Master Thesis report
Appreciation of Project Management by planning under uncertainties in a high-tech company

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Challenge the future

Appreciation of Project Management by planning under uncertainties in a high-tech company

by

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It is an amazing feeling to sit down and indulge in the reminiscence of my journey as a civil engineer. I heave a sigh of relief as I present to 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 amazed by the grandeur of the construction industry where large scale projects were led by a project manager with hundreds of people under his supervision. After joining CME I got an opportunity to look at the challenges faced by a construction manager, while following several courses. It is here, that I had a chance to meet Professor Hans Bakker. When I first met him, little did I know that he would be the most important person behind my accomplishments as a masters student. My passion in the field of project controls was well-understood by him, and it is due to his assistance that I met Herman Mooi, my supervisor at the ABC Company.

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Executive Summary

In the current fast-changing environment of the high-tech industry, organizations carry out projects with utmost scrutiny to deliver a well-furnished product and gain a competitive advantage in the market. Traditionally, project management has been used as an important guideline to manage these projects and project planning is an imperative of that. It facilitates in coordination of the different project teams working on the project thereby helping managing the projects. However, even though project planning is done in projects across various industries, it is seen that some of these projects fail and/ or deliver unsatisfactory results. This is due to the uncertainties which manifest themselves during the course of the execution of the projects. The project plan is developed before the start of the project and hence represents a state of the past. During the course of the project, newer risks and uncertainties begin to appear which are not accounted in the pre-defined project plan and as a result can have a high influence on the outcome of the project.

This graduation research is carried out to investigate the aforementioned problem of project planning under uncertainties within the ABC Company. The problem which is investigated in this research is the following:

Companies in the high-tech industry are characterized by high uncertainty and they encounter problems in managing projects while planning under uncertainties.

Based on this problem description, a research question is formulated. By answering this research question, the underlying problem description is satisfied. The research question is:

"How can project planning have an added value for project management in a high-tech company?"

Four sub-research questions are developed to answer this research question, and are elaborated in chapter 1.

By means of answering the sub-research questions and developing an answer to the main research question, the objective of the research is fulfilled. The research objective is to provide recommendations to the ABC Company for improving the practice of project management within the organization by analyzing the problem areas where project uncertainties are influencing project planning.

To achieve this objective, the research was divided into three phases. In the first phase, a literature review was conducted on the practices of project planning and scheduling in general. This was done in order to develop an understanding of the concepts of project planning and scheduling and also to get an insight into the benefits and pitfalls of them. Further to this, the literature review also forayed into the domain of project uncertainties. A demarcation of the different types of project uncertainties was done. This part of the literature review was conducted to facilitate the development of interview questions, which were used to conduct interviews within the ABC Company in the Phase-2 of the research.

In addition to this, literature review was also done to gather an insight of the impact of project uncertainties on project planning. The project scope, cost and time are the criteria which are traditionally used for defining the success of a project. The study highlighted a prominent impact of project uncertainties on these project performance parameters.

On completion of this literature review, the Phase-2 of the research was conducted. In this phase, semi-structured interviews were conducted of project planning experts within the ABC Company. The project leaders working in the organization were chosen as the subject matter experts on project planning. A total of 10 project leaders were interviewed who belonged to the different functional departments of the company. After the interviews were conducted in the company, the acquired data was transcribed

and analyzed. A cross-case examination of these interviews was done to obtain the issues with project planning within the company. The identified issues were: scope changes, delays, lack of governance, complexity and project escalations. Furthermore, to find the causes for these issues with project planning, a combined analysis was done. This was based on the data gathered from the interviews and the literature review on the impact of project uncertainties on project management (done in Phase-1). Based on this combined analysis, the causes of scope changes and delays within the company were obtained. Lack of governance support was also seen as an issue with project planning. Moreover, the technological complexity and the newness of the technology used for developing the end-product were also seen to influence the project performance parameters. It was also inferred from this analysis that project escalations stem largely from scope changes and project delays.

Following this analysis, the research proceeded into Phase-3. First, an investigation was done on the relevant techniques and methods which can be used to tackle the issues with project planning (identified in the interviews). The recommendations provided by the interviewees were used along with an in-depth study into the literature to identify the relevant methods and techniques which could be used to potentially mitigate/ minimize the impact of these project uncertainties. These methods and techniques included:

- Schedule risk analysis
- Stakeholder management
- Lessons learned

Further to this, a procedure was developed for project planning under uncertainties. This proposed solution was then tested within the ABC Company. The testing sessions comprised of five employees: a group manager, two managers belonging to the structural improvement department of the company; a project leader and a team leader from the technical department-2. The testing meetings were conducted to validate the proposed solution and also to adjust it to the way of working of the ABC Company. Based on the feedback received from the testing workshops, the validated procedure for project planning under uncertainties was developed and shown in figure 1:

