,227	-,105	,563
10. Client request to execute additional work	,136		,152

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 4 iterations.

Table 18 Loading of variables under fixed components

Reliability Statistics		Reliability Statistics		Reliability Statistics	
Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items	Cronbach's Alpha	N of Items
,744	5	,501	5	,291	3
Component 1		**Component 2**		**Component 3**	

Figure 25 Cronbach's Alpha reliability test results

Before proceeding to the next three phases, it should be acknowledged that all the steps taken above will be repeated. Therefore, only the results obtained from factor analysis will be presented without repeating the explanation given above.

Clustering consequences of scope changes

The eight consequences variables of scope change were subjected to factor analysis. The two preconditions for factor analysis are satisfied by obtaining highly reliable results which can be seen below.

KMO = ,801	Bartlett's sphericity p value = ,000

After satisfying the two pre-conditions, the variables were subjected to Eigen value analysis. The Eigen value analysis resulted in clustering consequences under two fixed factors. In the next step the number of component groups was fixed to two. The consequences variables were again interpreted and loaded under these two components using oblique promax rotation.

The rotation applied resulted in loading six variable under component 1 and two variables under component 2. Both these components were then subjected reliability test. The reliability test results obtained were highly reliable for component 1 as Cronbach's Alpha obtained was (, 820); however reliability results for component 2 were highly unreliable as Cronbach's Alpha obtained was (, 447). Thus, it can be stated that consequences of scope change cannot be clustered in more than one component by using the available data.

Clustering of scope creep causes

The forty one causes of scope creep variables were subjected to factor analysis. The two preconditions for factor analysis are satisfied by obtaining highly reliable results which can be seen below.

KMO = ,825	Bartlett's sphericity p value = ,000

After satisfying the two pre-conditions, the variables were subjected to Eigen value analysis. The Eigen value analysis resulted in clustering causes of scope creep under four components. In the next step the number of component groups was fixed to four. Thereafter, the cause's variables were again interpreted and loaded under these four components using oblique promax rotation.

The rotation applied resulted in loading eighteen variables under component 1, ten variables under component 2, five variables under component 3 and eight variables under component 4 . As in this case the author is going to shuffle some variables from one component to the other, based upon qualitative evidence. Hence, each component with their respective loaded variable will be illustrated in a table

format. The value of Cronbach's Alpha will also be attached to the tables representing the entire set of variables under a component.

To begin with, assigning names to the four component groups obtained using factor analysis. The four components are named as following

1. Component 1: All the scope creep causes clustered under this component occurs in the project execution phase. Therefore, it has been decided to name this component as "Project execution phase issues".

2. Component 2: All the scope creep causes clustered under this component occurs in the project front end loading phase, except point 3 and 4 respectively. It has been decided to name this component as "Project front end loading phase issues". That is why point 3 and 4 has to be shifted to some other component to which they belong.

   Point 3 concerns with "Bad management of changes" and point 4 concerns with "project managers focusing on big changes and not on small ones". Both of these causes occur in project execution phase, as they cannot occur without the project being initiated. Consequently, these two causes will be shifted to component 1. Thereafter a reliability check will be conducted to check reliability of new cluster.

3. Component 3: All the scope creep causes clustered under this component occurs due to poor project governance practiced in an organization. Hence, it has been decided to name this component as "Project governance issues".

4. Component 4: All the scope creep causes clustered under this component occurs due to client related issues, except point 1 and 5 respectively. Therefore, it has been decided to name this component as "Client related issues". That is why point 1 and 5 has to be shifted to some other component.

   Point 1 concern with "Unforeseen conditions" as it unknown, it is has been decided to eliminate this cause from the four developed component sets. However, point 5 concerns with "Scope definition done by wrong people", this issue occurs in frontend loading phase. Therefore, point 5 will be shifted to component 2 and point 1 will be eliminated from the component. Thereafter a reliability check will be conducted to check reliability of new cluster.

Table 19 portrays clusters of scope creep causes after shuffling the variables on basis of qualitative evidences. The reader can see the clusters of variables based on only factor analysis in appendix F.1.

As can be seen in table 19, Cronbach's Alpha is highly reliable for all the 4 developed components. However, it is important to note that table 19 portrays edited cluster of scope creep variables based upon statistical and qualitative evaluation. The changes in table 19 are made in line with the arguments made in the preceding paragraph. Furthermore, component 1 now has 20 variables loaded under it instead of 18, component 2 has 9 variables loaded under it instead of 8. The number of variable in component 3 remains the same, while the number of variables in component 4 has been reduced to 6 from 8. It is important to note that after shuffling the variables from one component to the other, there is only a minor deviation in the reliability. Thus, it can be concluded that the set of components portrayed in table 19, are highly reliable and are in line with statistical and practical scope creep evidences.

Clustered causes of scope creep under four components on the basis of statistical and qualitative analysis				
S.NO	Component 1 = Project execution phase issues	Component 2 = Project front end loading issues	Component 3 = Project governance issue	Component 4 = Client related issues
	Cronbach's Alpha = ,907	Cronbach's Alpha =,822	Cronbach's Alpha =,766	Cronbach's Alpha =,720
1	Design change due to poor design brief	Misappraisal of the original scope of work	Inappropriate project organizational structure	Intervention by politicians and senior government officials.
2	Poor communication between the key partners is a main cause for design changes and rework.	The data was not enough when the scope was defined.	Inadequate arrangement of contract interface	Client requirement s
3	Design errors and omissions	Unrealistic budget due to underbidding	Lack of organizational senior management support.	Ignorance of key stakeholders until the project is underway.
4	Inconsistency between drawing and site conditions	Contractual agreement open to wide interpretation	Poor documentation of agreements with key partners. (Lead/Sub consultant, client)	The project is executed after years of completion of study and scope definition.
5	Poor interdisciplinary communication	In government projects, it is not easy to differentiate between what is included in the project and what is not included.	Wrong selection of Sub-consultant	Conflict in different government agencies interests
6	Team instability e.g. disputes, bankruptcy etc.	Citations of inadequate specification		Government officials are always "ambitious" and unrealistic regarding the outcome of projects.
7	Delays in producing design documents	Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework		
8	Insufficient data collection and survey before design	Project managers too eager to get additional work without fully understanding scope of work.		
9	Inadequate design team experience	Scope definition is done by the wrong people.		
10	Errors and omissions in quantity estimation			
11	Necessary variation of work			
12	Delay in design information			
13	Long waiting time for			

	approval of drawing
14	Lack of accountability on project team members
15	Lack of frequent project site visits.
16	Push to use new technology in uncertain project environment.
17	Not utilizing available resources within the company.
18	Project team working from different offices.
19	Bad management of project changes, and absence of scope management and control systems.
20	Most managers focus on major scope changes and ignore small changes that could lead to bigger scope creep problems.

Table 19 Scope creep causes components adjusted using qualitative evidences

Clustering of scope creep consequences

The eight consequence variables of scope creep were subjected to factor analysis. The two preconditions for factor analysis are satisfied by obtaining highly reliable results which can be seen below

KMO = ,825	Bartlett's sphericity p value = ,000

After satisfying the two pre-conditions, the consequences variables were subjected to Eigen value analysis. The Eigen value analysis resulted in clustering consequences under two factors. In the next step the number of component groups was fixed to two. The consequences variables were again interpreted and loaded under these two components using oblique promax rotation.

Clustered consequences of scope creep under two components on the basis of statistical analysis		
S.NO	Component 1 = Soft Impacts	Component 2 = Hard Impacts
	Cronbach's Alpha = ,814	Cronbach's Alpha =,657
1	Damage to firm reputation	Increase in cost to the company i.e. decreased profitability
2	Low morale of project team	Inability to meet the client scheduled milestones
3	Poor quality of design deliverables	Rework in already completed design
4	Legal dispute between client and consultant	
5	Client dissatisfaction	

Table 20 Scope creep consequences components developed using factor analysis

The rotation applied resulted in loading five variable under component 1 and three variables under component 2. Both these components were then subjected reliability test. The reliability test results obtained were reliable for both component 1 and 2 as can be seen in table 20. Cronbach's Alpha obtained for component 2 is less than (,70) but, then how is it considered reliable. As, per the theory there is not much difference between (,657 and ,70). In addition Cronbach's Alpha obtained is usually low when the number of variable loaded under a component is less in number. Thus, based upon the argument made above the author considers both the components as reliable. The names assigned to the two component groups obtained using factor analysis are presented below

1. Component 1: All the scope creep consequences clustered under this component are considered as soft scope creep impacts. As all the scope creep consequence that fall under this component are not visible to the project team until their impact is large enough. Therefore, it has been decided to name this component as "soft scope creep impacts".

2. Component 2: All the scope creep consequences clustered under this component are considered as hard scope creep impacts. As all the scope creep consequence that fall under this component are visible to the project team as soon as they start impacting the project. Therefore, it has been decided to name this component as "hard scope creep impacts".

5.2.4 CORRELATION ANALYSIS

As stated in chapter 4, the respondents were asked to score causes and consequences of scope change and scope creep on a Likert scale of 5 point ranging from Never to strongly agree (according to their frequency of occurrence). In order to assess the questionnaire response, the type of Likert scale used has to be identified. Whether a Likert scale is an ordinal measuring scale or a ratio measuring scale is under ongoing debate in the literature. However, for this research the Likert scale used will be considered as an ordinal measuring scale. Field, (2009) states that in any situation in which we ask people to rate something subjective we should probably regard these data as ordinal although many scientist do not. It is important to note that scope change and scope creep questions asked in survey questionnaire are subjective and not quantifiable as they are not asked in context to a specific project.

Moreover, choosing between the types of scale does not affect correlation results of this research. As Spearman's correlation will be used and it does not rely on the type of scale being used. The reason behind opting for Spearman's correlation over Pearson's correlation is that the data obtained from the survey is not normally distributed. Pearson's correlation can only be applied on normally distributed set of data, which is not the case in this research. While Spearman's correlation can be applied to both normally and non-normally distributed data, that is why it is also called non-parametric analysis. It is also important to acknowledge that the results obtained from using either of these two correlation methods are similar to large extent.

For correlation analysis a two tailed test approach will be used, as no directional dependence hypothesis is made between the variables being investigated. According to Field, (2009) a two tailed test should be used when one cannot predict the nature of relationship that exist between the variables under evaluation. This decision was made as it is very complex to predict exact relationship between each cause and consequence of scope change and scope creep. Correspondingly, a holistic prediction cannot be made as an individual causes can have different relationship with different consequences. Therefore, in this research a no directional hypothesis will be used in which three possibilities exits between the investigated variables which are

1. A positive relationship can be found between the variables under evaluation or
2. A negative relationship can be found between the variables under evaluation or
3. No relationship can be found between the variables under evaluation

Furthermore, this research will define strength of correlation between two variables on the basis of strength scale defined in table 21.

Cohen's d	R-value	Effect size
< 0,2	<0,10	No effect
≥0,2	≥0,10	Small effect
≥0,5	≥0,30	Moderate effect
≥0,8	≥0,50	Large effect

Table 21 Correlation size effect (Valentine & Cooper, 2003)

While making interpretation of correlations that exists between two variables, one should not only consider strength of correlation, but should also consider significance of a correlation. A significant correlation means that the error in correlation measurement is small enough, hence a correlation can be

considered reliable. In this section correlation that exists between causes and consequences of scope change and scope creep will be highlighted. It has been decided not to include all the main tables of correlations under this section, due to their large size and number. This section will only present ranking of scope change and scope creep causes on the basis of highly significant correlation that exists between causes and consequences.

There are two levels of significance that can be achieved in correlation analysis. The two significance level can be distinct by considering significance level where $p<0.05$ as significant ($P<0.5$ means that probability of deviating from estimated relationship is less than 5%) and considering significance level where $p<0.01$ as highly significant. In this research only highly significant correlations will be considered as the margin of error is very small and the correlation results can be considered more reliable. The main tables of all the correlation analysis results are enclosed in the appendix G for the readers to acknowledge all the correlations that exits between causes and consequences.

In the following sub-sections the causes of scope change and scope creep will be ranked based upon the highly significant correlation that exists between a cause and multiple consequences. The ranking obtained from correlation will illustrate which cause has more potential of impacting multiple numbers of consequences. The objective is to develop two list of scope change and scope creep ranking. The first ranking list will be developed considering the frequency rate of scope creep causes occurrence in a project, while the second ranking list will be developed considering which cause, is more likely to have potential impact on multiple consequences based upon correlation analysis. The rankings will be presented under the following sub-sections

1. Ranking of scope change causes based upon frequency of occurrence and correlation analysis.
2. Ranking of scope creep causes components developed using factor analysis based upon frequency of occurrence and correlation analysis.
3. Ranking of scope creep causes in component one based upon frequency of occurrence and correlation analysis.
4. Ranking of scope creep causes in component two based upon frequency of occurrence and correlation analysis.
5. Ranking of scope creep causes in component three based upon frequency of occurrence and correlation analysis.
6. Ranking of scope creep causes in component four based upon frequency of occurrence and correlation analysis.
7. Ranking of scope change and scope creep consequences based upon their frequency of occurrence.

As the total number of correlation for scope changes variables are 104 out of which 11 are significant and 15 are highly significant. While, the total number of correlation that exist between scope creep variables are 328 out of which 72 are significant and 147 are highly significant. Acknowledging the total number of significant correlations for both scope changes and scope creep, it is not feasible to provide a context to each and every one of them explicitly in this research. Hence, only on the basis of highly significant correlation between scope change variables and scope creep components list of ranking will be developed. Ideally the highly significant correlations that exist between two variables should be provided a context by using a qualitative evidence, to explain their relationship. However, as the number of highly significant correlation between causes and consequences of scope change and scope creep is very large, it has been decided to just provide qualitative evidences for the causes which have potentials of causing high impact on the project.

The highly significant positive correlations that exist between these variables explain, occurrence of a scope change or a scope creep cause will lead to a positive increment on the consequence with which it is correlated. Even though, correlation does not tell us anything about causation or how much effect one would see on the consequences. Then again, these positive correlations only explain that if one variable increases (i.e. causes) the variable correlated with it would also increase (i.e. consequence). Acknowledging the argument made above, it can be stated that a cause which has highly significant positive correlation with large number of consequences can be considered critical. The reason behind considering it critical is its likelihood of causing an increase in the occurrence of multiple numbers of consequences.

Lastly, this paragraph will briefly explain how ranking of scope change and scope creep causes will be illustrated in the proceeding sub-sections. The ranking will be illustrated in a table with two columns of ranking. One of the columns will illustrate ranking of causes on the basis of their respective frequency of occurrence in a project. The frequency of occurrence is estimated by first taking mean of 120 responses for each and every scope change and scope creep causes and thereafter arranging them in a descending order. The frequency of occurrence is illustrated in the table format by using different colour shades as illustrated figure 27.

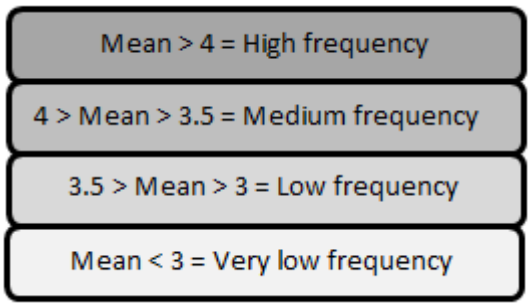


Figure 26 Frequency of occurrence ranking colour indicators

While the second the column illustrates ranking of causes based upon highly significant positive correlation that a cause shares with multiple number of consequences. The cause of scope change or scope creep which shares largest number of multiple highly significant positive correlations with consequences is ranked one. Thereafter, all the other causes are ranked using the same logic in a descending order of their multiple relationships with consequences. The correlation ranking criteria are illustrated in the figure 28.

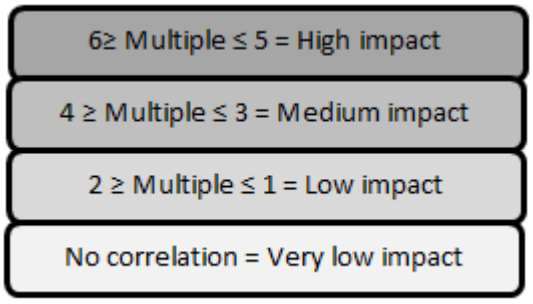


Figure 27 Multiple highly significant correlation ranking indicators

Correlation between causes and consequences of scope changes

In this sub-section on the basis of significant correlation that exists between causes and consequences of scope change and on frequency of occurrence, the causes of scope changes will be ranked. By means of Spearman's correlation matrix all the thirteen causes and the eight consequences of scope change were correlated, leading to a 21 (13+8) by 21 matrix. In the final correlation matrix (appendix G.1) only the correlations which are highly significant between causes and consequences of scope change is highlighted for reader convenience. Additionally, it is important to note that no negative correlations were found between the causes and consequences of scope change. As already stated while introducing correlation, that only 26 significant correlations were found, out of 104 total numbers of correlations. Acknowledging these numbers it can be stated that only 26 positive correlations exist between causes and consequences of scope changes and remaining 78 correlations shows no relationship. In table 22 the ranking of scope change causes is portrayed, the ranking is based upon frequency of occurrence and on correlation analysis.

Ranking scope changes causes		
S.NO	Based on frequency of occurrence by taking mean of all the response/cause	Based on highly significant positive relationship between causes and multiple consequences
1	Client request to execute additional work	Financial constraints on the client
2	Change initiated by Stakeholders.	Late changes due to delays in review and approvals caused by an inexperienced clients
3	Client request to modify design specifications	Abnormal site & ground conditions discovered during site investigation.
4	Incomplete project information provided by the client.	Slow decision making process by the
5	Abnormal site & ground conditions discovered during site investigation.	The original contract documentation from the client may contain
6	Change in client business case.	Change initiated by Stakeholders.
7	The original contract documentation from the client may contain errors, omissions and contradictions in specifications	Incomplete project information provided by the client.
8	Incorrect project information provided by the client	Incorrect project information provided by the client
9	Late changes due to delays in review and approvals caused by an inexperienced clients	Client request to execute additional work
10	Slow decision making process by the client.	Client request to modify design specifications
11	Financial constraints on the client	Change in client business case.
12	Consultants for other related project work fail to provide necessary information on time. (Interface problem).	Consultants for other related project work fail to provide necessary information on time. (Interface problem).
13	Changes in government Law & Standards.	Changes in government Law & Standards.

Table 22 Ranking of scope change causes based on frequency of occurrence and correlation analysis

Acknowledging the rankings of scope change causes under two criteria in table 22 arguments will made on the importance of causes which have high frequency of occurrence and which have high potentials of impacting the project. The arguments on ranking are made in the following to two paragraphs.

1. **Scope change causes importance on the basis of frequency of occurrence**

   As can be seen in table 22 four causes of scope change have high frequency of occurrence in a project. These causes of scope changes also have potentials to impact design and engineering firm project performance. Depending upon the terms and condition in contractual agreement, these changes can be considered as normal service of work, of the consultant by the client. In addition, these causes can also be seen in the list of scope creep causes developed in chapter 3 (table 7). Therefore, any uncertainty associate to these scope change causes should be critically acknowledged by the design and engineering consultancy firm. The proposed conceptual scope creep management model in frontend loading involves tools such as expert review which will enable identification of these uncertainties. The consultant can also try to leverage these scope change causes by making them opportunities, by mitigating their uncertainties for the company. Lastly, these ranking of scope change causes based on frequency of occurrence can also be leveraged by the client by mitigating/minimizing their frequency of occurrence in the projects.

2. **Scope change causes importance on the basis of correlation analysis**

   The ranking of causes shows that there is only one cause which has high potentials of impacting the project (significant correlation with consequences). The high impact on the project due to such a cause can also be seen in case studies (chapter 3, project D). Due to financial constraints on the client there was a total increase of 22.1% in the budget allotted to the consultant. Hence, acknowledging this relationship the client should always be very careful while planning for the project. Although the high-ranked cause might be in centre of attention, the other causes shouldn't be ignored. In addition, the consultant should also acknowledge the high, medium and low impact causes of scope change which can be considered by the client as normal service of work of the consultant based upon contractual agreement.

Correlation between causes and consequences (components) of scope creep

In this sub-section significant correlation that exists between causes and consequences components of scope creep is highlighted in table 23. Thereafter, in table 24 scope creep causes components are ranked on the basis of their respective frequency of occurrence and on the basis of significant positive correlation that exists between causes and consequences. By means of Spearman's correlation matrix all the four components of causes and the two components of consequences for scope creep were correlated, leading to 6 (4+2) by 6 matrix. The final correlation matrix table 23 portrays all the correlation that exists between the scope creep components. Correlation analysis shows that all the scope creep causes components have highly significant positive correlation with the consequences components. Furthermore, the scope creep causes components in table 24 have been ranked in descending order, on the basis of correlation strength they share with consequences components.

Ranking using significant correlations between scope creep causes and consequence components				
S.NO	Causes	Consequences	Correlations	Strength
1	Execution phase Issue	Soft scope creep impacts	,661**	Strong
		Hard scope creep impacts	,441**	Moderate
2	Frontend loading phase Issue	Soft scope creep impacts	,565**	Strong
		Hard scope creep impacts	,407**	Moderate
3	Project governance issues	Soft scope creep impacts	,510**	Strong
		Hard scope creep impacts	,321**	Moderate
4	Client related issue	Soft scope creep impacts	,391**	Moderate
		Hard scope creep impacts	,289**	Weak

Table 23 Ranking of scope creep causes components based on correlation analysis

Ranking scope creep causes components formulated using factor analysis		
S.NO	Based on frequency of occurrence by taking mean of all the response/cause	Based on highly significant positive relationship between causes and multiple consequences
1	Client related issue	Execution phase Issue
2	Frontend loading phase Issue	Frontend loading phase Issue
3	Execution phase Issue	Project governance issues
4	Project governance issues	Client related issue

Table 24 Ranking of scope creep causes components based on frequency of occurrence and correlation analysis

As can be seen in table 23, the execution phase, the front end loading phase and the project governance issues shows strong correlation with consequences components. While, the client related issues only shows moderate correlation but shows higher frequency of occurrence in table 24. Acknowledging these correlation trends it can be stated, that the scope creep causes initiated by the employees at a company has larger impact on the project. In addition, the execution phase issues are the most critical ones as they are most strongly correlated with the consequence components and thereafter come frontend loading phase issues. These trend shows that both the monitoring & controlling process group and the planning process group portrayed in figure 12 are very critical for a project to be successful.

Moreover, it is interesting to note that scope creep soft consequences component shows stronger correlation with all the causes components. But, when we see table 25 portraying correlation between soft and hard consequence components, it can be said that any increase in either of the two components will also lead to an increase on the other component.