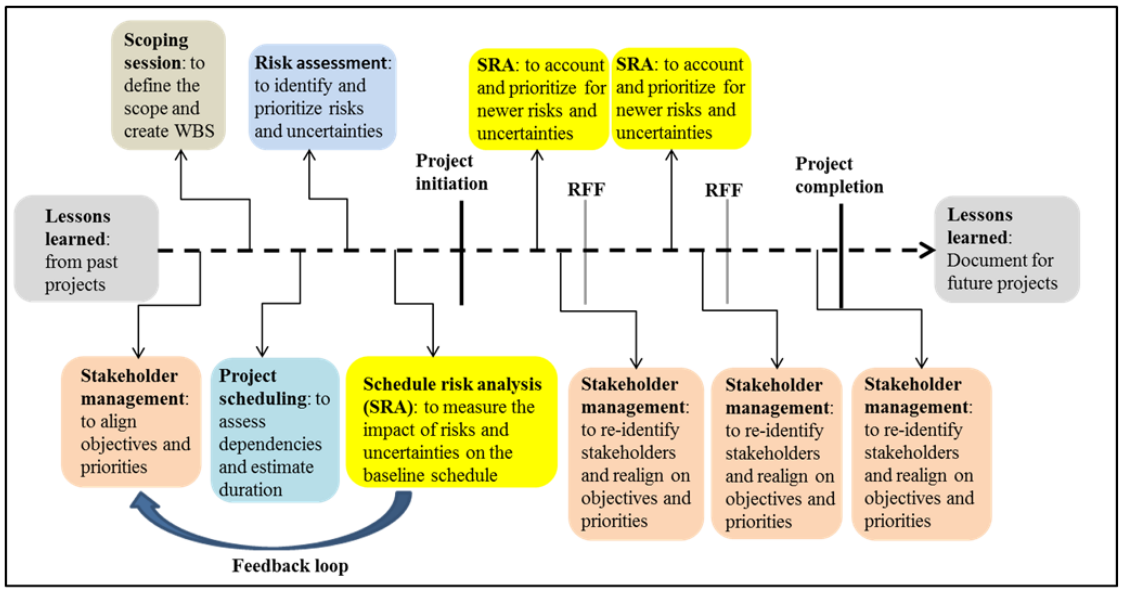

Figure 1: Validated procedure for project planning under uncertainties

This validated procedure comprises of:

- Lessons learned from past projects- to gain a perspective of the project to be undertaken and also to identify the unknown and unforeseen uncertainties
- Stakeholder management- to align on the project objectives and priorities such that the uncertainties which stem from misalignment of the stakeholders can be minimized
- Scoping session- to define the scope of work and develop the product breakdown structure (PBS). From the PBS, the work breakdown structure (WBS) is created
- Project scheduling- to assign time durations to work packages and assess the dependencies between the different activities of the project
- Risk assessment- to proactively identify and prioritize for the risks and uncertainties in the project
- Schedule risk analysis (SRA)- to measure the impact of the risks and uncertainties on the project baseline schedule

These techniques are deployed before the initiation of the project. A feedback loop is present between the outputs of the SRA and the stakeholder management. This is done so that, the stakeholders are updated and re-aligned on the project objectives and priorities based on the output of the SRA. During the project execution, the SRA and stakeholder management are conducted after every six months before the request for funds (RFF) meetings. This is done to account and prioritize for the newer risks and uncertainties and also to re-identify and realign with the stakeholders on the project objectives and priorities.

Thus the validated procedure for project planning under uncertainties helps in managing and minimizing the occurrence of project uncertainties while project planning.

Recommendations:

For further research:

As this research only considered the viewpoint of project leaders on project planning, further research should be done to understand the perspective of different project planning practitioners within the company. As a total of ten project leaders were interviewed, a further study should be done to interview more project leaders to gather a larger perspective. Also, as the procedure was tested by only five employees belonging to only two functional departments within the organization, further research validating the procedure by a larger pool of people within the company must be done. Research should also be done for implementing this procedure within the company. Research should also be done to investigate the extent of generalizability of the proposed procedure. Moreover, there can be various other techniques and methods, other than those used in this research, to mitigate/ manage the project uncertainties. Thus, investigation into the same should also be carried out. The validated design procedure is developed for project planning. Hence, further investigation should be done to apply this procedure at the portfolio level. Lastly, this research was conducted from the viewpoint of traditional project management practices; hence, further research should be done to look into the different types of project management and its effectiveness in managing project uncertainties.

For ABC Company:

In this research it was observed that the project leaders argued a lack of standardization of practices. Hence, the organization should probe into the ways of standardizing the practice of project management. Even though, lessons learned, stakeholder management and risk management are prescribed in the way of working of the company; they are not used effectively. Thus, the company should further look into the ways of improving and implementing these techniques. It was also seen during the research that project escalations are acceptable in the way of working of the ABC Company. However, these have a significant impact on the project cost and resources. Hence, the company should look into ways of improving the management of these escalations. Another recommendation which was inferred from the interviews of the project leaders was that better governance and upper management support

was needed. Therefore, the company should investigate this and consider improvements in the future projects. Finally, the project management organization in the company should increase the awareness amongst the project leaders on the available techniques and methods for managing project uncertainties. In addition to this, the workshops which are conducted within the company for teaching scheduling on MS Project should be improved and better support should be provided to the project leaders while performing the same.

Contents

List of Figures

List of Tables

1 Introduction

1.1. Background

In the present era of cut-throat competition, companies world-wide strive to expand their respective businesses. From the construction industry to the high-tech industry, the primary aim of each business is to create value from their products and services. In order to support these businesses, projects are conducted within these companies. In order to generate revenue and competitive advantage over its peers, companies carry-out projects (Shenhar, Dvir, Levy & Maltz, 2001). The outcome of these projects has a huge impact on the reputation of the company as well as its position in the market. Projects play a central role in governing the business done by the companies.

Even though projects are aimed at supporting their respective businesses, studies show that these projects go wrong as they frequently deliver disappointing returns (Matta & Ashkenas, 2003). There are numerous reasons which can be attributed to project failures, like cost and time overruns, poor quality of end-product, de-scoping of the final deliverable etc. Failure of projects has a lasting impact not only in monetary terms to the company, but also, in terms of its status in the market. Thus, successfully managing projects is important for a company's growth and stability. In the recent decades, project management has emerged as an important framework for successfully managing projects.