Significant correlations between scope creep consequence components				
S.NO	Consequences	Consequences	Correlations	Strength
1	Hard scope creep impacts	Soft scope creep impacts	,527**	Strong

Table 25 Correlation between scope creep consequences components

After evaluating and ranking scope creep components using correlations analysis, it is clear which component has more potential of causing harm to the project. However, it is also important to note which scope creep causes within these four components have large potential of harming the project performance. In the following sub-section the scope creep causes will be ranked under four components developed using factor analysis. The following sub-sections will rank causes of scope creep using two approaches. Firstly, the causes are ranked on the basis of their frequency of occurrence in a project. Secondly, the causes are ranked based upon their potential of causing large impact on the project. These ranking will help project managers/project team members to acknowledge which scope creep cause within these components is likely to cause a positive increment on large number of consequences and which cause has high frequency of occurrence.

Correlation between execution phase issues and consequences of scope creep

In this sub-section on the basis of significant correlation that exists between the project execution phase scope creep causes and consequences, and on frequency of occurrence, the causes of scope creep will be ranked. By means of Spearman's correlation matrix all the twenty causes in execution phase component and the eight consequences of scope creep were correlated, leading to a 28 (20+8) by 28 matrix. In the final correlation matrix (appendix G.2) only the correlations which are highly significant between causes and consequences will be highlighted for reader convenience. There were no negative correlations found between the causes in component 1 and consequences of scope creep. In total 160 correlations were obtained, out which 31 were found significant and 85 correlations were found highly significant. Acknowledging these numbers it can be stated that only 116 positive correlations exists between the execution phase causes and consequences. While the remaining 44 correlations shows no relationship. The ranking of project execution phase scope creep causes is portrayed in table 26.

Ranking scope creep execution phase causes		
S.NO	Based on frequency of occurrence by taking mean of all the response/cause	Based on highly significant positive relationship between causes and multiple consequences
1	Bad management of project changes, and absence of scope management and control systems.	Inadequate design team experience
2	Most managers focus on major scope changes and ignore small changes that could lead to bigger scope creep problems.	Lack of frequent project site visits.
3	Poor communication between the key partners is a main cause for design changes and rework.	Design errors and omissions
4	Poor interdisciplinary communication	Not utilizing available resources within the company.
5	Insufficient data collection and survey before design	Bad management of project changes, and absence of scope management and control systems.
6	Design change due to poor design brief	Delays in producing design documents
7	Inconsistency between drawing and site conditions	Errors and omissions in quantity estimation
8	Delay in design information	Insufficient data collection and survey before design
9	Inadequate design team experience	Lack of accountability on project team members
10	Long waiting time for approval of drawing	Project team working from different offices.
11	Necessary variation of work	Design change due to poor design brief
12	Project team working from different offices.	Team instability e.g. disputes, bankruptcy etc.
13	Design errors and omissions	Necessary variation of work
14	Errors and omissions in quantity estimation	Poor interdisciplinary communication
15	Lack of accountability on project team members	Inconsistency between drawing and site conditions
16	Delays in producing design documents	Poor communication between the key partners is a main cause for design changes and rework.
17	Not utilizing available resources within the	Most managers focus on major scope changes and ignore small changes that could lead to bigger scope creep problems.

	company.	
18	Lack of frequent project site visits.	Push to use new technology in uncertain project environment.
19	Push to use new technology in uncertain project environment.	Delay in design information
20	Team instability e.g. disputes, bankruptcy etc.	Long waiting time for approval of drawing

Table 26 Ranking of scope creep execution phase causes based on frequency of occurrence and correlation analysis

Although the extensive list of scope creep causes is important, there is always limitation and constraints to pay attention to all of them. Then by ranking them based on logic, project manager or project team can focus on the most important ones rather than the whole extensive list. In this research the ranking is given based on two different approaches; the frequency and the correlation with the consequences (the same as what has been done for scope change causes and consequences). Acknowledging the rankings of scope creep causes under two criteria in table 26 arguments will made on the importance of causes which have high and medium frequency of occurrence and on causes which have high potentials of impacting the project. The same logic will be used to rank causes of scope creep for the remaining three components.

In the following 2 paragraphs brief explanation of each ranking and its value is given

1. **Scope creep causes importance on the basis of frequency of occurrence**

   As can be seen in table 26 one cause of scope creep has high frequency of occurrence, whereas five causes have medium frequency of occurrence. These causes of scope creep are very important to be controlled for successful project execution. '*Bad management of project changes and absence of scope management and control systems'* has highest frequency of occurrence; it was observed from the case studies at the company (chapter 3) that there is hardly any unified structured scope management process followed by all the projects. Thus, all the projects are managed by the project managers on their own experience, which supports this cause; bad management. The main purpose of the proposed model in chapter 4 was to provide the company with a structured process for managing the project scope. Furthermore, the other five causes should be acknowledged by the project manager critically while executing the project due to their frequency of occurrence. The scope creep management model proposed in this research will help in mitigating/minimizing these causes of scope creep. For instance, while using scope creep management model execution phase tools such as Scrum process, RACI and PHC the project manager can minimize/mitigate occurrence scope creep causes 3, 4, 5 &6 which originates from poor communication. While the cause number 2 can be mitigated by having a structured scope management process proposed in chapter 4. Lastly, it is important to note that all the remaining execution phase scope creep causes with low frequency should be acknowledged by the project manager while using the proposed scope creep management model.

2. **Scope change causes importance on the basis of correlation analysis**

   The ranking based on correlation analysis (significant correlation with consequences) shows that there are ten causes of scope creep which have potential of causing high impact on the project execution phase performance. These causes of scope creep have also been identified in chapter 3 case studies. For instance all the following causes have been identified in project C, '*Inadequate design team experience'* in point 2 and 17, '*Lack of frequent project site visits'* point 21, Not utilizing available resources within the company point 5, '*Delays in producing design documents'* point 27, '*Lack of accountability on project team members'* point 3 and '*Project team working from different offices'* point 20 and 23. Causes identified in project B, '*Design errors and omissions'* point 8, '*Insufficient data collection and survey before design'* point 6 and '*Lack of accountability on project team members'* point 1. Causes identified in project A, '*Bad management of project changes, and absence of scope management and control systems'* point 4. However, no explicit evidence was

found in context to *'Errors and omissions in quantity estimation'* in the studied projects. In project A there is still an ongoing dispute between the client and the consultant on bill of quantities based on contractual agreement which can cause scope creep. Hence, acknowledging the highly significant relationships and qualitative evidences between the above mentioned causes and multiple consequences. It can be stated that the project managers and the project team members while executing the project should very critically acknowledge these highly ranked causes of scope creep. Although the highly-ranked cause might be in centre of attention, the other causes shouldn't be ignored. Correspondingly, the main purpose of proposed conceptual scope creep management model execution phase tools and techniques is to minimize/mitigate occurrence of scope creep causes in execution phase. The project managers can use ranked scope creep causes list as a check list while using the model.

Correlation between frontend loading phase causes of scope creep and consequences

In this sub-section on the basis of significant correlation that exists between the project frontend loading phase scope creep causes and consequences, and on frequency of occurrence, the causes of scope creep will be ranked. By means of Spearman's correlation matrix all the nine causes in front end loading phase component and the eight consequences of scope creep were correlated, leading to a 17 (9+8) by 17 matrix. In the final correlation matrix (appendix G.3) only the correlations which are highly significant between causes and consequences will be highlighted for reader convenience. There were no negative correlations found between the causes in component 2 and consequences of scope creep. The total number of 72 correlations was obtained, out which 19 were found significant and 35 correlations were found highly significant. Acknowledging these numbers it can be stated that only 54 positive correlations exists between scope creep front end loading phase causes and consequences of scope creep and remaining 18 correlations shows no relationship. The ranking of project frontend loading phase scope creep causes is portrayed table 27.

Ranking scope creep frontend loading phase causes		
S.NO	Based on frequency of occurrence by taking mean of all the response/cause	Based on highly significant positive relationship between causes and multiple consequences
1	The data was not enough when the scope was defined.	Project managers too eager to get additional work without fully understanding scope of work.
2	Misappraisal of the original scope of work	Unrealistic budget due to underbidding
3	Contractual agreement open to wide interpretation	Misappraisal of the original scope of work
4	Scope definition is done by the wrong people.	Citations of inadequate specification
5	Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework	The data was not enough when the scope was defined.
6	Unrealistic budget due to underbidding	Contractual agreement open to wide interpretation
7	In government projects, it is not easy to differentiate between what is included in the project and what is not included.	Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework
8	Project managers too eager to get additional work without fully understanding scope of work.	Scope definition is done by the wrong people.

9	Citations of inadequate specification	In government projects, it is not easy to differentiate between what is included in the project and what is not included.

Table 27 Ranking of scope creep frontend loading phase causes based on correlation analysis

In the following 2 paragraphs brief explanation on ranking illustrated in table 27 is given:

1. **Scope creep causes importance on the basis of frequency of occurrence**

   As can be seen in table 27 that no scope creep cause has high frequency of occurrence in project frontend loading phase. However, there are six causes of scope creep which have medium frequency of occurrence. All the medium frequency causes can be mitigated/minimized by use of proposed conceptual scope creep management model frontend loading phase tools, techniques and approaches such as BM technique, WBS tool, expert review and handover approach. However, it is important to note that two of the causes '*Misappraisal of the original scope of work'* and '*Unrealistic budget due to underbidding'* have high impact on the project performance. Acknowledging the medium frequency and high impact of these two causes the project proposal team should be very careful while preparing a project proposal along with its commercial cost. In addition, scope creep causes 1, 2, 3, 4, 5 & 6 can be mitigated/minimized in the expert review step of the model. If this step is missed than these causes impact cannot be mitigated but can only be minimised in handover step of the proposed model. While for cause 6 exclusive provisions have been made in the model, by using BM technique and coarse WBS actual operation cost of the project can be estimated.

2. **Scope change causes importance on the basis of correlation analysis**

   The ranking shows that there are three frontend loading phase scope creep causes which have potential of causing high impact on the project performance. All these high impact causes of scope creep have been identified in case studies (chapter 3). For instance '*Project managers too eager to get additional work without fully understanding scope of work*' have been identified in project A point 5, '*Unrealistic budget due to underbidding*' was identified at two occasions one in project B point 11 & the other in project C point 2 and '*Misappraisal of the original scope of work*' was identified in project C point 4. Furthermore two of the above mentioned causes have already been addressed in the preceding paragraph due to their medium frequency of occurrence. However, it is important to highlight that '*Project managers too eager to get additional work'*, only occurs when the project is under execution. But as per project management theory all additional scope of work is to be considered as a separate project in itself. Acknowledging this aspect the project manager should always try to follow the steps suggested in frontend loading phase of the proposed conceptual model. By following those steps the project manager will be able to minimize the uncertainties which are associated to additional work. Lastly, the project proposal team while giving high priority to the highly ranked causes of scope creep should also use the medium and low impact causes in the check list. It is important to acknowledge all the causes of scope creep in the check list irrespective of their ranking as all the projects have their own complexity and uniqueness which might lead to occurrence of any cause.

Correlation between project governance causes of scope creep and consequences

In this sub-section on the basis of significant correlation that exists between the project governance scope creep causes and consequences, and on the basis of their frequency of occurrence, the causes of scope creep will be ranked. By means of Spearman's correlation matrix all the five causes in project governance component and the eight consequences of scope creep were correlated, leading to a 13 (5+8) by 13 matrix. In the final correlation matrix (appendix G.4) only the correlations which are highly significant between causes and consequences are highlighted for reader convenience. There were no negative correlations found between the causes in component 3 and consequences of scope creep. The total number of 40 correlations was obtained, out which 9 were found significant and 17 correlations were found highly significant. Acknowledging these numbers it can be stated that only 26 positive correlations exists between scope creep project governance causes and consequences of scope creep and

remaining 14 correlations shows no relationship. The ranking of project governance scope creep causes is portrayed in table 28.

Ranking scope creep project governance causes		
S.NO	Based on frequency of occurrence by taking mean of all the response/cause	Based on highly significant positive relationship between causes and multiple consequences
1	Poor documentation of agreements with key partners. (Lead/Sub consultant, client)	Lack of organizational senior management support.
2	Inadequate arrangement of contract interface	Inadequate arrangement of contract interface
3	Inappropriate project organizational structure	Poor documentation of agreements with key partners. (Lead/Sub consultant, client)
4	Lack of organizational senior management support.	Wrong selection of Sub-consultant
5	Wrong selection of Sub-consultant	Inappropriate project organizational structure

Table 28 Ranking of scope creep project governance causes based on frequency of occurrence and correlation analysis

In the following 2 paragraphs brief explanation on ranking illustrated in table 28 is given

1. **Scope creep causes importance on the basis of frequency of occurrence**

   As can be seen in table 28 no project governance related scope creep causes have high or medium frequency of occurrence. Hence, acknowledging this aspect no elaboration will made on the frequency of occurrence of causes under this paragraph.

2. **Scope change causes importance on the basis of correlation analysis**

   The ranking based on correlation analysis (significant correlation with consequences) shows that there are two project governance related scope creep causes which have potential of causing high impact on the project performance. Both these causes of scope creep have been identified in case studies (chapter 3, Project B). '*Lacks of organizational senior management support*' have been identified in point 1 and '*Inadequate arrangements of contract interface*' have been identified in point 7. Consequently, acknowledging the highly significant relationships and qualitative evidences between the above mentioned causes and multiple consequences. The senior management at the company should critically acknowledge these causes of scope creep, as they are responsible to solve these issues. Moreover, the tools, techniques and approaches used in the proposed conceptual scope creep management model will also facilitate in minimizing these scope creep causes. For instance, '*Inadequate arrangements of contract interface*' can be identified and mitigated in the expert review step of the proposed model. While, PHC tool in the execution phase also makes senior management responsible for the project performance, thus involving senior management. Lastly, the entire ranking list should be used as a checklist by the concerned line manager and the proposal team to mitigate there occurrence.

Correlation between client related causes of scope creep and consequences

In this sub-section on the basis of significant correlation that exists between the project client related scope creep causes and consequences, and on the basis of their frequency of occurrence, the causes of scope creep will be ranked. By means of Spearman's correlation matrix all the six causes in client related issues component and the eight consequences of scope creep were correlated, leading to a 14 (6+8) by 14 matrix. In the final correlation matrix (appendix G.5) only the correlations which are highly significant between causes and consequences are highlighted for reader convenience. There were no negative correlations found between the causes in component 4 and consequences of scope creep. The total of 48 correlations was obtained, out which 13 were found significant and 10 correlations were found highly

significant. Acknowledging these numbers it can be stated that only 23 positive correlations exists between scope creep client related causes and consequences of scope creep and remaining 25 correlations shows no relationship. The ranking of project client related scope creep causes is portrayed in table 29.

Ranking scope creep client related causes		
S.NO	Based on frequency of occurrence by taking mean of all the response/cause	Based on highly significant positive relationship between causes and multiple consequences
1	Client requirements	Government officials are always "ambitious" and unrealistic regarding the outcome of projects.
2	Ignorance of key stakeholders until the project is underway.	The project is executed after years of completion of study and scope definition.
3	Government officials are always "ambitious" and unrealistic regarding the outcome of projects.	Conflict in different government agencies interests
4	The project is executed after years of completion of study and scope definition.	Intervention by politicians and senior government officials
5	Intervention by politicians and senior government	Ignorance of key stakeholders until the project is underway.
6	Conflict in different government agencies interests	Client requirements

Table 29 Ranking of scope creep client related causes based on frequency of occurrence and correlation analysis

In the following 2 paragraphs brief explanation on ranking illustrated in table 29 is given

1. **Scope creep causes importance on the basis of frequency of occurrence**

   As can be seen in table 29 no client related scope creep cause has high frequency of occurrence. However, there are six causes which have medium frequency of occurrence on a project. By making an observation from case studies, it can be said that client related causes of scope creep highly rely upon the terms and conditions mentioned in the lump sum contract. For instance, in project A (chapter 3) the client is demanding for an explicit list of “Bill of quantities”, while explicit list is not one of the deliverable mentioned the contract. Therefore, the consultant is not delivering the explicit detailed list. However, project B point 10 mentions a clause from the contract which obliges consultant to carry out additional work instructed by the client even if there is no commercial agreement. Due to this clause large amount of work was delivered for free to the client. Acknowledging the arguments made above and medium frequency of occurrence of all the client related scope creep causes. It can be stated that the ranking of all the client related causes should be used as a checklist in both of project phases. In frontend loading phase this list should be used by the proposal and expert review team to mitigate/minimize contract related uncertainties. While, in the execution phase this list should be used by the project manager to make sure no gold plating is happening on the project.

2. **Scope change causes importance on the basis of correlation analysis**

   The ranking based on correlation analysis shows that there is no client related scope creep cause which has high potential of impacting the project performance. Therefore, no explanation will be given under this paragraph. Correspondingly, as all the client related scope creep causes have medium frequency of occurrence, they have been addressed in the preceding paragraphs.

Ranking of scope creep causes irrespective of correlation analysis

In this section all the scope creep causes which have high and medium frequency of occurrence will be ranked independent of the components. This holistic ranking on the basis of high and medium frequency of occurrence will help project team members acknowledge which are the leading causes of scope creep in projects executed on lump sum price contracts. As can be seen in table 30 that bad management of project changes shows highest frequency of occurrence and thereafter it is followed by client requirements. Both these causes of scope creep occur in execution phase of the project. The explanations behind occurrence of these causes have already been given in the preceding sub-sections; therefore no explanation will be given under this sub-section. However, this ranking list should be used as lessons learned checklist in all the projects, which are executed on lump sum price contracts to minimise their occurrence.

S.NO	Ranking of scope creep causes on the basis of frequency of occurrence	Mean
1	Bad management of project changes, and absence of scope management and control systems.	4,1167
2	Client requirements	4,0500
3	The data was not enough when the scope was defined.	3,8833
4	Ignorance of key stakeholders until the project is underway.	3,8750
5	Misappraisal of the original scope of work	3,8667
6	Contractual agreement open to wide interpretation	3,7583
7	Most managers focus on major scope changes and ignore small changes that could lead to bigger scope creep problems.	3,7583
8	Poor communication between the key partners is a main cause for design changes and rework.	3,7583
9	Poor interdisciplinary communication	3,6083
10	Insufficient data collection and survey before design	3,5667
11	Design change due to poor design brief	3,5583
12	Scope definition is done by the wrong people.	3,5250
13	Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework	3,5000
14	Government officials are always "ambitious" and unrealistic regarding the outcome of projects.	3,5000
15	Unrealistic budget due to underbidding	3,4917
16	The project is executed after years of completion of study and scope definition.	3,4583
17	Intervention by politicians and senior government officials.	3,4417

18	Conflict in different government agencies interests	3,1500

Table 30 Ranking of scope creep causes based upon frequency of occurrence

5.2.5. Linking Scope creep consequences with project success criteria

In this sub-section makes a link between the highly ranked scope creep consequences and project success criteria identified in chapter two (section 2.1.3). The scope creep consequences are ranked on the basis of their respective frequency of occurrence in a project. As can be seen in table 31, scope creep consequences 1, 2, 3, 4, 6 & 8 are related to the project success criteria identified in literature study. Acknowledging this implicit relation between consequences and success criteria, it can be stated that scope creep causes affects project success. Therefore, the highly ranked scope creep causes in preceding sections should be critically acknowledged by design and engineering consultancy firms. The critical acknowledgment will help firms take action in due time and prevent occurrence of scope creep, so that their projects can be successfully executed.

S.NO	Ranked Scope creep consequences	Project Success criterion
1	Increase in cost to the company i.e. decreased profitability	Adherence to project budget
		Project profit
2	Inability to meet the client scheduled milestones	Adherence to project schedule
3	Rework in already completed design	Adherence to functional requirements
4	Client dissatisfaction	Client and stakeholder satisfaction
5	Low morale of project team	
6	Poor quality of design deliverables	Company reputation
7	Legal dispute between client and consultant	Market share
8	Damage to firm reputation	Company reputation

Table 31 Linking scope creep consequences with project success criteria

5.3 CONCEPTUAL SCOPE CREEP MANAGEMENT MODEL VALIDATION RESULTS

In this section, the data gathered using focus group validation process will be evaluated by making a qualitative analysis. Thereafter, on the basis of qualitative analysis this section will conclude workability, effectiveness and applicability of the developed conceptual scope creep management model.

Project scope management model

In this section first the two models adopted from leading project management manuals will be linked to the developed scope creep management model. As the developed model is designed to works under the umbrella of the scope management process suggested by PMBOK and change management approach suggested by PRINCE 2 project management manual. These two management models have been briefly explained in chapter 2 (section 2.2).

Furthermore, it is also important to note that the developed conceptual scope creep management model was validated in the focus group of experts. The author first introduced the experts to the two models adopted from project management manuals and thereafter, the developed conceptual scope creep management model was introduced and validated. The scope management process illustrated in figure 29 is chosen to make an explicit distinction between scope management processes used in project frontend loading phase and execution phase.

Figure 12 in chapter 2 illustrates scope management process proposed to be used in this research by making an argument on different approaches suggested by the project management manuals. The distinction under two groups namely planning process group and monitoring & controlling process group is suggested by ISO 21500 and PMBOK standards. While, the scope definition approach in this model is adopted from PRINCE 2 and APM manual. As these two standards do not disagree with defining scope of work using WBS but, they suggest using product breakdown structure (PBS) in addition to WBS. The PBS helps in defining product specification, on the basis of which planning and resource allocation can be done using WBS. Hence, by combining approaches from these project management manuals the scope management process was developed. Moreover, an extensive literature review was conducted to identify flaws in these two process groups. The flaws identified in these process groups facilitated in designing conceptual scope creep management model.

As can be seen in figure 29, conceptual scope creep management model frontend loading phase relates to planning process group, while the execution phase relates to monitoring & controlling process group. These two relations between scope management process and conceptual scope creep management model in combination tend to minimize/mitigate occurrence of scope creeps in projects. The scope management process tells us “what” should be done in each process group, while the conceptual model tells us how these things are to be done in order to minimize/mitigate scope creep causes. The model also provides a check list of scope creep causes which can be used by the project team to identify scope creep causes.

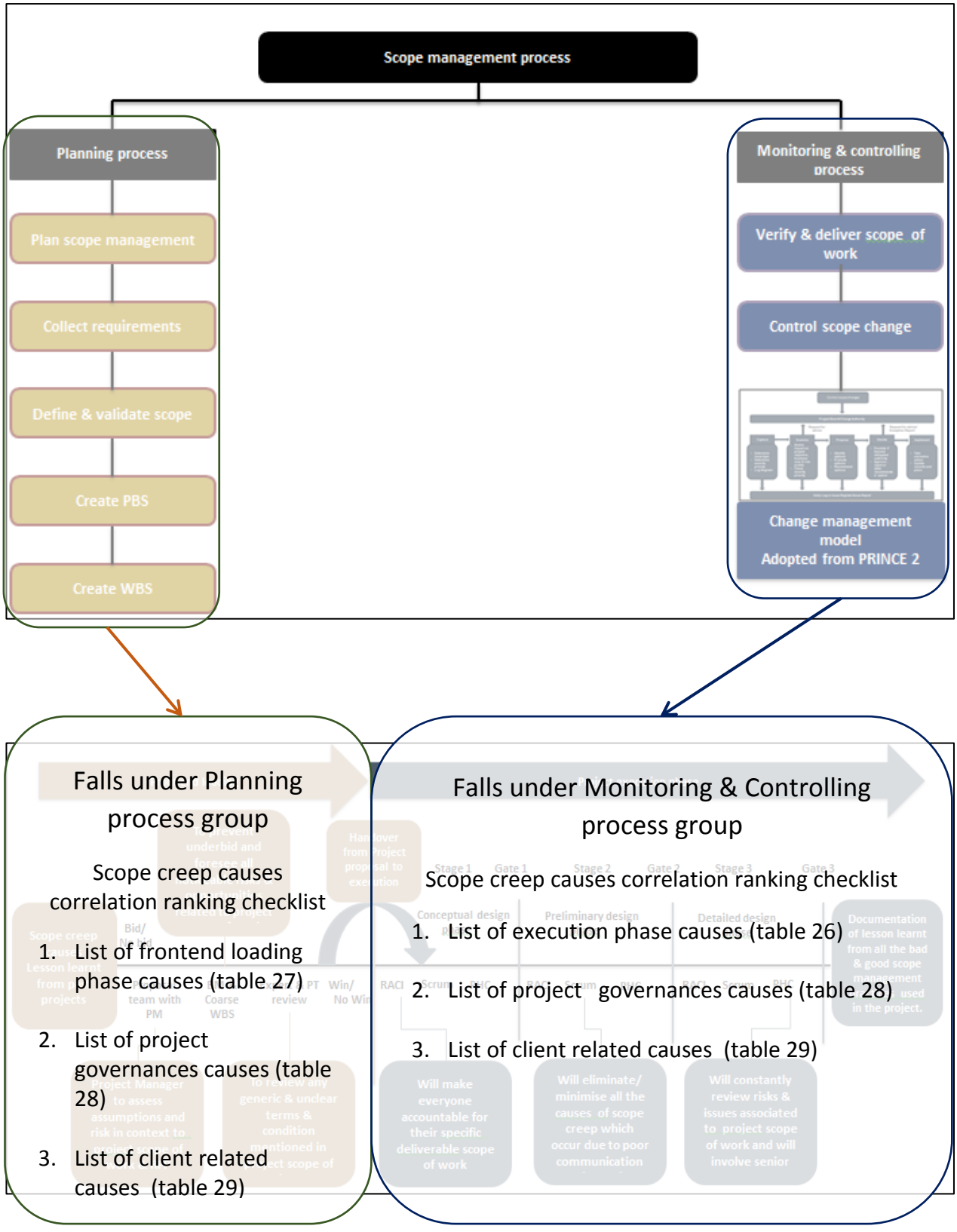
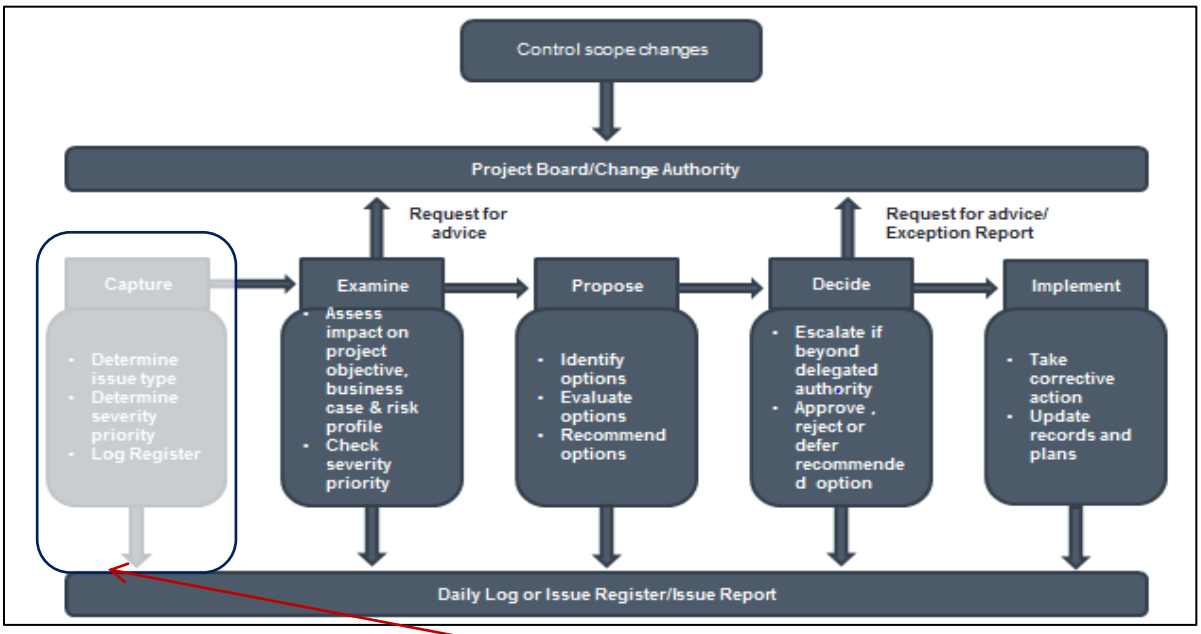


Figure 28 Linking scope management process suggested by PMBOK and conceptual scope creep management model

Figure 30 illustrates change management approach suggested by PRINCE 2 project management manual. This approach is an extension to "control scope change" step proposed in scope management process portrayed in figure 29. The scope management process only mentions to control scope change, without elaborating on how "scope change is to be controlled". The "how" question, is answered by using change management approach suggested by PRINCE 2 project management manual. Moreover, the change management approaches suggested by all the four project management manuals is alike but stated in different words as can be seen in table 5. PRINCE 2 change management approaches is chosen as its figure clearly explains what steps are to be taken and how they are to be taken while realising a change.



Necessary changes which are identified should follow change management procedure suggested by PRINCE2

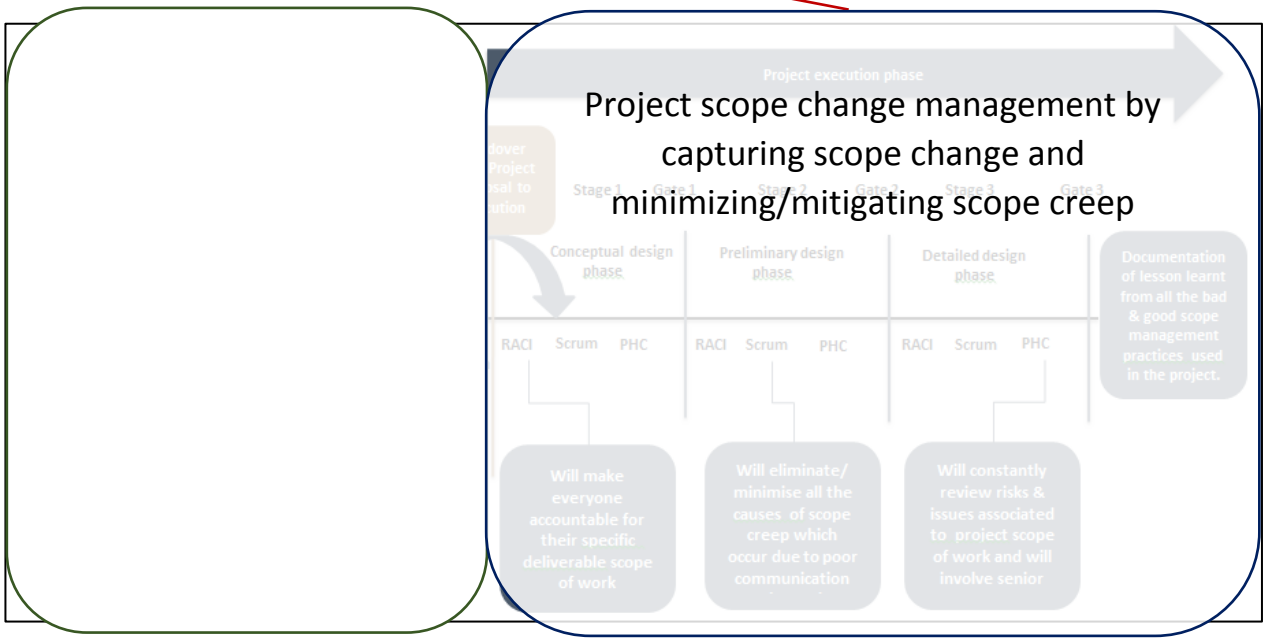


Figure 29 Linking change management approach suggested by PRINCE2 and conceptual scope creep management model

The execution phase of conceptual scope creep management model is linked to (Capture step of) change management approach suggested by PRINCE 2. The change management approach tells us how a change should be incorporated in a project, but it does not tell us how to capture these changes. Furthermore, at this point it is also important to recall scope creep definition which states that "scope creep causes are usually uncontrolled and **unnoticed**". Therefore, this noticeability issue of a change is addressed by conceptual model in execution phase of a project by using tools like RACI, Scrum process and PHC. It is also important to note that the model not only increases transparency in a project by noticing all the noticeable changes, but it also minimizes/mitigates causes of scope creep which originates from poor communication, lack of accountability and due to lack of planning.

5.3.1 RESPONDENT CHARACTERISTICS

The criterion used for selection of respondents has already been discussed in chapter 4. The model validation questionnaire was filled by 7 experts who were able to attend the validation process. All the seven experts were senior project managers working in Transport and planning business line. The characteristics of the experts who participated in the validation process are illustrated in figure 32.

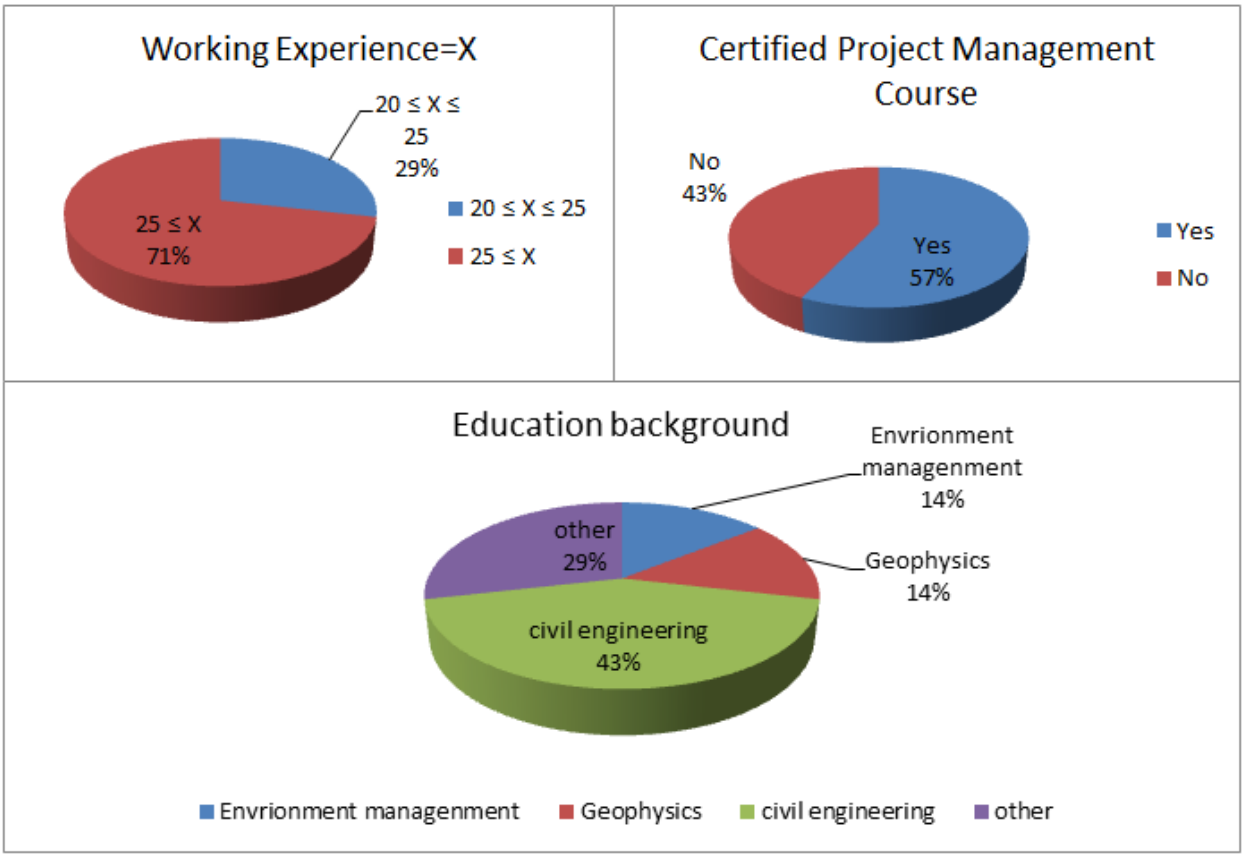


Figure 30 Validation process respondents' characteristics

The author will evaluate and discuss the outcome of the conceptual scope creep management model in two sub-sections, which are as following

1. Discussion on yes/no question results
2. Discussion on open questions result

5.3.2 DISCUSSION ON YES/NO QUESTION RESULTS

The yes/ no question were asked to the experts specifically in context to the tools, techniques and approaches which are used in developing a conceptual scope creep management model. The questions were aimed to acknowledge, whether the proposed tools, techniques and approaches will be effective in minimizing the targeted causes of scope creep. The causes of scope creep which each tool, technique and approach targets, is explained under chapter 4 sub-section 4.3. In this section each yes/no question will be separately evaluated, by highlighting how many number of experts agreed with the use of proposed tools, techniques and approaches.

1. **Do you think having project manager in the proposal team will reduce risk and uncertainties of wrong assumption?**
   There was a 100% response from the experts in the favour of having a project manager in the proposal team. This means that the scope creep causes which are being targeted by use of this approach will certainly be controlled and minimized.

2. **Do you think BM and Coarse WBS will help in better assessment of project execution cost along with risk and opportunities?**
   There was a 100% response from the experts in the favour of estimating project commercial bid using benchmarking techniques and coarse work breakdown structure. Furthermore, they also confirmed that the coarse WBS will certainly help in identifying risk and opportunities associated to the project scope of work. However, one of the experts expressed concern about getting reliable data for using benchmarking technique.

   The author agrees with the concern, but if the data is not reliable then the difference will be reflected in the price estimated using coarse WBS. This is the underlying reason of using two techniques concurrently, so that the quality of estimation can be cross checked. Hence acknowledging the experts response and the argument made above. It can be concluded that the chosen tool will help in minimizing wrong estimation of project operational cost.

3. **Do you think review of project proposal by selected specialist, risk manager and design leads will reduce uncertainties of unclear and generic terms and conditions in RFP?**
   There was a 100% response from the experts in the favour of getting the project proposal reviewed by selected specialists, risk managers and design leads to minimize uncertainties of unclear and generic terms and conditions mentioned in client request for proposal.

4. **Do you think review of project scope of work and contractual agreement at handover stage by PM and design leads, will eliminate liability of executing project on wrong terms and condition made by proposal team?**
   There was a 100% response from the experts in the favour of getting the awarded project scope of work and contractual agreement reviewed by the project manager and the design leads, if they were not involved in front end loading phase. Hence, it can be concluded that this approach will minimize the liability of executing project under wrong terms and condition made by proposal team on the project manager.

5. **Do you think RACI will help in making project team members accountable for their scope of work?**
   The response to this question had one expert, who had disagreed with the effectiveness of RACI in making members of project team accountable. However, rest all the 6 experts agreed to the application of RACI in making project team members accountable for their respective deliverables.

   It is important to note that one of the experts was not aware of this tool. But he did agree with its applicability on the basis of the description given by the author in the validation process. In the end it can be

concluded that, the use of RACI will make project team members more accountable for their respective deliverables as 86% of the respondents agrees with its effectiveness.

6. **Do you think use of scrum process will minimize communication problems faced by projects?**
   There was a 100% response from the experts in the favour of using scrum process as a communication tool in the project. However, one of the experts was not aware of this process but agreed on its effectiveness based upon the author's validation presentation.

   Furthermore, one of the experts while agreeing to the overall effectiveness of this process, expressed concerns regarding its use in teams working from different locations. The author acknowledges this concern, but scrum process mitigates this issue by using tools like video conferencing and skype meeting. However, there is still a limitation of internet connectivity at certain locations where these approaches won't work. The scrum process can then also be implemented using tele conference, but it will be less effective due to more room for error in understanding.

   In the end it can be concluded that scrum process will certainly reduce causes of scope creep, which originates due to poor communication. In addition, it will also help in aligning the client expectation with that of consultants through sprint review and planning meetings with the client.

7. **Do you think PHC is helping PMs in identifying risk and issues early in the project?**
   There was a 100% response from the experts in favour of using PHC tool, as it is effective in identifying risk and issues early in the project. In addition, one of the experts stated that it also makes the project manager more accountable to efficiently manage his/her project. Acknowledging the experts point of view it can be stated that PHC tool is effective in minimizing the targeted causes of scope creep.

8. **Do you think stage gate model will help in better planning of the project in terms of resources, time and budget?**
   There was a 100% response from the experts in favour of using stage gate model for planning project execution. However, one of the experts was unware about this tool but did agree on its applicability and effectiveness on the basis of arguments made by the author in the validation presentation. In the end it can be concluded that stage gate model will be effective in planning the resources required in different stages of project. Moreover, it will also prevent project managers from over spending time and budget at any stage of a project execution.

9. **Do you think documentation and use of lessons learned will help projects minimize occurrence of same mistakes as made in the past?**
   There was a 100% response from the experts in favour of documenting and using lessons learned, as it will minimize occurrence of mistakes made in the past, in future projects. Correspondingly, one of the experts suggested in documenting lessons learned at the end of each project phase. While, the other expert suggested in having a better mode of communication for lessons learned.

   In the end it can be concluded that use of lessons learned will certainly reduce occurrence of same mistakes in the future projects which were made in the past projects. Moreover, how documentation of lessons learned is to be done is out of the scope of this research.

5.3.3 DISCUSSION ON OPEN QUESTION RESULTS

The open questions were asked to the experts specifically in context to the workability and effectiveness of the proposed conceptual scope creep management model in containing and minimizing occurrence of scope creep. The type of questions asked in this section has already been discussed in chapter 4 sub-section 4.3. The answer to the question asked in this section will confirm whether the proposed model will work or not. Similarly, the answers will also explain how the proposed model can be re- structured or

improved along with the requirements for its implementation in practice. All the questions asked in this section will be separately answered.

1. **Do you confirm whether the proposed model is valid and useful in managing uncontrolled scope changes holistically?**
   All the 7 expert agreed that the proposed conceptual scope creep management model is valid and would be useful in controlling uncontrolled scope changes holistically. Furthermore, during the validation process the experts asked what does the author mean by holistically. Holistically is mentioned, to prevent experts going into very specific details of scope creep control. While explaining the model, it was specifically stated that the model has to be adjusted and adopted depending upon the requirements of the project.

   There were two comments made by the experts while answering this question. In the first comment the expert's states that he confirms the workability effectiveness, but as every project is different and unique so the project manager should think himself/herself. This point is in line with adjusting the model according to the requirements of the project. While, the second comment made by the expert is "*getting commitment from the client in validating product and procurement can be problematic*". The author agrees with the argument made by the expert; however this aspect depends upon the soft skill of a project manager managing the project.

   In the end it can be concluded that, the proposed conceptual scope creep management has been validated by the focus group of experts. Therefore, this model can be used in the design and engineering consultancy firm to control occurrence of scope creep. In addition this model is equipped with list of ranked scope creep causes developed using correlation analysis, which can be used as a check list while planning and executing the project. In frontend loading phase of the project ranking list from frontend loading phase, project governance and client related scope creep components can be used as a check list. Whereas, in project execution phase ranking lists from execution phase, project governance and client related scope creep causes components can be used as a check list to mitigate/minimize occurrence of scope creep.

2. **How would you re-structure the proposed scope creep management model?**
   The experts answer didn't really re-structure the proposed model, but provided some suggestion to make it more effective. Two of the experts suggested in evaluating project after every stage, to document lessons learned. The argument made by the expert for such a suggestion is to first make it easy to document all the lessons learned, as all the team members would be still working on the project. Secondly, it would help the project team to use the lessons learned in the same project proceeding phases.

   One of the experts suggested portraying scrum as a cyclic process in the model along with using explicit process of decision making on scope variation. The other expert suggested validating product breakdown structure before initiating a specific project execution phase. While, the remaining three experts stated that the proposed model is a good model and should be adopted without any re-structuring. However, one of the expert went on to state that this model is fit for particularly large design projects, but a more simplified version this model should be developed for small design and consultancy projects.

   Acknowledging all the arguments made by the expert, the author decides not to make any amendments to the proposed model. The reason behind making no amendments is all the suggestions made by the experts can be incorporated in the model as per the requirements of the project. The lessons learned documentation after every stage would be beneficial for the projects which have very long execution duration; while for small duration projects it can be done after the project completion. Moreover, there is logic seen in explicitly portraying scrum as a cyclic process in the model, as it is explicitly acknowledged while scrum process is understood. The scrum process also provides an opportunity to verify scope of each sprint with the client in the review meetings.

   In the end the author does agree, with the suggestion of developing a simpler version of the proposed model for its use in small project. However, this simple version will not be developed in this research as the scope of research focuses on large infrastructure projects.

3. **The tools and techniques used in the model are not new, then why don't practitioners use them?**
   The response of five experts to this question explains that the use of all these tools is not a general knowledge that all the project managers have. The basic reason behind such awareness is project managers being technical people, hence giving less importance to specifically management tools. In addition, one of the four expert states that if people might be aware of some of these tools but then also they do not have an exclusive working model which combines these tools in a systematic manner to control the project scope.

   While, the remaining two experts stated that the use of these tools needs sufficient time and discipline among the project team members for their implementation. The reason behind not spending sufficient time and having discipline within the project team is first, not having a structured process that should be followed and second is not having outside pressure and control to do it.

   Acknowledging the arguments made by the expert it can be said that these tools and techniques are not used in practice as everyone is not aware of all of them. Furthermore, the project managers do not have any structured working model that can be used by everyone on every project to control scope creep.

4. **What would you recommend to reduce or mitigate occurrence of scope creep, in addition to the proposed model?**
   The response from three experts suggested of using the proposed model without any more recommendation, as they think it will control occurrence of scope creep. While the other four experts individually provided some recommendations which are mentioned in the bullet points below

   - The project should be evaluated after every stage for documentation of lessons learned.
   - The sprint review meeting with the client should be used for obtaining mutually agreed results.
   - As all the project team members are made accountable of their deliverable using RACI, it is also recommended to get a written agreement from each individual for their respective deliverable.
   - Check and balance of deliverable from colleagues from the same discipline.

   Acknowledging the arguments made by the experts, it has been decided to make no amendments to the proposed model. As all the suggestion from the expert relates to project governance, which can be used as per the requirements of the project.