Project management encompasses project planning which facilitates development of project baseline and also monitoring them on a timely basis. Project planning should be done with utmost scrutiny as it is a vital starting point for project execution. It facilitates in coordinating the work and activities of all the parties involved in a project (Oberlender, 2000). The project plan involves development of a baseline schedule for the project, which is useful for monitoring and steering the project in the desired direction. Project planning is one of the key pillars for successfully managing and completing projects. There are various state-of-the-art computer-aided techniques and tools which are available for planning, such as MS Project and Primavera to name a few.

1.2. Problem analysis

Project planning is an important discipline for project management in the ABC Company which functions in the domain of the high-tech industry. This industry is characterized by the use of modern and state-of-the art cutting-edge technology. The ABC Company is involved in designing and manufacturing state-of-the-art machines which are its end-deliverables to its customers. High-tech companies such as ABC Company have their traditional planning techniques, which they use for the purpose of planning and baseline monitoring. The quality of the end-product and its delivery time is an important aspect for the reputation of the company as well as for the trust of the clients and other associated stakeholders; project planning plays an important role in the timely completion of the project with the intended quality.

Even though, project planning is performed in the ABC Company for driving the projects, it is seen that the projects tend to slip on their initial schedule, which can lead to project failure. The aim of the company is to meet the targeted end-date which they promise to the customer beforehand. In order to meet this expectation, the company has to allocate large amounts of money and resources to the project which happens to underperform, so as to deliver it on time. Some of the examples which lead to project failures due to non-compliance with the project plan are mentioned below.

According to the 2010 global survey, scope creep is a prime cause for project failures (Hussain, 2012). Scope creep is "the tendency for a project to extend beyond its initial boundaries" (Hussain, 2012, p.73). Further to this, communication between the project parties also plays an important role. Misalignment on the objectives between project parties (client and the developer) and also lack of clarity on the end goal leads to disruptions in the project plan (Chapman & Ward, 2002).

It can be seen from these examples that the reasons for schedule slippage can be attributed to uncertainties which are involved in projects. In the current fast-changing environment, there are various uncertainties which are associated with activities involved in projects. These uncertainties are internal to the project as well as they stem from the exterior uncertain world, where the project is set-in. Uncertainties arise when an event is not known completely or when the impact of the outcome (of an event) cannot be quantified (Usmani, 2012). The companies foraying into this domain of high-tech industry (like ABC Company) are characterized by high uncertainty (Raz & Michael, 2001). Also, due to the highly competitive and dynamic market, these companies take fast-paced decisions as there are very short windows of opportunity (Raz & Michael, 2001). Hence, project planning under uncertainties is important for such companies.

Project planning is done before the execution of the projects. If these projects are managed strictly on the basis of planning, then it may be detrimental for the project (Böhle, Heidling & Schoper, 2016). Newer events and situations (occuring during the course of the project) are not identified in the project plan (Böhle et al., 2016). The project uncertainties surface during the course of the project, which might not be identified during the process of making the project plan. Tight adherence to project planning can have repercussions for the project outcome as the uncertainties would not be dealt with properly. Moreover, to improve the value of the projects, the uncertainties steming from the projects should be identified and exploited (Böhle et al., 2016). Uncertainties are often regarded in its negative sense, i.e., the negative consequences that uncertainties can have on the project outcome. However, if the potential of these uncertainties is sufficiently exploited, it can be an opportunity for the project to generate added value. In a competitive environment, fruitful exploitation of these uncertainties is essential in order to derive maximum benefit and value for the project. Also, these projects are not isolated from the environment (Böhle et al., 2016). If they are considered as independent processes, then the environmental factors influencing these projects are not considered (Böhle et al., 2016). In the high-tech industry, multiple parties collaborate to deliver the project. In addition to this, the market scenario and requirements may also change during the course of the project, which can pave way for uncertainties in the project. Thus, uncertainties have a huge impact on the outcome of the project. Identification of these project uncertainties and managing them is important for project success.

There seems to be a deliberate ignorance or lack of knowledge of these uncertainties while developing the project plan, which might lead to delays in the project. However, projects in the ABC Company are plagued with uncertainties, which find its sources in the external environment or in the complex innovative approaches that are to be undertaken for a project. The planning practitioners within the ABC Company are having problems with planning under these uncertainties. Such uncertainties are pertinent to the high-tech industry as a whole. They surface in practice and are not properly encapsulated by the available academic techniques of project planning. Therefore, the current academic knowledge on scheduling should be extended to tackle the uncertainties (Mönch, Fowler, Dauzère-Pérès, Mason & Rose, 2011). There is a further need to develop new tools and techniques or modify the in-situ approaches in the industry in order to manage these practical constraints (here, uncertainties) (Mönch et al., 2011).

1.2.1. Problem Statement

On the basis of the aforementioned problem description, the following problem statement is formulated:

Companies in the high-tech industry are characterized by high uncertainty and they encounter problems in managing projects while planning under uncertainties.

1.2.2. Research Objective

The underlying objective of this research is to provide recommendations to the ABC Company for improving the practice of project management within the organization by analyzing the problem areas where project uncertainties are influencing project planning.

1.3. Research Question

Based on the problem statement and the research objective, we focus on the following main research question:

"How can project planning have an added value for project management in a high-tech company?"

The following sub-research questions guide the research project into answering the main research question:

1. What are the added value and pitfalls of project planning?
2. What are the different types of project uncertainties and their impact on project management?
3. What is the current practice of project planning in the company?
4. What is the best practice that should be adopted so as to make project planning an added value for project management at a high-tech company?

In order to answer the main research question, it is first important to understand the practice of project planning in general. Hence, sub-question 1 focuses on the added value and pitfalls of project planning. Next to this, it is imperative to recognize the different types of uncertainties which can influence a project (in general). Study should also be done to deduce the impact of these project uncertainties on project management. The second sub-question is framed accordingly.