5. **Do you think current working culture at RHDHV is suitable for implementation of this model? If not then please explain why it is not and what is required to implement this model within RHDHV?**
   All the experts think that the current working culture at the company is suitable for the implementation of this tool, as Project health check tool is still being implemented. This aspect will make it easy for people to adapt to the working of proposed model. However, as most of the project managers are not aware about the scrum process it will be problematic to implement. The scrum process can be implemented by conducting scrum learning workshop at the company so that people become aware about its workability. Moreover, for implementation of this model a well thought implementation strategy should be developed at the company. The strategy should include making project managers aware of the proposed model benefits along with giving them sufficient time for its learning.

   Lastly, one of the experts suggested of having less internal administrative work (ABW) and more focus should be on project management.

   Acknowledging the arguments made by the expert it can be stated that, the proposed model can be implemented at the company. However, for an effective and efficient implementation of the model workshops at the company should be organized. The workshops will make project managers aware about the usability of proposed tools, techniques and approaches along with their benefits and limitations.

Conclusion

In this chapter the data gathered from survey research and focus group validation process is evaluated. This chapter initiated by explaining the responses rate received from survey conducted at RHDHV. Thereafter, the data gathered for validation of scope changes and scope creep definition formulated by the author was evaluated. The proposed definitions were successfully validated by evaluating the survey response. In section three the scope change and scope creep causes and consequences were subjected to factor analysis using survey response. The factor analysis resulted in clustering causes of scope creep under four components and consequences of scope creep under two components. However, factor analysis did not show reliable results for clustering causes and consequences of scope change in more than one component. In section four the results obtained from factor analysis were used to find correlation between causes and consequences of scope change and scope creep.

The correlation analysis resulted in developing 104 correlations between scope change causes and consequences out of which 26 correlations showed positive relationship and 78 correlations showed no relationship. Similarly, correlation analysis resulted in developing 328 correlations between scope creep causes and consequences out of which 219 correlations showed positive relationship and 109 correlations showed no relationship. Additionally, relationship between scope creep components was investigated. The results shows that execution phase, frontend loading phase and project governance components shares strong positive relationship with soft scope creep impact component. Likewise, relationship between two consequence components was checked. The two components soft and hard scope creep impact shares strong positive correlation with each other. Therefore, it can be stated that the three scope creep causes components mentioned above have high potentials of impacting both soft and hard consequence components, thus impacting the project performance. The arguments made above answers research sub-question four.

Correspondingly, noting the strong positive correlation between scope creep components, it was decided to rank causes of scope change and scope creep based upon highly significant positive correlation they share with multiple consequences. The causes of scope change and scope creep were ranked using two approaches. The first approach ranks causes on their frequency of occurrence in projects executed on lump price contracts. Whereas, the second approach uses correlation analysis results to rank causes. The causes of scope creep are ranked under four components developed using factor analysis. Results of ranking using two approaches are portrayed in one table, while going though these tables it can be acknowledged that the ranks using these two approaches are different from each other. The difference between the ranks does not mean that one list of ranks is more important than the other. These lists of ranks developed component wise will be used as a lessons learned checklist while using the conceptual scope creep management model. Moreover, it is important to note that all the causes which can cause high impact on the project performance based on their positive relationship with multiple consequences were identified in the studied projects as well in chapter 3. Lastly, the causes of scope creep were also ranked independent of components on the basis of their frequency of occurrences. This list in table 30, illustrates which scope creep cause occur on more frequent basis in a project executed on lump sum price contracts. The scope creep and scope change causes ranking established in this chapter answers research sub-question six.

Section five very briefly establishes a link between scope creep consequences and project success criteria. This section illustrates why it is important to minimize/mitigate scope creep occurrence in projects, to complete the project successfully. In the end section six of this chapter, first explains the link between the three model (figures 29 & 30) used in this research to manage project scope. Thereafter, it evaluates the effectives of the chosen tools, techniques and approaches in controlling targeted causes of

scope creep. The evaluation shows that the chosen tools, techniques and approaches will be effective in controlling targeted causes of scope creep. This step further confirms answer of research sub-question four. Lastly, the conceptual scope creep management model validation data was evaluated. The evaluation results shows that the proposed model will be effective in managing scope creep causes in projects executed on lump sum price contracts. Hence, this step answers research sub-question seven.

CHAPTER SIX

Discussion, Conclusions and Recommendations

6. DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter will elaborate on research limitations, findings, conclusions and recommendations. Moreover, the research objective will be satisfied in the concluding remark of this chapter by answering the research main question. The chapter initiates by making a discussion on research findings and limitations. Thereafter, in a separate section research conclusions will be explained followed by recommendation for future research and for Royal HaskoningDHV. In the end this chapter will be concluded by answering the research main question.

6.1 DISCUSSION

In this section a discussion will be made on the research findings and limitations. The discussion will reflect on the limitations of this study and how these limitation influences research results. The discussion thus also provides in constraints for the conclusions and recommendations. In paragraph one research findings will be briefly discussed and in paragraph two the limitations of this research will be discussed.

6.1.1 RESEARCH FINDINGS

This MSc. graduation research is aimed to find answer to the following research main question: How to manage scope of large infrastructure projects for lump sum price contracts in construction industry in order to reduce uncontrolled scope changes? For answering this question an extensive literature view was first conducted to understand the theoretical background of the research problem. The literature review resulted in following findings. First definitions of scope change and scope creep were retrieved, which helped in aligning the research direction. Second based upon the definitions list of scope change and scope creep causes and consequences were developed. Third, scope management and change management processes suggested by leading project management manuals was presented. Fourth, the workability and applicability of the chosen tools and techniques was explained based upon their respective benefits and limitations in controlling uncontrolled scope changes.

Thereafter, in second phase of the research four case studies were carried out at design and engineering consultancy firm (RHDHV). The document review and interviews at the company contributed practical perspective on the problem of uncontrolled scope changes. The outcome of case studies was a list of scope creep and scope change causes which were then linked to the list obtained from the literature review. The case studies also helped the author in having a better understanding of the problem, as literature most of the times presents an ideal situation which makes practice distinct from theory.

In the third phase of this research all the finding from the literature review and the case studies were combined. This resulted in developing a complete list of causes and consequences of scope changes and scope creep. Furthermore, this phase also resulted in development of a conceptual scope creep management model. As all the tools, techniques and approaches were chosen to be used in the model in this section, based upon the feedback received from interviewed managers and literature study.

Phase four of this research focused on validating the research findings obtained in phase three. The scope change and scope creep definitions along with lists of causes and consequence were validated by taking practitioner opinion using a survey research. The data gathered using survey research was evaluated by making a quantitative analysis. The quantitative analysis resulted in obtaining the following

findings. First, the scope change and scope creep definitions developed in chapter two were successfully validated. Second, the causes and consequences of scope creep were clustered under different sets of components. Third, scope change and scope creep causes and consequences were ranked based upon their frequency of occurrence. Fourth, the scope change and the scope creep causes and consequences were ranked using correlation analysis which describes how big is the impact on the project, if a certain cause occurs. The ranks are based on the type of relationship a cause have with a consequence. Furthermore, in the second part of phase four the developed conceptual scope creep management model was validated in a focus group of experts at Royal HaskoningDHV.

Looking at the problem as formulated in the introduction, it can be concluded that this research has extended existing knowledge on the problem of uncontrolled scope changes in design and engineering consultancy projects which are executed on lump sum price contracts. Moreover, this research aimed at providing a solution in form of a model to minimize/ mitigate occurrence of uncontrolled scope changes occurrence in large infrastructure projects. Correspondingly, it is also important to note that the available research's either focus on scope creep or on scope changes problem exclusively. But, no research in literature makes a clear distinction between these two problems concurrently. This distinction has been explicitly made in this research which is an extension to the existing knowledge with a limitation of client perspective.

6.1.2 DISCUSSING THE LIMITATIONS OF THIS RESEARCH

This section will discuss limitations of this research by considering all the steps taken to conclude different chapters. The limitations are very important to be acknowledged before one could use the research findings. The research limitations are distinguished in the following points

- This research does not take client point of view in to consideration while evaluating scope change and scope creep causes and consequences. However, incorporating client perspective would help in making a complete observation on the problem of scope change and scope creep in design and engineering projects. The client perspective was not taken into consideration, as it was not possible for the author to get an access to a client for getting his/her perspective.
- As the research was conducted at one company, it does not necessarily explain uncontrolled scope change management problem faced by large number of design and engineering consultancy companies. It is a limitation as different organizations have different scope management guidelines, some may have better scope management approaches and some may not have a good scope management approach. Furthermore, as the research findings are supported by an extensive literature review, four case studies in different countries and interview of experts from three different countries namely the Netherlands, South Africa and United kingdom the results can be generalized to some extent.
- The tools, techniques and approaches used in developing the conceptual uncontrolled scope change management model, are not the only available tools, techniques and approaches which can be used for controlling scope creep. There might be other tools, techniques and approaches which can perform better than the ones proposed. However, the tools, techniques and approaches used in the research have been strongly endorsed by literature and by the interviewed experts.
- In correlation analysis to find out the relation between causes and consequences the causation is not taken into considerations. Two-tailed analysis was performed only due to limitations in the survey questionnaire.
- The developed conceptual scope creep management model has to be adjusted depending upon the project requirements. Additionally, this conceptual model has to be tailored for its use in small infrastructure projects.

6.2 CONCLUSIONS

In this section conclusion of the all research sub-question will be discussed. Thereafter, based upon the conclusion of research sub-questions the research main question will be answered. The research sub-questions are arranged and concluded in sequential order, which is in line with sequence of research chapters.

1. **How is scope change and scope creep defined in literature?**
   There was no universal scope change and scope creep definition found in the literature. Two definitions of scope change and seven definitions of scope creep in the literature were found (chapter 2). However, the definitions provided in the literature do not explain all the aspects of scope change and scope creep under one definition. In chapter two a discussion is made over the incompleteness of the definitions found in the literature.

   Acknowledging this gap in literature, new definitions of scope change and scope creep were formulated. The new scope change and scope creep definitions were developed by acknowledging the definitions provided in the literature and by understanding these two phenomenon's through an extensive literature review and four case studies. While formulating the new definitions an effort was made to bridge link between what has been said in literature and what is actually happening in practice.

   The developed scope change and scope creep definitions were validated by getting expert opinion through survey research conducted at RHDHV. On the basis of validation results the definitions were amended based upon the expert opinion in chapter five. The validated scope change and scope creep definition which is used in this research are mentioned below.

   "*Scope change is an official decision taken by the project manager and the client to change, expand or reduce originally defined scope of work. A scope change always results in making adjustment to the activities, resources and contractual agreement affected by the change.*"

   "*Scope creep is an uncontrolled and unnoticed scope change which occurs unofficially without addressing its impact on project activities and resources. These are the changes which occur without an official agreement between the client and the project manager*."

2. **What are the causes of scope change and scope creep for projects executed on lump sum price contracts? (Mentioned in literature and found in practice)**
   There were thirteen causes of scope change and thirty causes of scope creep identified in the literature. Thereafter through four case studies conducted at RHDHV ten more causes of scope creep were added to the list obtained from literature. The number of scope change causes and consequences remained the same as obtained from the literature. The list of causes obtained from literature study and case studies were combined in chapter three (tables 7 & 8), to answers this research sub-question. Table 7 illustrates complete list of scope creep causes and table 8 illustrates complete list of scope changes found in literature and practice.

   Additionally, the complete lists of causes both for scope change and scope creep obtained from literature and case studies were then used as an input for survey research. By means of the survey research, these lists of scope change and scope creep causes were validated in context to their occurrence in design and engineering large infrastructure projects which are executed on lump sum price contracts.

3. **How is scope management practised, in design and engineering consultancy firm?**
   There is no common scope management approach followed at Royal HaskoningDHV while managing large infrastructure projects, which are executed on lump sum price contracts. In chapter three, while reviewing documents of four large infrastructure projects it was observed that every project is being managed using a scope management approach which is preferred by the project manager. In addition, while interviewing the project managers it was again observed that everyone have their own approach of managing projects. It is important to note that there is a project management manual available at RHDHV, which provides some

guidelines of managing projects. However, when the project managers were asked about those guidelines mentioned in the project management manual, none of the interviewed project manager was aware of them.

Hence, based upon the observations made above it can be concluded that projects at RHDHV are being managed by project managers, on the basis of their experience/knowledge and no structured scope management approach is being followed.

4. Which tools and techniques have been chosen to be used in conceptual uncontrolled scope change management model?

The tools and techniques which are chosen to be used in conceptual uncontrolled scope change management model are explained in chapter two (section 2.3) and are listed below.

1. Documentation and implementation of Lessons learned: *Recommended by PRINCE 2*
2. Benchmarking techniques: *Recommended by interviewed project managers*
3. Work breakdown structure: *Recommended by interviewed project managers*
4. Stage- Gate- Model: *Recommended by interviewed project managers*
5. Project Health Check Model: *Recommended by RHDHV*
6. Responsibility assignment matrix (RACI): *Recommended by PMBOK 4th edition*
7. Formalized project communication plan Scrum Model: *Recommended by interviewed project managers*

There are seven tools/techniques chosen to be used in conceptual uncontrolled scope change management model. Out of these seven chosen tools/techniques two tools have been recommended by project management manual, while the remaining were suggested by the interviewed managers from the projects studied in chapter 3. Thereafter, retrospectively an explicit literature review on the suggested tools and techniques was conducted in chapter two. The decision of using tools and techniques which have been suggested by interviewed practitioner was taken, as these tools and techniques are being used by some managers in industry, which means their effectiveness is tested to some extent. However, the author would have chosen other tools and techniques which have been suggested in literature, but they might have not been tested in practice.

Correspondingly, these tools and techniques were chosen to exclusively target a certain cause of scope creep which is highlighted in chapter four. Thereafter, the effectiveness of the proposed tools, techniques and approaches chosen to be used in scope creep management model were validated in the focus group of experts. The experts participating in the focus group agreed to the effectiveness of the proposed tools, techniques and approaches chosen to be used in conceptual scope creep management model.

5. What is the relationship between cause and consequence of scope changes and scope creep?

The data gathered using survey research conducted at RHDHV was first subjected to factor analysis and thereafter to correlation analysis to find relationship between the causes and consequences. Using factor analysis an effort was made to understand whether causes and consequences variables follow any pattern. Based on the pattern that a certain cause or consequence follow it was decide to reduce the extensive list into more manageable groups. Factor analysis resulted in clustering causes of scope creep under four component and consequences of scope creep under two components. However, factor analysis did not show any reliable pattern for clustering causes and consequences of scope changes in more than one component.

The results obtained from factor analysis were then used to find relationship between causes and consequences of scope change and scope creep using correlation analysis. There were in total 104 correlations obtained between causes and consequences of scope change. Out of which 26 significant correlations showed positive relationship and the remaining 78 correlations showed no relationship. Likewise, there were in total 328 correlations obtained between causes and consequences of scope creep. Out which 219 significant correlations showed positive relationship and the remaining 109 correlations showed no relationship.

Results reveal that three components of scope creep causes being execution phase, front end loading phase and project governance share positive strong relationship with soft impact consequence component.

Identically, correlation analysis also shows highly significant positive strong relationship between soft and hard impact consequence components.

Altogether, it can be concluded that as scope creep causes shows large number of positive relationship with the consequences they should be critically acknowledged by the project team while executing the project. As these cause will likely cause a positive increment in the consequences. Similarly, the components list should be used as a check list while executing the project due to their positive strong relationship with consequences.

6. What are the rankings of scope change and scope creep causes?

The scope change and scope creep causes were ranked by evaluating the data gathered from survey research in chapter 5. The causes were ranked using two approaches; on the basis of frequency of occurrence and by using correlation analysis. Results show that the ranking is considerably different when different approaches had been used. Although the ranking results are different, it does not mean that practitioner should try to choose one of these two ranking lists. The author believes that each type of ranking can be used for different targets. It will be beneficial to use these two ranking lists depending upon the project stage and requirements.

The first approach of ranking shows which cause of scope creep occurs on a more frequent basis on projects executed on lump sum price contract. This type of ranking was first done for each component and then for the complete list of scope creep causes. The ranking done under each component will help project team acknowledge occurrence of scope creep in context to their origin. Correspondingly, the ranking list developed independent of components will show which causes in general occur more frequently in a lump sum priced project. The results show that '*Bad management of project changes, and absence of scope management and control systems*' is the most frequent cause of scope creep in lump sum priced projects. In addition, top five frequently occurring causes are listed below, while the entire list can be traced in table 30.

Top five frequently occurring causes of scope creep in projects executed on lump sum price contracts are mentioned below. Moreover, it is also important to note that out these to five causes, four causes are related to employees working at the company, while one cause i.e. *'Client requirements'* is not.

1. Bad management of project changes, and absence of scope management and control systems.
2. Client requirements.
3. The data was not enough when the scope was defined.
4. Ignorance of key stakeholders until the project is underway.
5. Misappraisal of the original scope of work.

The second approach of ranking shows which cause has more potentials of impacting the project performance. The cause which share highly significant correlation with multiple numbers of consequences has more potential of impacting the project. Using, this approach for each component shows which cause possess most risk in each component, so that the project team can identify these high impact causes and minimize their risk of occurrence. The results show that '*Inadequate design team experience*' scope creep causes which come under execution phase component possess maximum potential of impacting the project. Furthermore, project success criteria's identified in chapter two was compared with consequences of scope creep. The comparison resulted in showing an overlap between 5 consequences and project success criteria. This overlap makes the ranking of scope creep causes based on correlation analysis more relevant, as this means causes which are highly ranked have high potential of impacting project success.

In short it can be concluded that the ranking lists developed in chapter 5 (section 5.2.4), should be used by practitioners as a checklist while planning and executing a project. These lists will work as scope creep causes lessons learned checklist which can be used component wise or holistically depending on the project stage, requirements and drivers.

8. **What is the relevant framework that should be used to fulfil a conceptual uncontrolled scope change management model?**

   The proposed conceptual scope creep management model in chapter 4 provides a relevant framework for managing uncontrolled scope changes. All the steps that are supposed to be taken in the conceptual scope creep management model have been explicitly stated in chapter 4 (section 4.3). The proposed sequential steps in the developed model describe the criterion used in developing a relevant conceptual scope creep management framework.

   Additionally, the proposed conceptual model was validated in the focus group of experts at RHDHV. The experts in focus group agreed with the applicability and effective workability of the model. Then it can be concluded that the developed conceptual scope creep management model provides a relevant framework for managing uncontrolled scope changes. The model validation arguments can be traced in chapter 5 (section 5.3).

6.2.1 ANSWERING THE MAIN RESEARCH QUESTION

How to manage scope of large infrastructure projects for lump sum price contracts in construction industry in order to reduce uncontrolled scope changes?

In this research all the aspects of scope management were identified in detail. On the basis of literature review, case studies, survey research and focus group validation a conceptual model is presented. The model aimed at being effective in minimising occurrence of uncontrolled scope changes in design and engineering large infrastructure projects executed on lump sum price contracts.

The scope management model is split into two groups namely planning process group and monitoring and controlling process group as can be seen in figure 29 .According to experts the scope of large infrastructure projects can be efficiently managed by using combination of models as suggested in figure 29 and 30 respectively. Chapter 5 (section 5.3) clearly explains how these three models are to be used in managing project scope of work. Out of these three models, two of them namely the scope management process model has been adopted from PMBOK 4th edition and change management model has been adopted from PRINCE2 project management manual. Whereas, the third model has be developed as a result of this research to minimize/mitigate occurrence of scope creep and to makes scope management process more transparent in projects. The developed conceptual scope creep management model together with other two models has been validated in a focus group of experts at RHDHV.

The model portrayed in figure 32, have been split into two phases which is in line with the model adopted from PMBOK as can be seen in figure 29. It is important to note that scope management process suggested by PMBOK only tells “What” should in done in planning process group and monitoring & controlling process to manage project scope. But “How” these things suggested in scope management process are to be done is addressed by conceptual scope creep management model. Likewise, change management model adopted from PRINCE2 explains how a change has to be incorporated in a project. But, “How” a change (specifically unnoticed) has to be captured in a project is addressed by the conceptual scope creep management model.

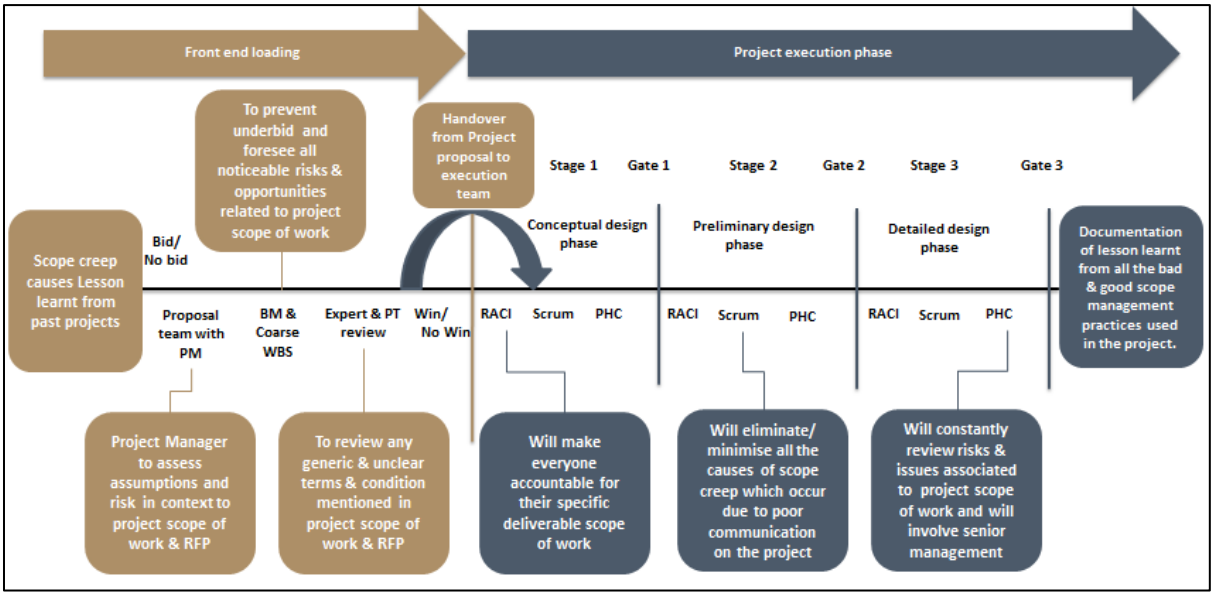


Figure 312 Conceptual uncontrolled scope change management model

Correspondingly, the scope creep management model has been equipped with lists of scope creep causes ranking which can be used as lessons learned checklist by the practitioners. In the frontend loading phase of a project it is suggested to use frontend loading phase (table 27), project governance (table 28) and client related (table 29) scope creep causes ranking lists as a checklist. Similarly in project execution phase it is suggested to use execution phase (table 26), project governance and client related scope creep causes ranking lists as checklist. This approach will help in creating more awareness within the project team while planning and executing a project. The ranked checklists can be found in chapter 5 (section 5.2).

Given the points made above and based upon focus group expert's feedback, it can be concluded that the proposed complete scope management model portrayed in figure 29 and 30, can help in managing project scope by minimizing/mitigating scope creep occurrences.

6.3 VALIDATED CONCEPTUAL SCOPE CREEP MANAGEMENT MODEL IMPLEMENTATION ADVICE FOR RHDHV

In this sub-section suggestion will be made to Royal HaskoningDHV on the implementation of conceptual scope creep management model in practice. Obviously the implementation of different project management tools and techniques at one time and especially for the first time at a company won't be an easy task. Then hereby it was decided to define few implementation steps for the proposed model. The suggestions will be made on the basis of answers received from experts while validating the model. In addition, there will be some suggestion made based on the observation made in chapter 3 case studies (document review and interviews). The model implementation suggestions are listed under the following points

- As can be seen in the conceptual model, lessons learned play an important role in reduction of scope creep/change occurrence. Then the first step would be to set a formalized procedure for capturing lessons learned especially those which are about scope creep/change. This helps in identification of other possible causes and consequences both for scope creep and scope change.

- Approaches such as 'project manager to be part of proposal team' , 'project proposal review by experts & project team design leads' and 'handover' can be right away implemented. Tools and techniques like coarse WBS and BM technique for estimation of project cost not only help in scope creep management process but also in making the project management process more formalized companywide. The use of these tools and techniques at the company can be leveraged by taking suggestions from project managers while organizing DECATHLON session. Furthermore, senior managers working in UK and South Africa offices can be contacted to get more information on how BM technique is being used.

- The tools and techniques suggested in project execution phase of the model require proper strategy to be devised for their successful implementation. The prerequisite of implementing such tools and techniques is the existence of standardized process. Some of the suggested tools and techniques like PHC are already implemented in the company. However, it is important to state that the benefits of using PHC tool should be shared in the knowledge sharing sessions like DECATHLON. As it was observed that there is still some friction from some project manager's side to use this tool. Furthermore, stage gate model and RACI matrix can also be easily put to use in the projects as most of the managers are aware of these tools. But before their full scale implementation some workshops/courses should be conducted at the company to make all the project managers aware about this model and tool with their benefits.

- Last but not least the scrum tool is recommended to be implemented. Since scrum is a new tool at the company and observations show that not many people are familiar with scrum process, there should be some training for implementation of scrum at the company.

6.4 RECOMMENDATIONS FOR FURTHER RESEARCH

In this section recommendations for further research will be provided. The recommendation will highlight which aspects of scope management should be investigated, so that project management can be made more efficient. The recommendations of this research will be based on the limitations of this research as discussed in aforementioned sub-section. The research recommendations are listed below

- The scope of this research only focused on problem of uncontrolled scope changes from design and engineering consultancy firm perspective. Hence, it recommended conducting the same research from contractor's perspective who eventually builds the design.
- The scope of this research only focused on problem of uncontrolled scope changes in lump price contracts. It is recommended to further investigate problem of uncontrolled scope changes in other type of contracts as well.
- As this research was executed and concluded without considering the client point of view on the problem under investigation. It is recommended for further research to consider client point of view on the problem of uncontrolled scope changes. Furthermore, it recommended taking client perspective into consideration under the following four categories.
  - Experienced client point of view
  - Unexperienced client point of view
  - Public client point of view and
  - Private client point of view
- All the positive and no relationship that is found between scope change and scope creep causes and consequences variables should be explained using qualitative evidences in further research.
- It is recommended to find causation of consequences due causes of scope change and scope creep using regression analysis in further research. In addition, it is also important to note that the causation can only be found when the further research is conducted in context to a specific project.
- For further research it is recommended to investigate new tools, techniques and approaches which can be more effective in controlling uncontrolled scope changes, then the one which have been proposed in this research.

- It is recommended for further research to investigate how the proposed model can be tailored for its use in small infrastructure projects. In addition, it is also recommended to investigate how the model should be adjusted for its use in projects other than large infrastructure projects.
- In this research it is suggested to use lessons learned from past projects in three different categories. However, this research does not tell how the lessons learned should be documented in these categories. Hence, acknowledging this aspect it is recommends to conduct a further research on how documentation of lessons learned should be done and how should the documented lessons learned should be communicated.
- The author in this research does not investigate how soft skills of senior managers working on a project affects occurrence of scope creep. Moreover, it is important to note that the effectiveness of proposed model in managing scope creep also depends on soft skills of a project manager. Therefore, it is recommended for further research to investigate how soft skills of project managers facilitates occurrence of scope creep and how can this problem be minimized.
- As the research was conducted at one company. It is recommended to investigated in further research, is management of uncontrolled scope changes a common problem faced by most of the organizations or it is only a company specific problem.

6.5 RECOMMENDATIONS FOR ROYAL HASKONING DHV

In this section recommendations for Royal HaskoningDHV will be provided to improve project scope management at the company. Correspondingly, it is also important to note that the '*Project Health Check*' tool alone cannot improve project performance. Therefore, the author provides some recommendations which should be acknowledged by the company to improve scope management practices. The research recommendations for RHDHV are listed below

- As the project managers at the company do not have a structured working process for managing project scope of work. It is strongly recommended to establishing a scope management guideline for manging the project scope work, which all the projects managers are obliged to follow. Additionally, it is also important to note that the established guideline should not be treated by project managers in the same way as project management guideline on insight are being treated, of which no one is aware off.
- It is recommended that the company formalise a structured way of documenting and communicating lessons learned from past projects, so that they can be used by the project managers.
- It is recommended that the company should also organize a tacit knowledge sharing session like "DECATHLON" with participation of RHDHV employees from different countries.
- It is recommended that the company should also document and share best practices and approaches used by project managers in successful projects.
- It is recommended that the senior management at the company should try to solve causes of scope creep which come under scope creep "project governances issue component".
- It is recommended that the senior management at the company should try to identify root causes behind poor allocation of resources on the projects.
- It is recommended that the senior management at the company should try to identify "*Why?*" employee don't want go abroad and work on international projects.
- It is recommended that "*ABW*" administrative works to be done by project managers should be reduced and more focus should be given on project management.
- There should be workshops conducted at the company to make project managers aware about the tools and techniques which are efficient in managing project scope of work not in theory but also in practice. It was observed that not all the project managers are aware of the available tools, techniques and approaches that can be used to improve project scope management.

- It is recommended that the senior management and the client should be made aware about the adverse consequences of the critical conditions of a project; so that the project managers are given sufficient time to adequately manage project scope of work.

6.6 RECOMMENDATIONS FOR DESIGN AND ENGINEERING CONSULTANCY FIRMS

In this section recommendations for design and engineering consultancy firms will be provided to improve scope management in large infrastructure projects executed on lump sum price contracts. The recommendations will highlight some important aspects of scope management which will help in controlling uncontrolled scope changes in projects.

- The companies should have a structure working process for managing project scope of work, which can be developed or adjusted by using this research finding such as, ranking of scope creep causes based on frequency of occurrence and correlation analysis in context to lump sum price contracts. Additionally the scope management model proposed in this research can also be adopted for managing project scope of work, as it is validated.
- It is recommended that the companies should have formalised structured way of documenting and communicating lessons learned from past projects, so that they can be used by the project managers.
- It is recommended that the companies should share tacit knowledge by organizing knowledge sharing sessions. This approach will strengthen communication of lessons learned.
- It is recommended that the companies should also document and share best practices and approaches used by project managers in successful projects.
- It is recommended that the senior management at the companies should try to solve causes of scope creep which come under scope creep “project governances issue component”.
- There should be workshops conducted at the company to make project managers aware about the tools and techniques which are efficient in managing project scope of work not in theory but also in practice.

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APPENDICES

APPENDICES

APPENDIX A: LITERATURE STUDY

APPENDIX A.1: LIST OF SCOPE CHANGE CAUSES IDENTIFIED IN SEPARATE RESEARCH PAPERS

S.NO	Author's	Causes of Scope Change
1.	(Bröchner & Badenfelt, 2011)	• The original contract documentation from the client may contain errors, omissions and contradictions in specifications. • Client finds that the primary business to be supported by the project or service contract has changed its needs in a way unforeseen in the original contract
2.	(Alnuaimi, Taha, Al Mohsin, & Al-Harthi, 2009)	• Owners instruction to execute additional work • Owners instruction to modify design specifications
3.	(Sun & Meng, 2009)	• Requirement change and variation • Funding change i.e. shortage of funding • Slow decision making • Payment delay • Difficulty in site acquisition • Client-initiated changes usually caused by variations in client's expectations, for instance, requirement updates, budget reduction, demand for accelerated completion, etc. • Inexperienced clients are particular prone to causing late changes due to delays in review and approvals; as well as inappropriate interference in design and project execution. • Site and ground conditions provide the foundation for developing design options. If some abnormal conditions are discovered during site investigation, the whole design basis is undermined. Remedial actions are required, most of which involve design changes.
4.	(Le-Hoai, Dai Lee, & Lee, 2008)	• Owners instruction to execute additional work • Owners instruction to modify design specifications • Owner unclearly specify scope of the project • Unrealistic design
5.	(Hanna & Swanson, 2007)	• Owner or his agent directs a change and all the parties agree to it. The only thing left is to quantify the impact of change on time and cost
6.	(Hsieh, Lu, & Wu, 2004)	• Requirements change

7.	(Chang, 2002)	• Owner's request
		  ○ Additional work: The owner or its functional units request additional work or change focus/decision at a later date due to new findings and other considerations.
		  ○ Optimistic schedule: The original schedule is overly optimistic and unrealistic, due to inaccurate estimates or political decisions.
		  ○ Omissions: Work that should have been included in the original scope is omitted by the owner.
		• Owner's failure
		  ○ Failure to provide information: The owner or its functional units fail to provide information, make

		decisions, or take actions in a timely manner. ○ Incomplete or incorrect information: The information provided by the owner is incomplete or incorrect. ○ Other consultants: Consultants for other related projects fail to provide necessary information on time. • Beyond either the owner's or consultant's control i.e. excusable change ○ Growing needs: It is not anticipated at the scoping stage; extra work or additional level of effort is needed after more studies, engineering, or design has been done. The work grows ''naturally'' without requests from the owner. ○ Stakeholders: Outside stakeholders, e.g., permitting agencies, community, etc., request more alternatives, investigations, and/or explanations. ○ Agencies: changes of laws or standards
8.	(Chan & Kumaraswamy, 1997)	• Client initiated variation • Unrealistic contract duration imposed by the client

APPENDIX A.2: LIST OF SCOPE CREEP CAUSES IDENTIFIED IN SEPARATE RESEARCH PAPERS

S.NO	Author's	Causes of Scope Creep
1.	(Alp & Stack, 2012)	• misappraisal of the original scope of work • unforeseen conditions and • owner requirements
2.	(O. A. Hussain, 2012) mentioned these reasons in context to Qatar construction industry only.	• Ignorance of key stakeholders until the project is underway. • The project is executed after years of completion of study and scope definition. • Scope definition is done by the wrong people. • Government officials are always "ambitious" and unrealistic regarding the outcome of projects. • Intervention by politicians and senior government officials. • The data was not enough when the scope was defined. • Bad management of project changes, and absence of scope management and control systems. • Most managers focus on major scope changes and ignore small changes that could lead to bigger scope creep problems. • In government projects, it is not easy to differentiate between what is included in the project and what is not included. • Conflict in different government agencies interests
3.	(Sun & Meng, 2009)	• Poor, incomplete drawings • Design change due to poor brief, errors and omissions • Poor communication between the key partners is a main cause for design changes and rework. • Design errors and omissions are one of the main causes for project change during the construction phase. Design errors and omissions can be caused by human error on the part of architects, structural engineers, as well as building services engineers. • Poor brief development at the start of a project often

		leads to a wrong understanding of client's requirements and wrong assumptions on key project aspects • Inconsistent site conditions • Poor interdisciplinary communication • Team instability i.e. disputes, bankruptcy etc. • Inappropriate project organisational structure
4.	(Le-Hoai et al., 2008)	• Mistakes in design
5.	(Assaf & Al-Hejji, 2006)	• Mistakes and discrepancies in design document • Delays in producing design documents • Unclear and inadequate details in drawings • Insufficient data collection and survey before design • Misunderstanding of owners requirements by the design engineer • Inadequate design team experience • Poor communication between consultant and other parties
6.	(Hsieh et al., 2004)	• Defects in design and planning • Errors and omissions in quantity estimation • Inadequate arrangement of contract interface • Inconsistency between drawing and site conditions • Citations of inadequate specification • Additional requirement of underground improvement. • Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework _Callahan 1998; Chang 2002; Harbuck 2004; Mackie and Preston 1998; Touran et al. 1994 • Defects, errors and omissions in design and planning, such as mistaken quantity estimates, planning mistakes, inadequate arrangement of contract interfaces, inconsistency between drawings and site conditions, citation of inadequate specifications, etc. • The work rules or regulations in force during the initial period of planning and design may be revised by the governing agency later in the construction stage. In a rare case even a completed work can be pending further modification before usage permission is granted.
7.	(Wu et al., 2005)	• Design changes in respond to site condition • Erroneous or incomplete design information • Insufficient site investigation prior to design
8.	(Chang, 2002)	• Consultant's failure o Consultant's inability: The consultant is not effective or efficient in performing the work, due to complicated work, insufficient staff, and/or lack of competent staff. o Underestimates or omissions: The actual scope of work is not well understood by the consultant at the time the work hours were originally estimated.
9.	(Chan & Kumaraswamy, 1997)	• Necessary variation of work • Delay in design information • Long waiting time for approval of drawing • Mistakes and discrepancies in design documents • Inadequate design team experience

APPENDIX A.3: KEY ASPECTS OF PLANNING PROCESS GROUPS

This section elaborates on scope management planning process group in three sub-sections. Each sub-section will address one part of planning process, starting with project front end loading followed by client requirement elicitation and scope baseline. Project front end loading is a process in which project business case is to be understood with an aim of developing project scope management strategy. Thereafter, comes project phase in which all the requirements of client along with all the stakeholders is to be understood and recorded which is explained under client requirement elicitation section. Lastly, comes the project phase where all the collected requirements leads to development of solution and thereafter translated in scope baseline.

Frontend loading

The front-end of a project is basically defined as the period from when an idea is conceived to where the decision to finance the project is actually made. This is the point where the complete project should have come together as one integrated whole, building the best fit with its market, environment, community and the corporate strategy of its sponsor (Morgan, 1987). The term front-end planning is often interchanged with feasibility analysis, pre-project planning, front-end loading, or conceptual planning (Ryan George, 2008). Despite the different definitions of front-end planning, many authors agree that front-end planning is a key element to overall project success (Gibson Jr, Kaczmarowski, & Lore Jr, 1995; Hartman & Ashrafi, 2004; Smith, 2000; Webster, 2004). Front-end decision making for projects according to (Samset, 2010) is very important since the need to "do the right project" is just as important as to "do the project right".

One of the most important phases of a project is the front-end phase, which is when the project exists only conceptually, before it is planned or implemented. It includes the entire set of activities from decision on the initial concept to the final decision for financing the project (Williams & Samset, 2010). In this stage resources should be expended without guarantee of return. The best project management practice is needed in this period to ensure that resources are spent as effectively as possible in order to provide highest likelihood of return (Morgan, 1987). During this phase, it is essential to have a broad perspective on the project and its features which are relevant for various stakeholders. It is also very important to take into account the uncertainty involved with the project's objectives and strategic framework. When it comes to large-scale public projects, with high level of complexity and risk, it is very important to spend enough time and effort on the front-end phase since the costs of changes are very high (Haji-Kazemi, Andersen, & Krane, 2013).

In this phase, many potential problems are identified proactively, before they can greatly affect project cost and schedule. Furthermore, successful planning identifies the areas within the project that need greater definition prior to design and execution (Ryan George, 2008). In the front-end development phases, a clear scope that optimally suits the project objectives needs to be developed. The scope is preferably frozen (as much as possible) early in the project, ultimately when the final investment decision is taken (PED Love, Holt, Shen, Li, & Irani, 2002). Note however that new, important inputs from the business perspective should not be discarded by definition. In case of very high-tech projects, a certain percentage of unidentified scope might be accepted and seen as a given for the project. It allows the project team to have greater influence over the project. As the project enters the execution phase, the project team has less influence to make low cost changes affecting the project. Once, the project commences the level of influence on project declines. Additionally, the expenditure to correct these changes increases. (Ryan George, 2008)

Haji-Kazemi et al., (2013) states that in case early warning signals are identified in the front-end stage of a project, the available time will be rather long enough for project managers to take the right actions in the subsequent stages of project. For example in case some warning signals related to cost and time limitation are identified in the front-end stage, budget estimating in the initiation phase can be done more accurately. In addition, it can be a guide to planning deliverables, baseline schedule and baseline budgets in the planning stage. Identification of early warning signs related to technical issues, can aid the responsible persons to make better decisions on risk management and production of key variables in the execution phase. Of course the challenge lies in the possibility of detecting the early warning signs and their level of reliability.

The business plan, or strategic plan, involves the goals and objectives of a business entity (Gibson, Kaczmarowski, & Lore, 1993). This phase provides a comprehensive structure to identify the business objectives of the company, and to ensure that the project's is in line with these objectives. (Ryan George, 2008)

Client requirement elicitation

In design projects, the design problem typically originates with a client (internal or external) who needs assistance solving a particular problem (Lawson, 2006). Such problem descriptions are typically accompanied by a set of requirements, some of which may be stated when the design problem is presented, while others emerge later (Buur & Andreasen, 1989; Cross, 2006; De Mozota, 2003).

The number and specificity of requirements defined by the client vary and in some cases, the client has a fairly specific idea about the direction of the design, while in other cases, the client has only an overall vision, goal statement or assumption of a particular market need, which then becomes the subject of exploration by the design agency(Haug, 2015). From the perspective of the designer, all client requirements would ideally be presented at the beginning of the project and remain unchanged throughout the project, since the emergence of requirements that were previously unknown or the redefinition of previously stated requirements risks making design proposals in progress infeasible, and the designer's efforts to create these proposals are wasted (Haug, 2015).

Invariably, scope information available to the project team during the planning process will differ in quality and level of detail. The quality of scope information is a key component to the planning process and can constrain the initial project planning outputs to a limited level of certainty and clarity (Alp & Stack, 2012). The most reported causes of scope creep are respectively, unforeseen conditions and owner requirements (Alp & Stack, 2012). The most obvious manifestation of this link occurs in situations where a designer works on a design proposal without being aware of certain client requirements that contradict the chosen design direction, which means that the proposal in progress has to be modified or even abandoned.

The reason why a designer works on a design proposal without knowledge of relevant client requirements is that these have yet to be considered by the client (Haug, 2015). Because clients are normally initiators as well as sponsors of design projects, their influence can be very direct on requirement specification (Pedgley, 2009). A project that has no definitive design documents available to the project manager will more likely deviate from any baseline scope established at the beginning of the project. Therefore, misappraisal of scope could likely be caused by deficient project information and not because of a deficient project manager. However, proficient project manager recognizes that project information might be deficient and would act upon this issue in time.

In contrast, for a project that has reasonable scope information available, a misappraisal of the scope of work could be a consequence of personnel failure to act on the information available. Each of these deficiencies is rooted in the quality of front-end planning (Alp & Stack, 2012). According to (Cross, 2006) a product design specification evolves from a design brief and aims to determine the precise limits for the full set of requirements in the product being designed. Design requirements may also go beyond what is stated in the design specification, for example including issues related to style and aesthetic preferences, which may be difficult to describe in detail.

A design brief includes information that frames the project by laying out what stakeholders hope to achieve with a specific assignment. Thus, rather than prescribing the end solution, the brief should focus on problems and opportunities (Dankl, 2013). According to De Mozota, (2003), a design brief includes three elements: the project objective, information about the company, and information about the project. It is the client's responsibility to produce the brief, although the design agency may contribute to its definitions. In other words, design briefs are often messy and incomplete, which leaves it up to the designer to clarify and determine what is relevant for the specific product development, and what is not (Dankl, 2013).

Several dynamics exist at the beginning of a project that can influence the effectiveness of defining and planning the scope of work. Most importantly is the understanding in the project team of the characteristics of the work to be performed. If the character of the work is understood then the team can provide critical thinking into the difficult-to-detect abnormalities or ill-defined project requirements before they become an issue on the project (Alp & Stack, 2012). The leading causes of scope creep are owner requirements. An owner requirement by definition includes any specification, requisite or constraint imposed on the work to be performed. Some owners know exactly what they want, while other owners are less definite and do not always identify their requirements. Often, it takes guidance by the project team to educate the owner on all the possible means and methods by which to design and construct a piece of machinery, a building, or a facility, to achieve defining the scope of work in terms of the owner's requirements. Owner requirements are different by nature because they are a product of the customer that a company is providing a service to and must yield to the requirements in order to please the customer (Alp & Stack, 2012).

To supplement the information provided by clients, designers draw on previous experiences and projects and consult a wide variety of tried and tested sources that they have at their disposal (Goodman, Langdon, & Clarkson, 2007). Because of tight schedules and resource constraints, however, design consultants often rely on current trends and developments rather than collecting primary data about the targeted users (McGinley & Dong, 2011). The full set of client requirements for a design solution should ideally be available in a clear and unambiguous form at the beginning of the design process. That is rarely the case in practice, however, in part because the client is not aware of the full set of relevant design aspects or has not given all the identified aspects adequate consideration at this point.

Furthermore, there are also certain communicative issues associated with the process in which a client shares this information with the designer. Often, the client's design requirements are formulated by a variety of experts, including marketing experts, engineers, and business managers, which may make it difficult for the designer to grasp the full or precise meaning or implications of the information e.g. (Badke-Schaub & Frankenberger, 1999; Badke-Schaub, Neumann, Lauche, & Mohammed, 2007; Bucciarelli, 1988; Kleinsmann & Valkenburg, 2008). Another potential problem in relation to the elicitation of clients' design requirements is that clients may not be fully able to articulate their

requirements. In other words, the client may appear to have a fairly fixed idea about what he/ she wants, yet still is unable to formulate clear and specific requirements (Gourlay, 2006).

The client requirements are typically not all given in advance; instead, some emerge during the design process. If client requirements change after the designer has completed a significant proportion of a design proposal, the design work may have been wasted if the emerging requirements contradict the choices made in the process so far (Haug, 2015). Furthermore, Haug, (2015) makes a distinction between the types of requirement changes that emerge during planning process. An 'emerged requirement' refers to situations in which a requirement for a product aspect appears that was previously unknown. A 'revoked requirement' refers to situations in which a client withdraws a previously stated requirement for a certain product aspect.

At the end of the process, i.e., after the designer has presented a design proposal to a client, the requirement state may have either changed or remained the same. Thus, after the presentation of the design proposal, the client's requirement for the particular product aspect may be either unknown or known. An 'unknown requirement' refers to a product aspect for which the designer does not know the client's requirement, regardless of whether the client does or not. The designer may have some idea about what a requirement concerns, but if the designer does not know exactly what the requirement is, the full requirement is unknown. A 'known requirement' refers to a product aspect for which the client has presented the designer with a requirement.