Having established and acquired the general knowledge on project planning and project uncertainties, the next step is to grasp the current practice of project planning within the ABC Company. This is understand the project planning practices within the ABC Company. The third sub-research question is formulated in the same manner.

Finally, a study is done so as to comprehend whether the general planning practices and project uncertainties are prevalent in the context of the ABC Company as well. The problems posed by the uncertainties in project planning would be recognized and an answer would be proposed to tackle this problem. Hence, the fourth sub-question is developed for the same purpose.

Conclusively, answering the four sub-research questions in accordance to their order would enable in providing an answer to the main research question.

2

Research Methodology

This chapter provides a detailed overview of the research methodology that is undertaken for answering the research question. This research is divided into three phases. These three phases are in accordance to the four research sub-questions that are posed in section 1.3. The schematic representation of the research methodology for answering the main research question is shown in figure 2.1.

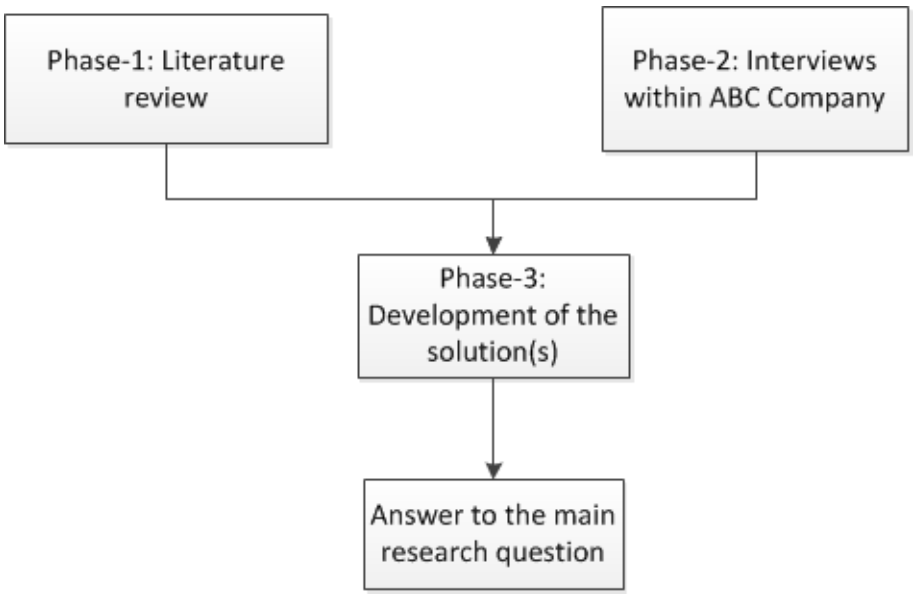

Figure 2.1: Schematic representation of the methodology for research

Section 2.1 introduces the research which would be undertaken in Phase-1. Literature review would be conducted in this phase. Further to this, Phase-2 would commence. Section 2.2 gives a description of this phase. Interviews would be conducted in this part of the research. The steps to be undertaken for interviewing would be focused upon.

Section 2.3 provides an insight into the Phase-3 of the analysis. The Phase-3 of the research delves into development of solutions based on the findings in Phase-1 and Phase-2. The procedure adopted in order to develop the solution is mentioned in this section. Finally, section 2.4 gives concluding remarks on the research.

2.1. Phase-1: Literature review on planning

In order to answer the first and the second research sub-question, a literature review on planning and project uncertainties is conducted. The purpose of this literature study is twofold:

1. To provide a guideline for designing the interview protocol (Phase-2). It is conducted to get an insight and develop an understanding into the practice of project planning. The study would encompass the concepts of project planning and scheduling and highlight the key benefits and pitfalls of project planning (in general). Additionally, the study will also delve into the project uncertainties which are identified in the literature. The underlying aim is to understand the notion of uncertainty and the difference between risk and uncertainties. Also, the various types of project uncertainties identified in the literature will be elaborated.

2. The literature study would also be conducted to understand the impact of project uncertainties on project planning. Project management is an important framework for managing projects successfully. The performance of a project (success/ failure) is measured by the means of project performance indicators which are: project scope, time and project cost (Kerzner, 2015). These three parameters are known as the triple constraint of project management. A project is considered a failure, if these project performance parameters change (in a negative manner) during the course of the project such that they reach unacceptable values, i.e., the cost and time overrun their tolerance limits and the scope of the work changes and/or underperforms significantly. A study would be done to understand the reasons for the changes in the triple constraint due to the different types of project uncertainties and its associated impact on project planning.

2.2. Phase-2: Interviews within ABC Company

In order to answer the research question 3: "What is the current practice of project planning in the company?" interviews will be conducted within the ABC Company. This phase is needed so as to understand the industry-specific project planning practices (In this case, high-tech industry).

Interviewing is used as a research method as it gives valuable insights into the functioning of the employees belonging to an organization. Interviewing enables to understand the observations made by others (the interviewees). Since, the focus of the research question is to obtain the current practice of planning in the company; interviews can play a central role in the acquisition of such information.

Interviews act as vital sources of evidence. The strength of the interviews is that they are targeted, i.e., they are focused directly at the case-study topics (Yin, 2009). As the focus of this study is to look at the planning practices, within the context of the ABC Company, the interviews would be designed to focus directly on the planning practices within the company. Strength of the interviews is that they are insightful, i.e., they provide perceived causal inferences and explanations (Yin, 2009). Also, we can learn about the experiences of the respondents and also about what they perceived (about a particular situation and/ or outcome) and how they interpreted their experiences (Weiss, 1995). Since, the ABC Company is a high-tech company; projects within the company are generally inter-disciplinary and involve people from different competencies. Interviewing such people gives insight into their perceptions and their ensuing explanation provides their viewpoint on a particular topic of interest. This diversity in the obtained data is invaluable for understanding the practice within the company, as diverse sources of information provide a higher degree of insight.