The problem of an emerged requirement is that it may contradict design decisions already made and thus require design work to be redone. Thus, unknown client requirements imply that the designer is unable to work on the design proposal without risking later emerging requirements that contradict initial design choices. The same applies to a revoked requirement, since it implies an unknown requirement for the particular product aspect. The potential problem with a redefined requirement is that it too may contradict design decisions already made and require design work to be redone. Thus, there are two potentially problematic situations that need to be considered: 1) unknown requirements and 2) known requirements that are redefined (Haug, 2015).

Project scope baseline

The processes used to manage project scope, as well as the supporting tools and techniques, vary by application area and are usually defined as part of the project life cycle. The approved detailed project scope statement and its associated WBS and WBS dictionary are the scope baseline for the project. This baselined scope is then monitored, verified, and controlled throughout the lifecycle of the project (PMBOK®Guide 4 Edition).

By starting the scope definition process with a WBS in place, the project team can think at a higher level making it easier to capture the scope details. Once sufficient WBS development has occurred, the project scope can then be detailed at a lower level. All too often this process is made convoluted and complex (Alp & Stack, 2012). Creating WBS is the process of subdividing project deliverables and project work into smaller, more manageable components. The work breakdown structure (WBS) is a deliverable-oriented hierarchical decomposition of the work to be executed by the project team to accomplish the project objectives and create the required deliverables, with each descending level of the WBS representing an increasingly detailed definition of the project work.

The WBS organizes and defines the total scope of the project, and represents the work specified in the current approved project scope statement. The planned work is contained within the lowest level WBS

components, which are called work packages. A work package can be scheduled, cost estimated, monitored, and controlled (PMBOK®Guide 4 Edition). As the project is executed, documentation of the scope will enable the project team to control any scope changes to the project in a quantitative and packaged manner. If for instance, design changes the electrical panel that the instruments will draw power from and requires 100 LF of additional conduit and cabling, the project team can easily balance the change back to the baseline scope definition line item to evaluate impact and justify any cost or schedule impact. It is important to consider a WBS as a management tool and not another description of the project work.

WBS can be used to manage scope and changes by controlling the work packages parameters such as activity duration, labour hours, material quantities, or subcontractor bids. Changes to any of these parameters should be evaluated against the planned scope as defined by the work package inside the WBS. All changes need to be evaluated to quantify the cost and schedule impacts before a decision is rendered regarding the change (Alp & Stack, 2012). Construction has no idea how the design has changed and cannot easily determine the impact on the cost and schedule of the project. Unfortunately, it takes many work hours to reconcile the differences between the drawings to determine the new scope of the design which leads to further delays on the project.

Stated in a different way, if the scope management process is designed to work hand in hand with the work breakdown of scope then unauthorized changes to the scope would be more effectively identified and mitigated (Alp & Stack, 2012). Ideally, the work breakdown structure is utilized with the division of responsibility. By linking the WBS to the DOR (Division of responsibility), the union creates an accountability program for the project participants and scope of work. In other words, change management can be efficiently performed on work packages assigned to project participants whether those are subcontractors, suppliers, and internal divisions. A rigorous process centred on the Work Breakdown Structure (WBS) methodology, enables the work to be subdivided into manageable packages (Alp & Stack, 2012).

APPENDIX A.4: KEY ASPECTS OF MONITORING AND CONTROLLING PROCESS GROUPS

This section will elaborate on scope management monitoring and controlling process group in three sub-sections. Each sub-section will address one part of monitoring and controlling process, starting with communication management followed by change and configuration management and tools & techniques that can be used to control scope change and scope creep. Communication management is an approach which not only plays an important role in verification of originally defined scope in contrast to actual scope of work being executed. But it also facilitate in registering a change request and helps in making aware all the stakeholders along with the project team about a change. Thereafter, configuration management is used to identify the impact of change on all the activities, resources affected by it. Lastly, certain tools and techniques are used with an aim of increasing the awareness within the project team about the project status and it requirements.

Communication management

The “process of exchange of information between sender and receiver to equalize information on both sides” is called communication (Den Otter & Prins, 2002). This definition is consistent with “sharing of meaning to reach a mutual understanding” den Otter & Emmitt, (2008) and as a “cognitive and social process by which messages are transmitted and meaning is generated” (Maier et al., 2008). Problems related to the elicitation of client requirement are, to a large extent, linked to designer-client communication issues (Haug, 2015).

The architecture, engineering, and construction (AEC) industry delivers increasingly complex projects to meet the financial, social, and environmental goals of stakeholders. Ideally, project teams would continue to effectively and efficiently communicate despite this complexity. Yet, even with the increased availability and pervasiveness of information technology (IT), project teams still struggle to communicate. These struggles limit the ability of project teams to manage complexity to achieve stakeholder goals.(Eckert & Clarkson, 2004; Haymaker, Chachere, & Senescu, 2011; Luiten & Tolman, 1997; R Senescu & Haymaker, 2008; RR Senescu, Haymaker, & Anderson, 2010)

The communicative issue stems from the designer failing to elicit certain information from the client or the client failing to provide information that the designer could reasonably expect to be given without asking for it (Haug, 2015). The reason why a designer works on a design proposal without knowledge of relevant client requirements is that these have yet to be considered by the client. The link to communicative issues in this type of situation is that the designer to a large extent, through communication with the client, has the opportunity to stimulate the client to develop these requirements rather than risk having them emerge later in the design process and render design proposals in progress infeasible (Haug, 2015).

Communication between project team members plays a critical role in the performance of how scope changes are identified, documented, and managed on a fast-tracked project. Nowadays, communications happen so instantaneously with e-mails, text messages, and phone calls, it is very easy for project team members to issue information, ask questions, and generally stay plugged in to work. There are advantages and disadvantages to this present state, but the piece to explore are the consequences of losing control of project scope, due to poor or reactive communications in a project environment. Three consequences occur when communications are not controlled that affect scope management are confusion, reaction, and results (Alp & Stack, 2012).

Confusion is a significant productivity killer for non-manual project work. But more importantly, confusion can lead people to do the wrong things which in turn create more problems. This is often seen in project based on work where usually lower level workers are assigned tasks by managers where the daily work is not clearly defined leading to misunderstanding of the task and expected results. Consequently, action leads to reaction by project personnel. Reaction is the second consequence and it results in real work being performed but not for the good of the project. Reactive work efforts stemming from confusion can be very detrimental to a project, especially if the work is not stopped quickly (Alp & Stack, 2012).A communication plan should outline who, what, when, and how regarding project communications. In regard to electronic communications, specifically e-mail and text messaging, caution should be maintained when using these methods because they lack the non-verbal elements of communication. Messages can be misconstrued or taken out of context in text form which leads to misunderstanding (Alp & Stack, 2012).

There is also a link between communication issues and problems with eliciting client requirement in cases where previously stated requirements are redefined during the design process. In these cases, through communication with the client, the designer may develop a deeper understanding of the client and, thus, a better ability to anticipate which client requirements may be subject to changes (Haug, 2015). In fact, the process of communicating with a client during a design project may be perceived as a ‘reflective conversation’, which is not only about understanding the client’s demands but also about understanding the client (Haug, 2015). This information exchange is, however, not always unproblematic, since design briefs often lack information, are not communicated in a ‘designedly’ way, have little

consistency between content and format, and are accompanied by reference materials of varying quality (McGinley & Dong, 2011).

Clients' failure to recognize the importance of communicating requirements for certain product aspects was explained by the client falsely assuming that a requirement was unimportant or self-evident. When the designers suspected this, they typically addressed the issue in discussions with the client and by presenting sketches of design ideas, which often triggered the communication of such requirements (Haug, 2015).

Clients sometimes falsely assuming that certain design requirements had been communicated was explained by the designer misunderstanding information from the client or the client falsely believing they had provided such information (Haug, 2015). The construction projects stand out because of their high frequency of change due to errors and contradictions in the original project documentation. For the IT support service contracts, 'lack of communication between the contractual parties' is a prominent reason for change (Bröchner & Badenfelt, 2011). Organizational related issues refer to change in management, lack of timely and effective communication, and lack of integration between departments (Ibbs, Wong, & Kwak, 2001). Stakeholder related issues are for instance, design errors, omissions, or modifications to the drawings leading to infective design, poor project definition by owners, inadequate pre project planning, inadequate project change management, poor communication among owners, designers and constructors, or constructability ignored in the design process (Hwang & Low, 2012).

Many efforts to improve communication do not consider that "the person responsible for recording information is typically not the person who would benefit from the information once it is recorded" (Eckert, Clarkson, & Stacey, 2001). Conklin, (1996) described a project memory system to define this knowledge and make it available to other projects. According to Conklin, (1996), the project memory system is necessary for knowledge sharing between projects because organizations lack ability "to represent critical aspects of what they know." Once this system enables knowledge acquisition, Conklin claimed that the knowledge must be structured (R. R. Senescu, Aranda-Mena, & Haymaker, 2012).

In relation to designers' elicitation of clients' design requirements, there is the issue of the media used to communicate about such design requirements. Typically, design processes rely heavily on designed artefacts, such as sketches, renderings, models, and prototypes, as communication media for exploring and testing possibilities and to communicate these options (Carlile, 2002; Crilly, Maier, & Clarkson, 2008; Eckert & Boujut, 2003; Stevens, 2013). In studies of design communication, the concept of 'boundary objects', introduced by Star & Griesemer, (1989), is often used to describe artefacts that persons in different 'object worlds' use as a medium of communication between them (Eckert, Stacey, & Earl, 2013). This is also the case in relation to designer client communication, where the use of other media beside speech and text may be necessary to achieve a common understanding, not least when discussing certain aspects of product appearance. (Haug, 2015)

Change and configuration management

Ibbs, (2001) stated that any additions or deletions to project goals or scope are considered to be changes, whether they increase or decrease the project cost, schedule or quality. Similarly, Manzoor Arain & Sui Pheng, (2005) defined that a change is any modification to the contractual agreement provided by the contractors or owners. When project changes occur, there are bound to be certain consequences. The impact of project changes can either be significant or trivial as it may affect the operation and progress of the project (Hwang & Low, 2011).

Furthermore, creating a project management plan is one of the first challenges for a project manager. It is not an easy task due to the complex interdependence among its comprising documents. The elaboration of a project document requires bearing in mind the information contained in other project documents and it often requires updating other documents already developed. Therefore, it is essential to develop a well-defined procedure that guarantees the coherency among the documents of the project management plan i.e. the configuration management (CM) plan. PMBOK defines CM as a subsystem of overall project management that deals with the following four aspects: version control, change control, changes notification and changes record(Ruiz-Martin & Poza, 2015).

The control actions to address changes can have intended effect of resolving the issues that initiate the control actions, if the decision is correct and well implemented. At the same time, they can produce a side effect that may create some unintended problems, if the decision is incorrect, not well implemented, exceeds the time frame of its effectiveness or if a project manager does not realize the impact of the control actions on other related activities (I. A. Motawa, C. J. Anumba, S. Lee, & F. Peña-Mora, 2007).

The reconciliation of the gap between the initial work scope and the actual work scope can also result in these feedback processes. After the project starts, the actual work scope may be increased, since additional work is often added to the project scope in order to deal with changes. Moreover, these unintended effects become more detrimental when concurrent engineering techniques are applied. This is because the decision to take control actions against unanticipated additional work has to be made within the complex inter-relationships of activities, even with a lack of complete information about predecessor activities (Lee, 2003).

However, change management in construction industry is an important aspect of project management, as changes constitute a major cause of delay and disruption. It is widely accepted by both owners and constructors that change effects are difficult to quantify and frequently lead to disputes (I. A. Motawa et al., 2007). Changes in plans can cause high transaction costs, which have a negative impact on project results. Changes in plans may be introduced for various reasons. They may come from a change required by the customer, or due to new and better ideas suggested by the project team, or even from the dictate of a new manager, who comes in at a later stage and wants to impose its own twist to the project. Quite often, projects undergo tremendous changes and when the project is finally completed it may no longer be relevant, too much “tweaking” can result in loss of the original project focus (Dvir & Lechler, 2004).

One major cause of change effort failure is resistance from organizational members B. C. Lines, Sullivan, Smithwick, & Mischung, (2015), where resistance to change is defined as any dissenting actions that slow, oppose, or obstruct a change management effort (Armenakis & Harris, 2009; Giangreco & Peccei, 2005). Moreover, the organization's approach to change implementation is also important to consider. Unrealistic expectations that underestimate the amount of time and effort required to accomplish a change may lead to resistance (Ankrah, Proverbs, & Debrah, 2009; Armenakis, Harris, & Feild, 2000; Sullivan, 2010). A change originating with the client is due to high initial search or information costs for the client; as a consequence, and unintentionally, the original contract documentation from the client may contain errors, omissions and contradictions in specifications (Kadefors, 2008).

When the client finds that the primary business to be supported by the project or service contract has changed its needs in a way unforeseen in the original contract. This category is often referred to as scope issues (Bröchner & Badenfelt, 2011) . Furthermore, Dvir & Lechler, (2004) distinguished between plan changes and goal changes, where plan-changes are by definition lacking impact on project goals and are typically induced by the project environment. While, Hsieh et al., (2004) studied public works projects and they split the causes of change orders into technical and administrative. A recent overview of earlier

investigations of change in construction projects suggests that there are three main types of change causes: external, organizational and project internal causes (Bröchner & Badenfelt, 2011).

External causes are thus a narrower concept than 'environmental uncertainty', as used by Barthélemy & Quélin, (2006) in their study of outsourcing in several industries, and who consider uncertainty from the viewpoint of the provider and thus also include all client-initiated changes in the environment of the contract. External causes can be of natural origin or societal. So there may be unexpected natural events, although many such risks are routinely allocated to the client in a force majeure clause of the contract and thus in most cases will not lead to any contractual changes.

Finally, there are the external disruptions of societal or human origin, such as unexpected legal changes, political turmoil and labour unrest. Research in the areas of resistance to change often describes it on the individual level as three dimensions: cognitive, affective, and behavioural (Erwin & Garman, 2010; Isabella, 1990)**.** The cognitive dimension refers to how employees think about the change, including their perceived capability to be effective in new work roles (Giangreco & Peccei, 2005). The affective dimension is defined as the emotional and psychological reactions employees experience in how they feel about the change (Denhardt, Denhardt, & Aristigueta, 2015).The behavioural dimension examines resistance in terms of employee action responses, and whereas the first two dimensions are often accepted as the sources or reasons causing resistance, the behavioural dimension is the actual manifestation of resistance in the form of observable conduct, deeds, and events (Fiedler, 2010; Giangreco & Peccei, 2005; B. Lines, 2014).

APPENDIX B: INTERVIEWS

APPENDIX B.1: INTERVIEW QUESTIONNAIRE

Interview Questionnaire

Personal information of interviewee:

Name:

Background:

Years of experience:

Any Project Management Certified course done:

Introduction to research problem questions in context to: **How to reduce unwanted scope changes and creep in large infrastructure projects for lump sum contracts in construction industry**

In this research I have differentiated between scope creep and scope changes definition which are as following:

- **Scope creep** is generally referred to as the phenomenon where the original project scope to build a product with feature X, Y, and Z slowly grows outside of the scope originally defined in the statement of work. **(O. Hussain, 2012)**
- **Scope Change** is an official decision made by the project manager and the client to change a feature X to expand or reduce its functionality. Generally, scope change involves making adjustments to the cost, budget, other features, or the timeline. **(O. Hussain, 2012)**

1. Are you often confronted with scope creep in your projects? (***it is unapproved and undocumented scope changes happens usually due to inefficient communication***)
   a. What are the main reasons that lead to scope creep?
   b. Do you consider scope creep as a problem in your project or not?
   c. What do you think about its impact on project performance?
   d. How do you usually deal with scope creep?

2. What are the main reasons that lead to scope change?
   b. Do you consider scope change as a problem in your project or not?
   c. What do you think about its impact on project performance?
   d. How do you usually deal with scope changes?
   e. Do you differentiate between unwanted and wanted scope changes?
      i. If yes then, how do you do that?
      ii. If no then, why don't you acknowledge it?
      iii. Do you think wanted changes can also sometimes lead to unwanted changes? (***Knock on effect based upon contractual agreement***)

3. How do you define project scope baseline? (***To get to know about tool that is being used***)
   a. Do you use the WBS as a schedule baseline as well? (***most probably the tool will be WBS***)

b. How do you take consideration of knock on effect caused by changes in scope baseline? (***To check how do they link scope baseline with available resources and project drivers***)
c. How do you make members of project team accountable for managing and delivering different work packages? (***To get an idea about how division of responsibility is practiced with in the team***)

- **Questions covering all the relevant aspects of front end loading:**

1. How do you prepare for the front end loading of a project in context to project scope? *(**Below are follow up questions which will be asked depending upon the interviewer response***)
   a. Is scope of the project clearly identified?
   b. Does it optimally suit client's project vision and objective?
   c. Do you acknowledge how client perceive RH input?
   d. How do you deal with the circumstances where the project budget is fixed and project scope is large? (***tender***)

2. How do you make sure that right information is available at right time? (***In context to understand the project business plan for developing contract strategy, project execution plan, facility scope plan, and product technical plan)***
   a. How do you estimate commercial bid for tender application?
      i. How do you incorporate and value risk associated with scope changes and creep in the tender bid? (***Contingency***)

3. Is there hierarchy in accepted tender documents in terms of one document overruling the other?
   a. If yes, then how do you deal with misalignment between them?
   b. Does misalignment occur between tender documents?

4. What considerations are made while taking a part of assignment from the lead consultant to avoid scope creep and scope changes liability?
   a. How do you take care of the liability issues?(***Contract)***
   b. What criterion is ideal in this case? i.e. Dealing directly with the client by by-passing lead consultant or with the lead consultant and not with the client to minimize transfer of risk?

5. What considerations do you make while going into contract with the sub-consultant, in or out of the country where the project is being realized?
   a. What kind of project scope risk do you prefer transferring to sub consultant? (***Permits approval and etc***.)

- **Question covering all the relevant aspects of client requirement elicitation as well as scope definition criterion:**

1. What are the main reasons for change in client requirements?
   a. How often are client requirements not clearly understood and defined?
   b. Why is it so?

2. How do you deal with incomplete and generic, unclear design brief provided by the client? (***is the company struggling to understand contractual agreement in different countries***)
   a. What approach is followed to make assumptions about the client's deliverables expectation, in the case when the client himself is not able to fully articulate their requirements?
   b. How you deal with the situation where the firm proposal is not taken into the contractual agreement?
   c. Is usually in lump sum contracts functionality being decided by the client and the scope by the firm?
   d. What do you do to make sure you understand contractual agreement correctly?
   e. Do you make contract together by stimulating a healthy communication with the client or is it imposed on the firm?

f. How do you provide information/ input to the client is it objective, quantifiable or it is generic?
g. What level of detail is used in the contractual agreement? (***poor contract management***)
   i. What is your opinion about how much and how detailed it should be? And why? (***can it control dynamic behaviour of project***)

3. How do you communicate within the project teams at RHDHV, while realizing a project?
   a. How do you keep record of all the communication that is held with the client or his team?
   b. What mode of communication is mostly used? (***to get an idea is the mode of communication used, vulnerable to interpretation and misunderstanding***)
   c. How do you use these documented records of communication with the client? (***Objective of this question is to check- Do they make client aware of what they have perceived as a result of the discussion and do they get it notified***)
   d. How often do you clarify and get notified, concluding remarks of a communication with client? (***Agreeing on only those aspects which are in line with the contractual agreement and on available resources at that point in time***)
   e. How do you control and document communication with in the project team? (***To get an idea of any communication lag w.r.t any changes no matter very minor or major and to make sure that everyone is aware of project current status***)
   f. How do you control and document communication with the lead and sub- consultant?

4. How do you prepare prior to final project scope (could be addendum as well) and it cost negotiation with the client? (***To check the procedure followed to come on an agreement and to acknowledge how and who makes the most crucial decision***)

➢ **Question covering all the relevant aspects of change management:**

1. How do you deal with changes in already completed work of scope?
   a. What considerations do you make in these situations? (***to see how do they acknowledge resources to accomplish new work and time required to make changes***)

2. How do you guarantee coherency between project management documents? (***Interface management***)

3. How often activities resource allocation in the project is revised? (***to check cyclic update of activities and the resources available to achieve milestones***)

➢ **Open unstructured questions:**

1. While realizing transnational projects is there any learning document used as a starting point from the project done in the past? (***Can facilitate in dealing with the cultural problems to great extent***)

2. How do you differentiate between the issues and risk related to project scope? (***Define them first***)

3. While executing a project, which document is acknowledged as a single point of reference (SPOR) so that all the activities are align to it?

4. On an average, does large number of projects are worked on a fast-tracked schedule and why?
   a. Is it one of the causes of unwanted scope changes?

5. Do you think having additional staff full or part time will help in coordinating and managing scope changes? (***Idea that a process is only as good as the people who execute it, it seems that adding additional resources will only treat the symptoms and not the illness)***

6. How is project scope managed where more than one business line is working together under a lead business line?
   a. Is RHDHV approach effective in dealing with conflict of interest of different business lines working on a project?

7. How effective is project health check tool in controlling project scope changes and creep?
   a. Is it successful in identifying early symptom?
   b. How easy is it for you to use this tool?
   c. What else benefit or pitfalls that you think this tool has?

APPENDIX B.2: INTERVIEW ANSWERS

Explored Items		Scope management questions	What is being practiced at RHDHV
Scope Creep	S.NO		
	1.	Occurrence of scope creep?	• Scope creep is encountered in all the projects and projects managers should be very cautious about it.
	2.	Main reasons leading to scope creep?	• Scope of work is ill defined • Client requirement which are small in size, but cumulative is large. • Project team members are not fully aware of scope of contract and negotiated budget. • Knock on effects of scope change • Changes made by project team members without communicating it to the project manager.
	3.	Impact of scope creep on project performance?	• Negative impact on project finance, schedule and morale of project team. • Rework and stakeholders losing confidence in the company.
	4.	How do you deal with scope creep?	• These are minor deviation from the project scope of work hence, they are adjusted in contingency. However, for big changes a change or request is filed.
Scope Change	S.NO		
	1.	Main reasons of scope changes?	• Changing in client contracting strategy, changing stakeholder and client requirements. • Permitting issues and gaps in client intent and vision. • Change due to lack of planning and changes due to introduction of new information.
	2.	Do you make distinction between wanted and unwanted changes?	• Scope changes that client consider within consultants normal service of work are considered unwanted. • Scope change requested by the client, which would be out of original scope of work and might require help of third

			party for its execution would be unwanted.
	3.	Do you think wanted scope changes can lead to unwanted scope changes?	• Knock on effects of wanted scope changes leads to unwanted scope changes. • Scope change that reduces the original scope of work is usually unwanted
	4.	How do you deal with scope changes?	• Follow the contractually specified rule for managing scope change. • For scope changes the client is usually notified and in case of small changes a COR is filed. However, large scope changes are initiated by having a dialogue with the client.
	5.	How do you deal with changes in already completed scope of work?	• The PM would brief and try to justify to the client, that it is a change to the basis. But if the client does not agree then a strategy is made to deal with the change.
Scope baseline	S.NO		
	1.	How do you define Scope baseline?	• The scope of work specified in the contract is treated as scope baseline. Furthermore, the scope of work mentioned in the contract is imaged in project execution plan.
	2.	Do you use WBS for splitting work in different work packages?	• WBS is used for dividing scope of work in several manageable work packages.
	3.	How do you make schedule for the scope of work?	• There are baselines for several project drivers which sit in project execution plan. For example Primavera Gantt chart is used as a schedule baseline.
	4.	Do you make members of your project team accountable?	• Project team members working on time basis are not really made accountable. However, full time team members are assigned responsibility of certain task by allotting time and budget to finish the assigned task.
	5.	How often do you update allocation of resources to different work packages or activities?	• The resources allocated to different work packages are updated depending upon the length and type of the project.
Front end loading phase	S.NO		
	1.	How do you prepare for front end loading?	• It depends if PM is involved in the front end loading or not. But, usually the RFP is screened by the team of directors and thereafter passed on to proposal team where, RFP is screened by financial, legal experts and RHDHV project proposal is developed. However, if the project managers are involved then they use their own preferred approach.

	2.	How do you incorporate and value risk in a commercial bid?	• In most of the projects risk is estimated and valued using thumb rules. But sometimes in case of large projects the scope of work is split into work packages and thereafter risk are identified and valued in context to each work package.
	3.	Do you acknowledge order of precedence in the project contractual documents and does it cause problem?	• Yes there could be conflicting information in the contract document. However, RHDHV tries to offer a project proposal which is in line with client RFP and pre-tender questions & answers. But there could be misalignment between the contract documents which leads to initiation of dialogue with the client.
	4.	What consideration do you make while taking an assignment from a lead consultant to avoid scope creep and scope change liability?	• It is usually difficult as lead consultant tries to push the same amount liability on us as they have it with the client. However, RHDHV prefers to sign a letter with lead consultant, which states that they are not going to blame each other for the mistakes in design caused by either of the two parties.
	5.	What considerations are made while outsourcing work to sub-consultants to avoid scope creep and scope changes liability?	• RHDHV has to be very careful while outsourcing work to sub-consultants as they are not accountable to the client. Generally we prefer to have a back to back contract with sub-consultants so that they are aware of their work interdependencies. Furthermore, RHDHV tries to make liable and responsible for their scope of work.
Change Order Request	S.NO		
	1.	Do you acknowledge how client perceive your input i.e. advice, feedback, proposal etc.?	• This aspect depends upon the type of client we are dealing with. Generally clients from Middle Eastern countries are suspicious, while clients in Europe are not. However, usually when we are dealing with a client for the first time he/she is suspicious.
	2.	How detailed information do you provide to the client? Especially in context to change order requests (CORs)	• RHDHV project team usually tries to furnish client with detailed COR with objective and quantifiable information. However, sometimes few CORs are send to the client with generic information, as it is difficult to collect all the required information needed for a detailed COR.
Client Requirement Elicitation	S.NO		
	1.	Main reasons that lead to change in client requirements?	• Changes in government standards and guidelines along with changing stakeholders requirements. • Budget restrictions on the client. • Client didn't fully realize their

			requirements at the first place. • Once client see something related to the product, he/she would usually come up with "Nice to haves"
	2.	How do you deal with incomplete, generic, unclear client design brief?	• In case of incomplete and generic requirements RHDHV prefers to ask questions in the clarification opportunity provided by the client. However, when the scope of work asked by the client is too vague then the company prefers to not to bid.
	3.	Asking too many clarifications might be advantageous for the competitor. How do you deal with this situation?	• RHDHV project team prefers to ask questions in clarification session which tend to increase the commercial bid of the project. While the questions which cannot be asked are clarified by making assumption is the project proposal document.
	4.	But if your proposal is not part of the contractual agreement. Then what happens to the assumptions made?	• Then we have to deliver whatever has been specified in client RFP. But we can in this case start managing the client expectation from very beginning of the project. This approach would help us reduce losses.
Contract	S.NO		
	1.	Is the contract imposed on the company or is it developed in discussion with the client?	• Both. It depends on how RHDHV have been procured. In a competitive bidding environment the contract is imposed on the company. But if you have been procured or selected in an open environment then the client is happy to resolve some issues with the company.
	2.	In lump sum contract is functionality being decide by the client and detailed scope by the consultant?	• Although we offer a lump sum price. But we often rate those specialist individuals working in company on hourly basis. We advise client that we are putting a price for the scope. But if you want any functional or additional requirement then these are our hourly rate which will be charged.
Communication Management	S.NO		
	1.	How do you communicate with in the project team?	• We communicate by using a lot of Phone calls along with telephonic conferences, e-mails and non-verbal communication which makes communication difficult. However, conversation on a table makes communication better, so that is why we usually prefer to organize meetings where we can sit together and discuss project progress. But this not always possible as project team members are working from different offices.

	2.	How do you document the minutes of the meeting held with the client and do you get them signed by the client?	• Usually RHDHV project team tries to record all the crucial minutes of the meetings and get it signed by the concerned party. However, it is a desired situation which is not being practiced at all the projects concurrently.
	3.	How do you prepare for final scope and its cost negotiation with client? In context to addendum	• From the very beginning the company knows what is required and that's what we present to the client. This requirement then set the basis for negotiation. We don't go for negotiation alone, there are discipline experts accompanying the project manager.
Configuration Management	S.NO		
	1.	How do you guarantee coherency between project management documents? In context to interface management	• We always make sure before entering into a new agreement to check what is written in our contract along with what will be done by us and what by our sub-consultant so the client deliverables are in line. In case of small interface we just copy paste some clauses but in case of bigger work we attach entire scope of work to sub-consultant contract. However, for internal project team interface management, we use interface management tool along with some inter-disciplinary checks in place.
Project Health Check	S.NO		
	1.	Effectiveness of project health check tool (PHC) in controlling scope changes and scope creep?	• It is very effective in setting an agenda and it's very good to think about question every month. Furthermore, it helps PM to first develop him/her opinion about the project and then later PM discuss it with an external observer. • It is not very effective in managing a project because it's too late if PM leaves an issue for a month. It's a tool to escalate issues to higher management but when it is done it is too late. However, it is a good tool for monitoring purposes.
	2.	Is PHC successful in identifying early symptoms?	• Yes, it is good tool together with moment of reflection for the PM and stimulating a discussion with external observer.
	3.	What is the pitfall of PHC tool?	• It's only good as the information put in it and it is too late.
	4.	Can PHC be used for recording lessons learned from a project?	• It will be hard to track lessons learned, as everyone is putting data into PHC in a different style. Furthermore, the project team members have to really think what is the lessons learned here as it is a long process with several steps to bring an

			activity back to green from red.
Open Unstructured Questions	S.NO		
	1.	Is there any lessons learned document used as a starting point in transnational projects? And will it be helpful from client working culture perspective?	• RHDHV does not use any such document. But, there should certainly be used as it would help in acknowledging client working culture and in making go/no go decision for a project.
	2.	How do you make distinction between issues and risk related to project scope?	• Most of the project managers were not aware of the explicit difference between issue and risk. However, they do update project risk log on timely basis, where both these variable are acknowledged.
	3.	Which document do you consider as single point of reference (SPOR)?	• For discussion with the client the PM treats scope of work mentioned in the contract as SPOR however, for internal coordination project execution plan is used as SPOR.
	4.	Are the projects now days worked on fast track basis? And why?	• Yes projects are being worked on fast track basis because the client wants them quick probably due to their business case, business model or they might have made some commitments at higher level. It is important to acknowledge that these projects to greater extent are vulnerable to scope creep.

APPENDIX C: SURVEY

APPENDIX C.1: SURVEY QUESTIONNAIRE

Validation of research findings on reasons of scope changes and scope creep in design and engineering consultancy projects. Validation deadline 23rd of September, as this research is on a critical schedule

1. Introduction and General questions

I am a master student at Technical University of Delft, the Netherland pursuing MSc. Construction management and engineering. Furthermore, now I am working at Royal HaskoningDHV as a graduate research intern in project excellence team.

My research focuses on "Management of uncontrolled scope changes in large infrastructure projects executed on fixed price contract in construction industry". The goal of this research is to provide recommendation on how to improve scope definition along with scope management in projects to minimize occurrence of scope creep and strengthen the application of the Project health check tool.

This survey is divided into four sections. Section 1 concentrates on general question associated to the respondent. Section 2 focuses on definition of scope changes and scope creep. Section 3 & 4 focuses on questions related to causes and consequences of scope changes and scope creep respectively.

Moreover, all the information retrieved from this survey will be treated anonymously and will only be used for survey evaluation, unless you want your name to be mentioned in the preface acknowledging the contribution of experts. The results of this survey will be further used to validate "Scope creep management model". Thereafter, both the survey results as well as the result of validated model will be published in a report. The findings of this research will be shared with you as well.

It will take you less than 20 minutes to finish this survey. Furthermore, I Kindly request all the respondents to complete the entire survey without leaving any question, as the survey with one unanswered question cannot be used in the analysis.

Lastly, please respond to the causes and consequence of scope change and scope creep keeping in mind not only the national projects, but also the international projects. Furthermore, all the questions should be answered from design and engineering consultancy firm perspective.

Thank you in advance for your valuable feedback and cooperation,

Looking forward to your kind response,

Best Regards,
Rahul Sharma

If you have any questions about the survey or if you are interested in the results of this study, please contact me via the contact details below:
E-mail: Rahul.Sharma@rhdhv.com
M.No: +31659699238

Name of the respondent

Which business line are you working in?

At what position are you working on? (e.g.project manager, project leader etc.)

How many years of working experience do you have?

What is your field of educational background?

Have you undertaken any certified project management course?

2. Questions in context to definitions of scope changes and scope creep

To what extent do you agree, with the following definition of scope change?

	Strongly disagree	Disagree	Neutral	agree	Strongly agree
Scope change is an official decision taken by the project manager and the client to change, expand or reduce originally defined scope of work. A scope change always results in making adjustment to all the activities, resources and contractual agreement affected by the change.	○	○	○	○	○

If you strongly disagree or disagree please explain the reason behind your disagreement

To what extent do you agree, with the following definition of scope creep?

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Scope creep is an uncontrolled scope change which occurs slowly and unofficially without addressing its impact on project activities and resources. These are the changes which occur without an official agreement between the client and the project manager.	○	○	○	○	○

If you strongly disagree or disagree please explain the reason behind your disagreement

It is important to note, that irrespective of the answer that you have given for the definitions above, please answer all the follow up questions of scope change and scope creep in line with the definitions mentioned above.

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3. Questions in context to causes and consequence of scope change

How often does the following causes lead to scope changes in a project?

	Never	Rarely	Neutral	Sometimes	Most of the times
1. Financial constraints on the client	○	○	○	○	○
2. Change in client business case.	○	○	○	○	○
3. Change initiated by Stakeholders.	○	○	○	○	○
4. Changes in government Law & Standards.	○	○	○	○	○
5. The original contract documentation from the client may contain errors, omissions and contradictions in specifications	○	○	○	○	○
6. Incomplete project information provided by the client.	○	○	○	○	○
7. Incorrect project information provided by the client	○	○	○	○	○
8.Client request to modify design specifications	○	○	○	○	○
9.Abnormal site & ground conditions discovered during site investigation.	○	○	○	○	○

	Never	Rarely	Neutral	Sometimes	Most of the times
10. Client request to execute additional work	○	○	○	○	○
11. Consultants for other related project work fail to provide necessary information on time. (interface problem).	○	○	○	○	○
12. Slow decision making process by the client.	○	○	○	○	○
13. Late changes due to delays in review and approvals caused by an inexperienced clients	○	○	○	○	○

Please specify any other cause of scope change which you think has not been mentioned above

How often scope changes lead to the following consequences on the client?

	Never	Rarely	Neutral	Sometimes	Most of the times
1. Increase in project cost i.e. decreased profitability	○	○	○	○	○
2. Extention in project schedule	○	○	○	○	○
3. Poor Quality of deliverables	○	○	○	○	○
4. Client dissatisfaction	○	○	○	○	○
5. Low morale of project team	○	○	○	○	○
6. Legal dispute between client and consultant	○	○	○	○	○
7. Damage to reputation	○	○	○	○	○
8. Rework	○	○	○	○	○

Please specify any other scope change consequence which you think has not been mentioned above

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4. Questions in context to causes and consequences of scope creep

How often does the following causes lead to scope creep in projects?

	Never	Rarely	Neutral	Sometimes	Most of the times
1. Unforeseen conditions	○	○	○	○	○
2. Client requirements	○	○	○	○	○
3. Misappraisal of the original scope of work	○	○	○	○	○
4. Ignorance of key stakeholders until the project is underway.	○	○	○	○	○
5. The project is executed after years of completion of study and scope definition.	○	○	○	○	○
6. Scope definition is done by the wrong people.	○	○	○	○	○
7. Government officials are always "ambitious" and unrealistic regarding the outcome of projects.	○	○	○	○	○
8. Intervention by politicians and senior government officials.	○	○	○	○	○
9. The data was not enough when the scope was defined.	○	○	○	○	○

	Never	Rarely	Neutral	Sometimes	Most of the times
10. Bad management of project changes, and absence of scope management and control systems.	○	○	○	○	○
11. Most managers focus on major scope changes and ignore small changes that could lead to bigger scope creep problems.	○	○	○	○	○
12. Conflict in different government agencies interests	○	○	○	○	○
13. Design change due to poor design brief	○	○	○	○	○
14. Poor communication between the key partners is a main cause for design changes and rework.	○	○	○	○	○
15. Design errors and omissions	○	○	○	○	○
16. Inconsistency between drawing and site conditions	○	○	○	○	○
17. Poor interdisciplinary communication	○	○	○	○	○
18. Team instability e.g. disputes, bankruptcy etc.	○	○	○	○	○
19. Inappropriate project organizational structure	○	○	○	○	○
20. Delays in producing design documents	○	○	○	○	○
21. Insufficient data collection and survey before design	○	○	○	○	○
22. Inadequate design team experience	○	○	○	○	○
23. Errors and omissions in quantity estimation	○	○	○	○	○

	Never	Rarely	Neutral	Sometimes	Most of the times
24. Inadequate arrangement of contract interface	○	○	○	○	○
25. In government projects, it is not easy to differentiate between what is included in the project and what is not included.	○	○	○	○	○
26. Citations of inadequate specification	○	○	○	○	○
27. Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework	○	○	○	○	○
28. Necessary variation of work	○	○	○	○	○
29. Delay in design information	○	○	○	○	○
30. Long waiting time for approval of drawing	○	○	○	○	○
31. Project managers too eager to get additional work without fully understanding scope of work.	○	○	○	○	○
32. Lack of organizational senior management support.	○	○	○	○	○
33. Poor documentation of agreements with key partners. (Lead/Sub consultant, client)	○	○	○	○	○
34. Wrong selection of Sub-consultant	○	○	○	○	○
35. Unrealistic budget due to underbidding	○	○	○	○	○
36. Lack of accountability on project team members	○	○	○	○	○
37. Lack of frequent project site visits.	○	○	○	○	○

	Never	Rarely	Neutral	Sometimes	Most of the times
38. Push to use new technology in uncertain project environment.	○	○	○	○	○
39. Not utilizing available resources within the company.	○	○	○	○	○
40. Project team working from different offices.	○	○	○	○	○
41. Contractual agreement open to wide interpetation	○	○	○	○	○

Please specify any other cause of scope creep which you think has not been mentioned above

How often scope creep lead to the following consequences on the company?

	Never	Rarely	Neutral	Sometimes	Most of the times
1. Increase in cost to the company i.e. decreased profitability	○	○	○	○	○
2. Inability to meet the client scheduled milestones	○	○	○	○	○
3. Poor quality of design deliverables	○	○	○	○	○
4. Client dissatisfaction	○	○	○	○	○
5. Low morale of project team	○	○	○	○	○
6. Legal dispute between client and consultant	○	○	○	○	○
7. Damage to firm reputation	○	○	○	○	○
8. Rework in already completed design	○	○	○	○	○

Please specify any other scope creep consequence which you think has not been mentioned above

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5. Thank you

Dear Sir/Mam, thank you very much for taking some time out of your busy schedule to add value to my research and to the academics. I assure you, that your feedback will definitely add value to RHDHV to enhance project performance.

Best Regards,
Rahul Sharma

APPENDIX D: MODEL VALIDATION

APPENDIX D.1: SCOPE CREEP MANAGEMENT MODEL VALIDATION QUESTIONNAIRE

All the questions should be answered from design and engineering consultancy firm perspective on projects executed on fixed price contract.

General Question:

1. Name of the respondent
2. Which business line are you working in?
3. At what position are you working on? (E.g. Project manager, project leader etc.)
4. How many years of working experience do you have?
5. What is your field of educational background?
6. Have you undertaken any certified project management course?

Yes/No Questions:

1. Do you think having project manager in the proposal team will reduce risk and uncertainties of wrong assumption?
2. Do you think BM and Coarse WBS will help in better assessment of project execution cost along with risk and opportunities?
3. Do you think review of project proposal by selected specialist, risk manager and design leads will reduce uncertainties of unclear and generic terms and conditions in RFP?
4. Do you think review of project scope of work and contractual agreement at handover stage by PM and design leads, will eliminate liability of executing project on wrong terms and condition made by proposal team?
5. Do you think RACI will help in making project team members accountable for their scope of work?
6. Do you think use of scrum process will minimize communication problems faced by projects?
7. Do you think PHC is helping PMs in identifying risk and issues early in the project?
8. Do you think stage gate model will help in better planning of the project in terms of resources, time and budget?
9. Do you think documentation and use of lessons learned will help projects minimize occurrence of same mistakes as made in the past?

Questions in context to proposed scope creep management model:

Open Questions:

1. Do you confirm whether the proposed model is valid and useful in managing uncontrolled scope changes holistically?

2. How would you re-structure the proposed scope creep management model?

3. The tools and techniques used in the model are not new, then why don't practitioners use them?

4. What would you recommend to reduce or mitigate occurrence of scope creep, in addition to the proposed model?

5. Do you think current working culture at RHDHV is suitable for implementation of this model? If not then please explain why it is not and what is required to implement this model within RHDHV?

APPENDIX E: SCOPE CHANGE AND SCOPE CREEP DEFINITION VALIDATION

APPENDIX E.1: SCOPE CHANGES DEFINITION DISAGREEMENT COMMENTS

S.NO	Survey respondents comments on proposed scope change definition
1	Scope change is not always an official decision. it can happen organically as a project evolves or changes in the project team occur. The most difficult scope changes to manage are those that only change one elements of the project or an external factor outside both the client and your control. Such as change of political support or approach to an infrastructure project.
2	not always all changes
3	There is often a huge conflict and disagreement between Client and consultant when scope change occurs. Client will say that it is not, consultant will say it is. And then there is a problem.
4	A scope change can be a small change in quality, time, money or anything else. It's not always necessary to adjust all the activities etc.
5	Scope change affects the team, the programme and the process. Be careful with scope changes. It affects your results!
6	It's an official decision but not always taken by PM and Client. Client can also decide without involving PM just because the contract terms. Regarding the adjustments, I agree.
7	In my experience, scope change does require adjustment to activities and resources but doesn't always require adjustment to the contractual agreement
8	Scope change does not necessarily imply contract amendment. Could also be considered an adjustment of the scope and remains in the agreed hours/ fee and therefore does not required contractual agreement. However, amendments should be approved by both parties in written form.
9	Remark: The client but not the PM (contractor takes the decision for a scope change
10	Some scope changes are officially taken, but in (smaller) consultancy projects many (often smaller) scope is often not that clearly defined, and as long as the result is satisfactory for both parties agreed on a 'gentlemen's agreement' basis. Formal paperwork is perceived as too time consuming.
11	This is the formal definition. We also need to be flexible (agile) in case of small changes.
12	Scope change is often unilateral (due to unequal power positions in the Services Agreement) and sometimes of our synchronisation with the programme. It is a function of the Client organisational culture and leadership
13	I agree with the first sentence, but not with the second. There is not always an adjustment to ALL activities etc.
14	In an ideal world
15	It may mean making adjustments to all the activities. But it does not necessarily mean that the resources and contractual arrangements must change, albeit that it could result in resource inputs and compensation changing
16	Often scope changes are recognised and agreed, while consequences (time, budget) still are not agreed and client will continue to dispute these consequences
17	Agree with the first part of the statement - it is an official change (or should be). But it does not necessarily have the impacts described in the second part of the statement, I disagree with that - not all resources, etc. will change.
18	Scope change does not necessarily change all activities and resources. Usually only a limited number of these.
19	Scope change is made by the Client (the one who pays our invoices) maybe following a recommendation by the PM but the decision lies with the Client. Adjustments to activities depend on the change itself which could be limited to some (not all) activities.
20	A scope change is not always a decision. Sometimes there is a gap that needs to be sorted or a different approach could lead to scope change without decision made.
21	Scope change is a response to a changing project environment or risks that were unforeseen at the time of determining the project scope. To be properly managed, the impact of the change must be agreed between the

	PM and the client. This must include the impacts on time and costs.
22	Official decision may not be taken, but still have change
23	It is not always necessary to make changes to the contractual documents, most of the times an amendment to the contract will do.
24	It doesn't always result in a change in all...
25	I agree but the total effect of the change is not always appreciated by the Client and usually only entails extra payment.
26	Scope change is decided by client only (and not by our PM also) and by definition does not need to effect all activities. For instance instead of design for object A, a design for object B is made without any effect on any of the aspects.
27	Clients determined if addition works needs to be done. So a decision should always been taken by the client and no by the project manager.
28	This definition is only relevant in case the client and RHDHV jointly agreed a scope change. However, in most cases, RHDHV and the client don't share the same opinion whether a supposed scope change is really a scope change or a normal part of the assignment.
29	A scope change may have impact on all activities, resources etc. but can also be limited to just one or a few mentioned topics. For example: only one discipline is affected
30	Would be ""strongly agree"" if your text did not mention it to affect ALL activities and resources.
31	It is important to emphasize on ""taken by the project manager and the client to change""...
32	Not all scope changes are official nor by mutual agreement of PM & client.
33	Scope change does not necessary always results in making adjustments to all activities. It can lead to adjustments in a part of the activities.
34	The definition describes the ideal situation. In real life scope changes happen all the time and in many cases they are not (timely) recognised. Is see that you define this as scope creep, so I change my mind: I agree with the definition
35	A scope change can also be a change to the originally agreed scope as a result of a difference in interpretation of the original scope between the PM and the client.
36	Not ALWAYS decided, and not ALWAYS requiring adjustment in ALL activities etc.
37	But there is a grey area, especially in the international projects. Internally it very important to see it firstly black-white and address these kinds of things as scope changes. But probably due to more political / emotional reasons the project director has to decide not to start discussion about scope changes with the client. These grey areas then are part of our contingency. Probably he still can mention the issues to the client, but not ask for scope change at that moment later, but be very clear in what circumstance / due what reason it will be a change later on. So first do your work good and do a little bit extra (to influence the happiness of the client) and then later on you will be paid back. More info with Rudolf Mulder.
38	Scope change has in my opinion nothing to do with a decision. Scope changes will and must lead to a decision but like change of weather you cannot decide to let the sun shine.
39	But scope changes also sometimes come undemand. Shit happens!