2.2.1. Methodology for conducting interviews

Interviews can be broadly classified into two categories: Quantitative interviews and qualitative interviews. Quantitative studies aim is to investigate and report on how many people (quantity) are in particular categories or what is the comparative relation between the different categories. A table of numbers is generated as a result of such studies (Weiss, 1995). Structured questions are asked in this type of interview technique, which is similar to a formal survey. This can produce quantitative data as evidence for the case study (been conducted) (Yin, 2009). This type of technique gives quantifiable

results which can prove as strong valid arguments for decision-making. Since the surveys are structured in its approach, each respondent is addressed to the same set of questions and the answers to which are quantifiable (for example, in the form of numbers presented in a table). The pitfall of such standardized studies is that they do not obtain the complete insight. As every respondent is asked the same questionnaire (in the same order); a complete report is not obtained (Weiss, 1995). The obtained information may be fragmented and might not reflect the holistic view of the interviewee.

On the other hand, qualitative interviews are aimed at achieving the complete information, and as a result the uniformity of the questionnaire is sacrificed (Weiss, 1995). This method is particularly useful as the interview questions are crafted for the respondent so that we get depth in the collected information. The interview is designed such that it permits the reader to be better informed about the experiences of the respondents as opposed to the brief answers which are obtained during the quantitative interviewing method. The analysis of the data acquired from these qualitative studies depends significantly on summarizing, interpreting and integrating (Weiss, 1995). This is done because it is difficult to categorise the responses obtained from these studies (Weiss, 1995).

The underlying objective for which the interviews are conducted is to understand the current practice of planning in the company. For this objective, it is important that a holistic view on the planning practices of the company be known and documented. The requirement from the interviews is to gather as much information about the planning practices in the company as possible so as to have coherent and dense information set. Keeping this view in mind, the qualitative interviewing method is chosen for conducting the interviews within the company. This method would provide better insight into the planning practices of the company as opposed to the quantitative approach, which is restrictive in nature.

Interview protocol

Interview structure

While conducting qualitative interviews, it is important to structure the interviews systematically. This enables the interview to proceed in the intended direction (in line with the objective). For obtaining a rich and thick data by utilizing a qualitative approach, various forms of interview structures can be designed and developed (Creswell, 2007). There are essentially two ends of a spectrum, which are chosen for interviewing. These are the journalistic and the ethnographic style of interviewing (Leech, 2002).

Some interviewing techniques are like informal conversations rather than interviews, where the topic of conversation can also change as the interview progresses (used by ethnographers) (Leech, 2002). When the interviewer has very less knowledge about a particular topic and wants to further gain an insider perspective, these soaking and poking experiences are most appropriate (Leech, 2002). These types of unstructured interviews are like informal discussions between the interviewee and the interviewer. A downside of such interviews is that, it may wander in any direction and lose sight of the objective for which the interviews are conducted.

Structured interviews are used when the researcher already knows a lot about all the responses which are possbile for the given topic and also about the various categories of the same(Leech, 2002). To obtain a statistical count of how many people fall into each of these categories is the sole aim of such interviews (Leech, 2002). This is the journalistic approach where closed questions are asked; but it might backfire in some cases. Important responses can be negated or omitted if we assume ourselves to be in a familiar domain and thereby ask the wrong questions in the wrong way (Leech, 2002). Content validity would be lacking from the data that we acquire from these interviews (Leech, 2002).

In order to tackle this, a middle path is taken, where the interviewer can "soak-in" the insider perspective and also be aligned to the underlying objective of the interview (without wandering from the topic) (Leech, 2002). This method is a combination of both the journalistic and ethnographic style of interviewing and known as semi-structured interview, which enables the interviewer to analysis the obtained data qualitatively and allows for the testing of the pre-defined hypotheses (Leech, 2002). Even

though, the composition of the semi-structured interviews is quite flexible, they are more structured than the informal conversation (unstructured interviews) (Gall, Gall & Borg, 2003). This way of conducting the qualitative interview gives more space to manoeuvre than the structured interviews and enables in gaining wider perspective related to the topic. As the high-tech industry is characterized by fast-changing environment, generalizability of project planning practices within the ABC Company would be difficult. Hence, a structured interview cannot be conducted to give conclusive evidences (as the full spectrum of view may not be covered). Therefore, semi-structured interviewing technique would be used (as it gives wider perspective) for interviewing the employees within the ABC Company.

Interview questions

The interview, though, semi-structured in nature, has to be designed such that it follows a designated path. The questions for the interview would be derived based on the findings from the literature (Phase-1). The semi-structured interview questions provide a line of inquiry to the interviewer. Keywords and notions from the literature study on planning and project uncertainties would be used to make the questionnaire.

Another important aspect to be considered while designing the interview questions is that the interviewee should feel comfortable while answering. There is a striking difference between posing a "why" question and a "how" question. In a "how" question, the interviewer expresses his views more freely and independently in comparison to a "why" question which creates defensiveness on the part of the respondent (Howard, 1998). The interview should be designed in such a way that the line of inquiry is followed (using "why" questions) and the same time posing "how" questions leads to more friendliness and openness in the interviews.

Selection of the interviewees

The selected data-set for conducting interviews is important for the richness of the information that is obtained through them. Selecting the appropriate panel of respondents plays a crucial role in the kind of information which would be made available. There are essentially two categories of respondents:

- Panel of knowledgeable informants- As the name suggests, these people are experts in a particular domain. They possess unique and in-depth information about a particular area (Weiss, 1995).
- Sample of representatives- This type of interviewees are chosen in case of an event or a situation, where the affected set of people who (taken together) display what happens within a population (Weiss, 1995).

If the aim of the study is to describe an event or development of an institution, then it would be best to interview people who are knowledgeable and experienced in such circumstances (Weiss, 1995). Also, to enrich our information and gather different perspectives of an event, people who have different perceptions (on that event) can be interviewed. Encompassing such various views in the interviews would be possible by developing a panel of knowledgeable informants. As the aim of the interviews is to understand the current practice of project planning within ABC Company, a panel of knowledgeable informants would be selected. Project planning is carried out by planning experts who are experienced in the discipline as well. Hence the project leaders (PLs) would be interviewed. Interviewing these people would provide a holistic view on the planning practices within the company. A total of 10 PLs would be interviewed from different disciplines within the company to understand the planning practices undertaken in the different departments.

Pilot interviews

Three pilot interviews would be conducted before commencement of the main interviews. Semi-structured interviews are aimed at foraying into a domain which is lesser known to the interviewer. Even though, the interview questions are prepared, they are subject to changes based on findings from the interviewees. While entering a new conceptual area, pilot interviews should be conducted, so as to obtain ideas and viewpoints at the beginning of the interviews. The interview protocol for the pilot

interviews is based on the literature review on project planning. However, initial expectations are likely to be inaccurate and the interview guides for the pilot interviews can be largely misdirected (Weiss, 1995). Topics chosen in the interviews can turn out to be unproductive while areas not included in the interview guide might be critical (Weiss, 1995). Thus, three preliminary interviews (of the PLs) would enable the interviewer to restructure the interview questions and the overall protocol, based on the feedback from these pilot interviews.

2.2.2. Data analysis

Data analysis is the central theme of an interview. Based on the response received from the interviewees, the investigator analyses the presented data. The first step into the data analysis is that of transcribing the interviews. Once the interviews are taped and recorded, they are subject to transcription. Transcribing is done for facilitating proper flow of information from the interviews. Broadly, there are two different ways of analyzing the interviews: issue-focused analysis and case-focused analysis (Weiss, 1995).

The issue-based analysis focuses on analyzing and reporting issues as they are learned from the respondents themselves (Weiss, 1995). On the contrary, the case-focused analysis focuses more on the interviewee and his/her specific case (Weiss, 1995). This type of case-focused analysis is useful when insights about the complete case (for example, complete project) are to be obtained. However, the semi-structured interviews are based on gathering insights from the PLs into the current practice of project planning and not on their respective projects. The issue-focused analysis technique would be more useful as it would specifically focus on the issues with the project planning practices.

Further to this, the focus would be on within-case analysis. In this, the recorded interviews are transcribed in detail. A sound and holistic generation of the insights of the interviewees is possible by means of these simple write-ups (Gersick, 1988). As these qualitative interviews generate volumes of data, the first step in the analytical process is to describe the interviews in detail. The central theme behind this transcription is to make the investigator familiar with each case as a single independent entity (Eisenhardt, 1989). As the cases are transcribed, patterns that are unique to each case become evident to the investigator (Eisenhardt, 1989). Concentrating specifically on issues enables the investigator to identify the key-issues and unique patterns which are relevant to the interview. This familiarity of the investigator with each case plays an important role while dealing with the cross-case examination.

Cross-case examination

The within-case analysis is coupled with cross-case examination to identify patterns within the interviews. This cross-case examination is important for proper decision-making. In reality, the respondents are notoriously poor at processing the information specific to a particular case and hence, the tactics of cross-case examination are used (Eisenhardt, 1989). They have incomplete or limited data and they reach their conclusions based on that (Kahneman & Tversky, 1973) or it might happen that they sometimes provide disconfirming evidence on particular insights (Nisbett & Ross, 1980). To overcome such biases in observations, cross-case examination is done.

Eisenhardt (1989) mentioned in context of the cross-case examination that, "the tactic used is to select categories or dimensions, and then to look for within-group similarities coupled with intergroup differences" (Eisenhardt, 1989, p.540). These categories were derived from the underlying research question and also chosen by the investigator (with the support of the literature). The dimensions were then used to analyze the data-sets and this enabled to prioritize between the issues with project planning (which come up during the analysis).

The categories which were chosen for analysis were:

- Link to the literature- Based on the findings from the cross-case examination, the issues with project planning which occur due to the different types of uncertainties were identified and fragmented in the different categories.
- Headcount of the issues- Based on the findings from the previous category, specific issues from

the interviews were identified. Those issues which had a head-count ranging from the highest mentioned-to-those which were mentioned only once were used. In this case, the head-count is the total number of PLs mentioning about that particular issues. These were then analyzed qualitatively and the issues which were mentioned by most of the PLs were used for further investigation.

2.2.3. Causes of the issues

First, the issues which are influencing project planning would be elaborated. This is important for designing the solution, as a thorough research into the issues would enable the author to understand the intricacies of them. As a literature study was conducted beforehand, in Phase-1, the problems with project planning due to project uncertainties were known. This would be compared to the issues with project planning within the ABC Company. This comparative study was done to understand and validate the causes for the specific issues within the ABC Company. Further to this, the issues would be defined in the context of the ABC Company in order to proceed towards development of the solution based on the data obtained from the combined analysis of the interviews and the literature.

2.3. Phase-3: Development of solution

In order to answer the third research sub-question, a solution would be designed and proposed within ABC Company. Based on the data analysis from the interviews, a priority list of issues with planning is identified. The solution is designed for the issues having the highest priority.