APPENDIX E.2: SCOPE CREEP DEFINITION DISAGREEMENT COMMENTS

S.NO	Survey respondents comments on proposed scope creep definition
1	Again this polar opposite definition to the first. The point about the challenge of managing scope creep is it is often difficult to define. e.g. your weekly client catch up call booked for an hour regularly over runs by 10/15 mins over a year that is 13 hours of PM time that if you have more than 1 member of staff on the call could significantly harm forecasted profit on a fixed priced job.
2	There should be no scope-creep. Manage your scope!
3	Mainly related to a poor scope description.
4	Scope creep can occur within the project team and not be brought to the attention of the project manager due to a culture of project team members working hard to please the client.
5	Often the definition stated here is correct. However: Scope creep - especially in international projects - can be the result of 'Quality Assurance' teams of the client that simply seek to maximum our output by putting us under pressure (e.g. by not paying bills, pointing at very vague ToR's etc.). We do assess that this influences our project result, but the client is not willing to pay more.
6	Most of the time scope creep is the accumulation of a lot of small changes.
7	Agree, provided that the Scope Change definition allows for instructed change without addressing impact on project activities and resources.
8	Not necessarily always uncontrolled or unofficial. Can be driven by poor design by others.
9	May not happen slowly.
10	Scope creep is uncontrolled for RHDHV but not always uncontrolled for the Client. The latter sometimes introduces scope creep on purpose to avoid payment.
11	Any scope change is controllable. The question is to what extend do you allow it to happen. This is often the grey area in a project and also has to do with the relation between Client and Consultant to what extend this is happening.
12	Scope creep is an unnoticed uncontrolled scope change etc. The key word is unnoticed. A noticed uncontrolled scope change without addressing impact etc. is bad project management. Also when we accept a change you may consider it also as an official agreement.
13	Changes are never uncontrolled.
14	Not all scope creep is unofficial nor without mutual agreement of PM & client.
15	As a PM you must be able to recognize the scope creep as early as possible. You have to pinpoint the expectations of the customer as soon as possible as a reference for the scope creep
16	Internally we should be very explicit and use the definition >> so our lead engineers / design managers have to mention changes directly. Depending on the situation per issue an explicit decision can be made by the project manager / project director whether or not to ask for scope change with the client. Of course the project director will inform the responsible line manager about these issues.
17	Strongly disagree. Scope creep is the moment the project manager takes no action when this happens.

APPENDIX F: FACTOR ANALYSIS

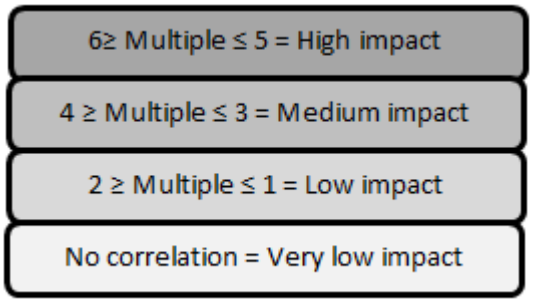
APPENDIX F.1: CLUSTERING OF SCOPE CREEP CAUSES ONLY ON THE BASIS OF STATISTICAL EVIDENCES

Clustered causes of scope creep under four components on the basis of statistical analysis				
S.NO	Component 1 = Project execution phase issues	Component 2 = Project frontend loading phase issues	Component 3 = Project governance issue	Component 4 = Client related issues
	Cronbach's Alpha = ,910	Cronbach's Alpha =,826	Cronbach's Alpha =,766	Cronbach's Alpha =,749
1	Design change due to poor design brief	Misappraisal of the original scope of work	Inappropriate project organizational structure	Unforeseen conditions
2	Poor communication between the key partners is a main cause for design changes and rework.	The data was not enough when the scope was defined.	Inadequate arrangement of contract interface	Client requirements
3	Design errors and omissions	Bad management of project changes, and absence of scope management and control systems.	Lack of organizational senior management support.	Ignorance of key stakeholders until the project is underway.
4	Inconsistency between drawing and site conditions	Most managers focus on major scope changes and ignore small changes that could lead to bigger scope creep problems.	Poor documentation of agreements with key partners. (Lead/Sub consultant, client)	The project is executed after years of completion of study and scope definition.
5	Poor interdisciplinary communication	In government projects, it is not easy to differentiate between what is included in the project and what is not included.	Wrong selection of Sub-consultant	Scope definition is done by the wrong people.
6	Team instability e.g. disputes, bankruptcy etc.	Citations of inadequate specification		Government officials are always "ambitious" and unrealistic regarding the outcome of projects.
7	Delays in producing design documents	Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework		Intervention by politicians and senior government officials.
8	Insufficient data collection and survey before design	Project managers too eager to get additional work without fully understanding scope of work.		Conflict in different government agencies interests

9	Inadequate design team experience	Unrealistic budget due to underbidding
10	Errors and omissions in quantity estimation	Contractual agreement open to wide interpretation
11	Necessary variation of work	
12	Delay in design information	
13	Long waiting time for approval of drawing	
14	Lack of accountability on project team members	
15	Lack of frequent project site visits.	
16	Push to use new technology in uncertain project environment.	
17	Not utilizing available resources within the company.	
18	Project team working from different offices.	

APPENDIX G: CORRELATION ANALYSIS

COLOUR INDICATORS FOR RANKING OF CAUSES USING CORRELATION ANALYSIS



APPENDIX G.1: RANKING USING SIGNIFICANT CORRELATIONS BETWEEN SCOPE CHANGES VARIABLES

Spearman's rho			1.Increase in project cost	2. Extension in project schedule	3. Poor Quality of deliverables	4. Client dissatisfaction	5. Low morale of project team	6.Legal dispute between client and consultant	7. Damage to reputation	8. Rework
	1.Financial constraints on the client	Correlation Coeffic ient	,161	,120	,276**	,368**	,277**	,199*	,312**	,363**
		Sig. (2-tailed)	,079	,191	,002	,000	,002	,029	,001	,000
		N	120	120	120	120	120	120	120	120
	2. Change in client business case.	Correlation Coeffic ient	,008	-,093	,051	,025	,019	,071	-,064	-,158
		Sig. (2-tailed)	,934	,310	,581	,786	,838	,442	,490	,085
		N	120	120	120	120	120	120	120	120

	3. Change initiated by Stakeholders.	Correlation Coeffic ient	,233*	,199*	-,080	-,029	-,014	,102	-,048	,028
		Sig. (2-tailed)	,010	,029	,388	,751	,877	,267	,605	,761
		N	120	120	120	120	120	120	120	120
	4. Changes in government Law & Standards.	Correlation Coeffic ient	,003	,022	,000	,003	-,023	,032	,008	-,080
		Sig. (2-tailed)	,971	,813	,999	,974	,801	,726	,934	,386
		N	120	120	120	120	120	120	120	120
	5. The original contract documentation from the client may contain errors, omissions and contradictions in specifications	Correlation Coeffic ient	,000	,137	,103	,202*	,262**	,105	,243**	,075
		Sig. (2-tailed)	,996	,135	,261	,027	,004	,254	,008	,415
		N	120	120	120	120	120	120	120	120
	6. Incomplete project information provided by the client.	Correlation Coeffic ient	-,067	,018	,162	,166	,220*	-,071	,137	,136
		Sig. (2-tailed)	,467	,842	,077	,071	,016	,442	,135	,139
		N	120	120	120	120	120	120	120	120
	7. Incorrect project information provided by the client	Correlation Coeffic ient	-,109	,114	,130	,163	,193*	,122	,140	,025
		Sig. (2-	,235	,216	,158	,075	,035	,186	,126	,790

	tailed)								
	N	120	120	120	120	120	120	120	120
8.Client request to modify design specifications	Correlation Coeffic ient	,032	,170	,033	,133	,047	,029	,131	-,049
	Sig. (2-tailed)	,731	,064	,724	,148	,613	,753	,153	,592
	N	120	120	120	120	120	120	120	120
9. Abnormal site & ground conditions discovered during site investigation.	Correlation Coeffic ient	,065	,063	,163	,311**	,247**	,215*	,282**	,094
	Sig. (2-tailed)	,482	,492	,075	,001	,007	,019	,002	,305
	N	120	120	120	120	120	120	120	120
10. Client request to execute additional work	Correlation Coeffic ient	,073	,192*	-,115	,078	-,058	,039	-,028	-,139
	Sig. (2-tailed)	,431	,035	,212	,397	,530	,668	,765	,129
	N	120	120	120	120	120	120	120	120
11. Consultants for other related project work fail to provide necessary information on time. (Interface problem).	Correlation Coeffic ient	-,104	,020	,124	,159	,069	,126	,191*	-,073
	Sig. (2-tailed)	,258	,826	,178	,082	,457	,169	,036	,430
	N	120	120	120	120	120	120	120	120
12. Slow decision making process by the client.	Correlation Coeffic	,119	,058	,270**	,315**	,167	,085	,229*	,099

		ient								
		Sig. (2-tailed)	,195	,532	,003	,000	,069	,357	,012	,281
		N	120	120	120	120	120	120	120	120
	13. Late changes due to delays in review and approvals caused by an inexperienced clients	Correlation Coeffic ient	,143	,108	,341**	,338**	,199*	,095	,269**	,208*
		Sig. (2-tailed)	,120	,241	,000	,000	,029	,300	,003	,023
		N	120	120	120	120	120	120	120	120

APPENDIX G.2: RANKING USING SIGNIFICANT CORRELATIONS BETWEEN SCOPE CREEP VARIABLES OF PROJECT EXECUTION PHASE

Spearman's rho		1.Increase in cost to the company i.e. decreased profitability	2.Inability to meet the client scheduled milestones	3. Poor quality of design deliverables	4.Client dissatisfaction	5. Low morale of project team	6.Legal dispute between client and consultant	7. Damage to firm reputation	8.Rework in already completed design
	10. Bad management of project changes, and absence of scope management and control systems.	Correlation Coeffic ient	,249**	,264**	,197*	,314**	,318**	,342**	,297**	,155
		Sig. (2-tailed)	,006	,004	,031	,000	,000	,000	,001	,090
		N	120	120	120	120	120	120	120	120
	11. Most managers focus	Correlation	,139	,244**	,218*	,184*	,257**	,120	,266**	,211*

	on major scope changes and ignore small changes that could lead to bigger scope creep problems.	Coeffic ient								
		Sig. (2-tailed)	,130	,007	,017	,045	,005	,193	,003	,021
		N	120	120	120	120	120	120	120	120
	13. Design change due to poor design brief	Correl ation Coeffic ient	,247**	,173	,141	,138	,233*	,292**	,323**	,345**
		Sig. (2-tailed)	,006	,058	,123	,132	,010	,001	,000	,000
		N	120	120	120	120	120	120	120	120
	14. Poor communication between the key partners is a main cause for design changes and rework.	Correl ation Coeffic ient	,069	,120	,141	,162	,096	,304**	,282**	,248**
		Sig. (2-tailed)	,453	,190	,124	,077	,295	,001	,002	,006
		N	120	120	120	120	120	120	120	120
	15. Design errors and omissions	Correl ation Coeffic ient	-,016	,171	,397**	,335**	,288**	,385**	,458**	,263**
		Sig. (2-tailed)	,860	,061	,000	,000	,001	,000	,000	,004
		N	120	120	120	120	120	120	120	120
	16. Inconsistency between drawing and site conditions	Correl ation Coeffic ient	,023	,153	,220*	,229*	,154	,295**	,357**	,271**
		Sig. (2-tailed)	,802	,095	,016	,012	,093	,001	,000	,003
		N	120	120	120	120	120	120	120	120

17. Poor interdisciplinary communication	Correlation Coeffic ient	,178	,186*	,294**	,225*	,224*	,227*	,476**	,315**
	Sig. (2-tailed)	,051	,042	,001	,013	,014	,013	,000	,000
	N	120	120	120	120	120	120	120	120
18. Team instability e.g. disputes, bankruptcy etc.	Correlation Coeffic ient	,089	,137	,269**	,195*	,279**	,310**	,421**	,231*
	Sig. (2-tailed)	,336	,134	,003	,033	,002	,001	,000	,011
	N	120	120	120	120	120	120	120	120
20. Delays in producing design documents	Correlation Coeffic ient	-,045	,105	,349**	,285**	,238**	,308**	,435**	,292**
	Sig. (2-tailed)	,629	,252	,000	,002	,009	,001	,000	,001
	N	120	120	120	120	120	120	120	120
21. Insufficient data collection and survey before design	Correlation Coeffic ient	,189*	,269**	,217*	,330**	,219*	,353**	,415**	,405**
	Sig. (2-tailed)	,039	,003	,017	,000	,016	,000	,000	,000
	N	120	120	120	120	120	120	120	120
22. Inadequate design team experience	Correlation Coeffic ient	,132	,271**	,308**	,368**	,318**	,311**	,357**	,138
	Sig. (2-	,152	,003	,001	,000	,000	,001	,000	,134

	tailed)								
	N	120	120	120	120	120	120	120	120
23. Errors and omissions in quantity estimation	Correlation Coeffic ient	,088	,271**	,275**	,268**	,231*	,400**	,442**	,343**
	Sig. (2-tailed)	,337	,003	,002	,003	,011	,000	,000	,000
	N	120	120	120	120	120	120	120	120
28. Necessary variation of work	Correlation Coeffic ient	,144	,206*	,187*	,246**	,169	,290**	,379**	,399**
	Sig. (2-tailed)	,116	,024	,041	,007	,065	,001	,000	,000
	N	120	120	120	120	120	120	120	120
29. Delay in design information	Correlation Coeffic ient	-,022	-,034	,080	,214*	,147	,107	,277**	,196*
	Sig. (2-tailed)	,812	,711	,385	,019	,108	,247	,002	,032
	N	120	120	120	120	120	120	120	120
30. Long waiting time for approval of drawing	Correlation Coeffic ient	,003	,097	,153	,198*	,189*	,101	,257**	,146
	Sig. (2-tailed)	,971	,294	,095	,030	,039	,271	,005	,111
	N	120	120	120	120	120	120	120	120
36. Lack of accountability on project team	Correlation Coeffic	,183*	,295**	,318**	,313**	,356**	,214*	,464**	,215*

members	ient								
	Sig. (2-tailed)	,045	,001	,000	,000	,000	,019	,000	,019
	N	120	120	120	120	120	120	120	120
37. Lack of frequent project site visits.	Correlation Coeffic ient	,110	,192*	,451**	,294**	,324**	,326**	,442**	,289**
	Sig. (2-tailed)	,231	,036	,000	,001	,000	,000	,000	,001
	N	120	120	120	120	120	120	120	120
38. Push to use new technology in uncertain project environment.	Correlation Coeffic ient	,003	,072	,200*	,065	,213*	,331**	,231*	,160
	Sig. (2-tailed)	,972	,437	,028	,477	,019	,000	,011	,081
	N	120	120	120	120	120	120	120	120
39. Not utilizing available resources within the company.	Correlation Coeffic ient	,171	,280**	,472**	,413**	,298**	,260**	,428**	,245**
	Sig. (2-tailed)	,062	,002	,000	,000	,001	,004	,000	,007
	N	120	120	120	120	120	120	120	120
40. Project team working from different offices.	Correlation Coeffic ient	,214*	,134	,281**	,298**	,249**	,174	,396**	,265**
	Sig. (2-tailed)	,019	,145	,002	,001	,006	,058	,000	,004
	N	120	120	120	120	120	120	120	120

APPENDIX G.3: RANKING USING SIGNIFICANT CORRELATIONS BETWEEN SCOPE CREEP VARIABLES OF PROJECT FRONTEND LOADING PHASE

Spearman's rho		1. Increase in cost to the company i.e. decreased profitability	2. Inability to meet the client scheduled milestones	3. Poor quality of design deliverables	4. Client dissatisfaction	5. Low morale of project team	6. Legal dispute between client and consultant	7. Damage to firm reputation	8. Rework in already completed design
3. Misappraisal of the original scope of work	Correlation Coefficient	,319**	,326**	,191*	,269**	,168	,210*	,299**	,291**
	Sig. (2-tailed)	,000	,000	,036	,003	,066	,022	,001	,001
	N	120	120	120	120	120	120	120	120
6. Scope definition is done by the wrong people.	Correlation Coefficient	,114	,166	,214*	,190*	,262**	,265**	,350**	,234*
	Sig. (2-tailed)	,215	,070	,019	,038	,004	,003	,000	,010
	N	120	120	120	120	120	120	120	120
9. The data was not enough when the scope was defined.	Correlation Coefficient	,219*	,210*	,156	,266**	,261**	,300**	,486**	,222*
	Sig. (2-tailed)	,016	,022	,089	,003	,004	,001	,000	,015
	N	120	120	120	120	120	120	120	120
25. In government projects, it is not	Correlation	,230*	,226*	,165	,104	,357**	,270**	,228*	,080

easy to differentiate between what is included in the project and what is not included.	Coefficient								
	Sig. (2-tailed)	,012	,013	,071	,256	,000	,003	,012	,382
	N	120	120	120	120	120	120	120	120
26. Citations of inadequate specification	Correlation Coefficient	,189*	,267**	,098	,152	,380**	,328**	,413**	,212*
	Sig. (2-tailed)	,038	,003	,287	,098	,000	,000	,000	,020
	N	120	120	120	120	120	120	120	120
27. Contract document conflicts lead to errors and confusion while bidding and later during project execution they cause change orders and rework	Correlation Coefficient	,193*	,276**	,180*	,215*	,222*	,321**	,357**	,183*
	Sig. (2-tailed)	,035	,002	,049	,018	,015	,000	,000	,045
	N	120	120	120	120	120	120	120	120
31. Project managers too eager to get additional work without fully understanding scope of work.	Correlation Coefficient	,048	,217*	,291**	,208*	,389**	,316**	,357**	,239**
	Sig. (2-tailed)	,602	,017	,001	,023	,000	,000	,000	,008
	N	120	120	120	120	120	120	120	120
35. Unrealistic budget due to underbidding	Correlation Coefficient	,159	,285**	,253**	,223*	,346**	,276**	,409**	,194*
	Sig. (2-tailed)	,083	,002	,005	,014	,000	,002	,000	,034
	N	120	120	120	120	120	120	120	120

	41. Contractual agreement open to wide interpretation	Correlation Coefficient	,165	,258**	,130	,242**	,257**	,280**	,232*	,148
		Sig. (2-tailed)	,071	,004	,157	,008	,005	,002	,011	,107
		N	120	120	120	120	120	120	120	120

APPENDIX G.4: RANKING USING SIGNIFICANT CORRELATIONS BETWEEN SCOPE CREEP VARIABLES OF PROJECT GOVERNANCE

Spearman's rho			1. Increase in cost to the company i.e. decreased profitability	2. Inability to meet the client scheduled milestones	3. Poor quality of design deliverables	4. Client dissatisfaction	5. Low morale of project team	6. Legal dispute between client and consultant	7. Damage to firm reputation	8. Rework in already completed design
	19. Inappropriate project organizational structure	Correlation Coefficient	,159	,162	,254**	,190*	,232*	,126	,178	,022
		Sig. (2-tailed)	,082	,077	,005	,037	,011	,171	,052	,812
		N	120	120	120	120	120	120	120	120
	24. Inadequate arrangement of contract interface	Correlation Coefficient	,174	,379**	,371**	,208*	,293**	,463**	,367**	,233*
		Sig. (2-tailed)	,057	,000	,000	,023	,001	,000	,000	,010
		N	120	120	120	120	120	120	120	120

	32. Lack of organizational senior management support.	Correlation Coeffic ient	,156	,303**	,445**	,193*	,298**	,239**	,404**	,268**
		Sig. (2-tailed)	,089	,001	,000	,035	,001	,009	,000	,003
		N	120	120	120	120	120	120	120	120
	33. Poor documentation of agreements with key partners. (Lead/Sub consultant, client)	Correlation Coeffic ient	,153	,188*	,375**	,151	,349**	,187*	,255**	,214*
		Sig. (2-tailed)	,096	,040	,000	,100	,000	,041	,005	,019
		N	120	120	120	120	120	120	120	120
	34. Wrong selection of Sub-consultant	Correlation Coeffic ient	-,007	,130	,222*	,169	,191*	,236**	,400**	,217*
		Sig. (2-tailed)	,938	,157	,015	,065	,037	,009	,000	,017
		N	120	120	120	120	120	120	120	120

APPENDIX G.5: RANKING USING SIGNIFICANT CORRELATIONS BETWEEN SCOPE CREEP VARIABLES OF CLIENT RELATED

Spearman's rho		1. Increase in cost to the company i.e. decreased profitability	2. Inability to meet the client scheduled milestones	3. Poor quality of design deliverables	4. Client dissatisfaction	5. Low morale of project team	6. Legal dispute between client and consultant	7. Damage to firm reputation	8. Rework in already completed design
2. Client requirements	Correlation Coefficient	,187*	,143	-,012	,111	-,044	,083	,130	,222*
	Sig. (2-tailed)	,041	,118	,901	,227	,632	,369	,157	,015
	N	120	120	120	120	120	120	120	120
4. Ignorance of key stakeholders until the project is underway.	Correlation Coefficient	,113	,165	,180*	,230*	,114	,231*	,213*	,101
	Sig. (2-tailed)	,220	,071	,049	,011	,214	,011	,020	,272
	N	120	120	120	120	120	120	120	120
5. The project is executed after years of completion of study and scope definition.	Correlation Coefficient	,055	,153	,158	,117	,135	,377**	,251**	,284**
	Sig. (2-tailed)	,549	,096	,085	,202	,142	,000	,006	,002
	N	120	120	120	120	120	120	120	120
7. Government officials are always	Correlation	,203*	,207*	,189*	,203*	,306**	,238**	,236**	,296**

	"ambitious" and unrealistic regarding the outcome of projects.	Coefficient								
		Sig. (2-tailed)	,026	,023	,039	,026	,001	,009	,010	,001
		N	120	120	120	120	120	120	120	120
	8. Intervention by politicians and senior government officials.	Correlation Coefficient	,073	,132	,021	,128	,092	,247**	,217*	,177
		Sig. (2-tailed)	,427	,150	,823	,164	,315	,006	,017	,053
		N	120	120	120	120	120	120	120	120
	12. Conflict in different government agencies interests	Correlation Coefficient	-,024	-,051	,244**	,182*	,162	,183*	,280**	,167
		Sig. (2-tailed)	,792	,580	,007	,047	,077	,046	,002	,069
		N	120	120	120	120	120	120	120	120