2.3.1. Investigation study on the relevant tools and techniques

An investigation study (based on literature) would be conducted on the available tools and techniques which are relevant to manage the problems with project planning. Such an extensive literature study is conducted at a later stage in the research. While conducting the interviews, the experts were also asked about their point of view on dealing with the issues that they are facing while planning (if any). These viewpoints were analyzed and documented as recommendations from experts for dealing with the underlying problem and/or extending the existing practice within the company. It is important to note that, the relevant tools and techniques (found in the literature) would encompass the recommendations which are provided by the PLs. As they are provided by the experts working in the company, the recommended solution would be in accordance to the culture of the organization. Hence, findings from the literature and the recommended solution (from practice) would be compared in order to arrive at a solution.

2.3.2. Developed procedure for managing project uncertainties (Design of the solution)

A model/procedure for managing the project uncertainties was developed after the completion of the literature review on the tools and techniques for managing project uncertainties. This model/procedure is developed in accordance to the findings mentioned in sections 2.2.3 and 2.3.1. The priority list of issues (with project planning) and the literature study on the tools and techniques are pre-requisites which lay a foundation for the development of the solution. The aim of the model/procedure is to control or mitigate the problems which occur in project planning due to uncertainties. This would be done by linking the relevant issues (with project planning) to the appropriate tools and techniques which can control or mitigate these project uncertainties.

2.3.3. Testing of the solution

This step would be carried out to validate the proposed model/solution. The testing would be done based on the testing workshops. The testing committee comprises of five employees at different hierarchical levels in the company. A planning expert (at the same hierarchical level as the interviewees), a planning practitioner (at a level lower to the interviewees) and three employees from upper management were chosen and the solution was presented in front of them. The purpose of this testing is to verify

and validate if the designed solution is applicable in the context of a high-tech company.

2.4. Conclusions and recommendations

The tested solution would be the final step and the answer to the underlying research question. On the basis of the findings from testing workshops (section 2.3.3), the research would be concluded by closing remarks. Also, the limitations of the study and research would be presented. The author would provide recommendations to the ABC Company which would be in-line with the research objective.

2.5. Scope of Work

This research is carried out in ABC Company which is a part of the high-tech industry. This research is confined to the boundaries of project planning practices within the ABC Company. In addition to this, the research focuses on investigating the project planning practices under uncertainties. The choice of focusing on project uncertainties was due to personal interest which aligned with the interest of the ABC Company for whom this research was conducted. This research was conducted from the viewpoint of traditional project management. This was done as the ABC Company also prescribes to the traditional project management practice in their way of work. Thus, the investigated problem areas and proposed solutions were in the domain of these triple constraints used in traditional project management.

The research methodology is schematically represented below. Figure 2.2 shows the action-result diagram for the research. This figure is the elaboration of the theoretical framework (refer figure 2.1). It elaborates the actions (steps) which are undertaken in each of the three phases in order to arrive at the required solution.

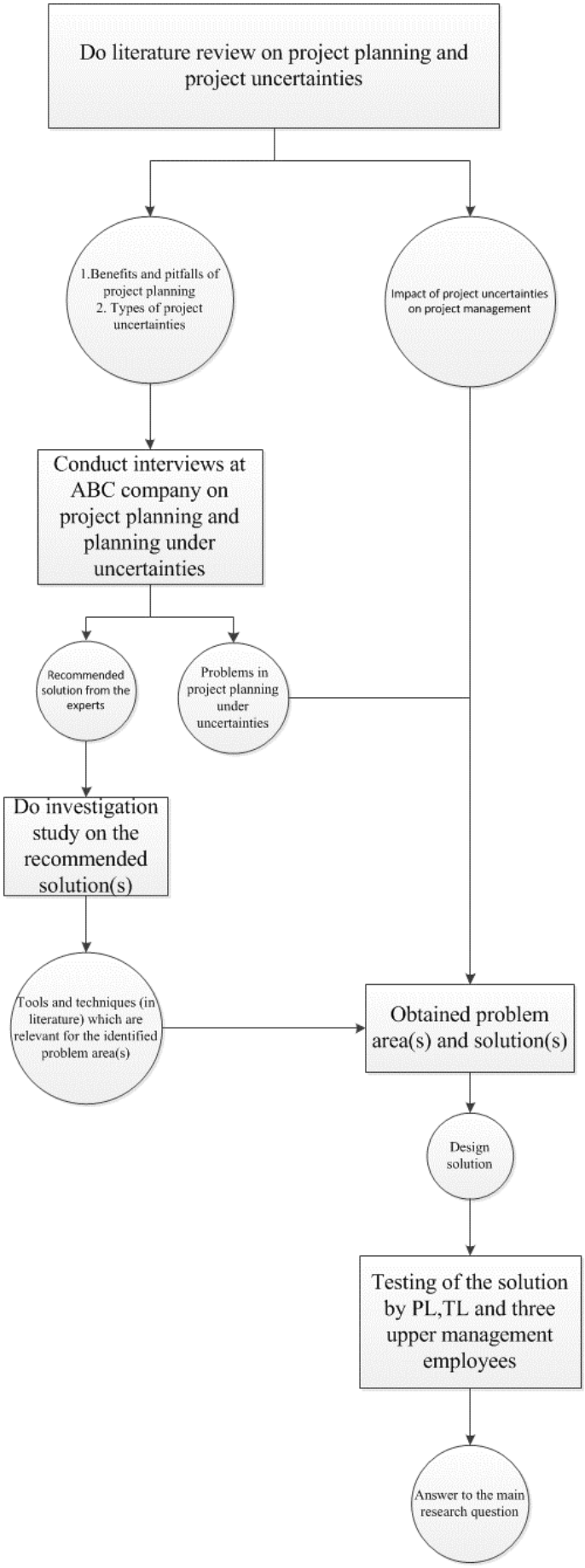

Figure 2.2: Action-result diagram for the research methodology

3

Literature Review

This chapter encompasses the literature review which is important for the purpose of this research. Section 3.1 delves into the concepts of project planning and scheduling. The benefits and pitfalls of project planning are discussed. Section 3.2 is based on the project uncertainties and section 3.3 gives a description of the impact of these uncertainties on project planning.

3.1. Planning and Scheduling

Planning and scheduling are important disciplines for project controls within project management. Planning and scheduling go hand-in-hand and hence, these terms are often referred interchangeably (Oberlender, 2000). However, there is a difference between planning and scheduling. Oberlender (2000) differentiates between planning and scheduling. He states that, "Planning is the process of identifying all activities necessary to complete the project while scheduling is the process of determining the sequential order of activities, assigning planned duration and determining the start and finish dates of each activity" (Oberlender, 2000, p.139). All the project activities are identified in the project plan and thereafter these activities are scheduled. Thus, for scheduling of activities, the project plan should be established and is a pre-requisite for project scheduling (Oberlender, 2000). Once all the activities for a particular project are defined (by means of a Work-Breakdown Structure (WBS)), these activities are scheduled, generally with the help of computer-aided tools for scheduling. Project scheduling involves arithmetic calculations for estimating the activity durations and the computer is used universally to perform these calculations (Oberlender, 2000). Project planning and scheduling are instrumental for a sound project management and the Project Management Institute emphasizes that; for establishing sound project management, project scheduling is imperative (PMI, 2004).

As mentioned earlier, planning is a pre-requisite to a project schedule.Once, all the activities are established, the project schedule is created. The timings of specific project activities and project milestones are shown in a project schedule (Nicholas & Steyn, 2012). Project events and milestones (which are defined in the project plan) show the progress of the project (Nicholas & Steyn, 2012). Project is completed when the final event is finished and the project completion milestone is reached (Nicholas & Steyn, 2012). Several scheduling techniques are used to monitor this project plan. Some of the commonly used scheduling techniques are the Gantt charts, Critical Path method (CPM), Network analysis systems (NAS), PERT (Program Evaluation Review Technique) etc. (Oberlender, 2000).The critical chain method (CCM) is also used widely for project scheduling, where-in the Theory Of Constraints philosophy is applied to project scheduling and control (Goldratt, 1997).

3.1.1. Benefits of planning and scheduling

Planning is an important aspect for robust project management. If it is performed properly, it can reap influential results for the project. The key benefits which are derived from planning are:

- When applied properly, sound planning facilitates continuous uninterrupted flow of work which helps the project to finish on time (Oberlender, 2000). Project planning is a vital cog for successful

project completion and sound planning helps to complete the project on the required targeted time (Oberlender, 2000).

- Since, key reporting milestones are embedded in the project schedule; it is used for the purpose of reporting the status of the project to the management (Oberlender, 2000).
- Project planning helps in keeping the stakeholders updated with the progress of the project and provides an insight into the problems (if any) to the upper management. Proper communication with the upper management facilitates in resolving the problems (which can appear during the project execution).
- During the execution of projects, reviews and approval meetings are conducted between the different project parties and hence, the project plan should have a sufficient amount of time for the exchange and communication of this information (Oberlender, 2000). Exchange of information, as mentioned earlier, is important as it minimizes confusion and misunderstandings between project parties related to the project work. This also reduces the amount of rework in the project as the parties are aware about the individual responsibilities.
- Who does what, how much and when is shown in the project plan (Oberlender, 2000) as sound planning identifies and scrutinizes the work that is required to be done by each individual worker. This provides direction of work to the project workers. This clarity on direction can mitigate the problems of low worker morale and low productivity which happens during the projects (Oberlender, 2000). Having clarity on the accountability of work for the project workers helps in minimizing delays and also helps in eliminating uncertainties within the project.
- It is often noticed that, there are interruptions and delays during work which reduce the efficiency of project participants (Oberlender, 2000). These delays, cost overruns and interruptions in work may sometimes lead to legal disputes and thus, project planning and project scheduling can facilitate as an effective means of preventing these problems.

To facilitate project planning and scheduling, various tools and techniques have been developed over the past decades. One of the commonly accepted techniques for scheduling is the network diagram. For coordinating and defining work graphically, the network diagrams are used (Oberlender, 2000). The interdependencies between the different project activities and its impact on the schedule are clearly shown by these network diagrams (Nicholas & Steyn, 2012). Having a perspective of the interdependencies between project activities enables project planners to perform better project planning and control as it helps in determining the critical activities in the project (Nicholas & Steyn, 2012). The knowledge of the slack times provides the project managers to deal with the problems of fluctuating resources in the project; and the project managers can also focus more on the critical part of the project (Nicholas & Steyn, 2012).

Most of the scheduling tools make use of the Critical Path Method (CPM). MS Project is an example of such scheduling software, which functions on the CPM methodology to generate baseline schedules. Interrelationships of activities and their associated time durations and costs are provided by the CPM technique and is a widely used technique for project scheduling owing to its effectiveness (Oberlender, 2000). It is further extended to the cost-time trade-off in a project. All the activities in the project are systematically allocated resources (in the CPM) such that it reduces the overall project duration for the least cost (Nicholas & Steyn, 2012); it is effectively used for establishing the cost and time relationship in a project. Another important benefit of such software is that it can be operated under resource-constrained environments as well (Kolisch, 1999).

Also, the critical chain concept is a widely-used methodology for project planning. The Critical Chain Scheduling and Buffer Management (CC/BM) is also used in project management where-in the concept of Goldratt's Theory of Constraints (TOC) is directly applied to the project management practices (Herroelen & Leus, 2001). The critical sequence is not just a function of the given schedule but is also determined by considering the resource constraints, the set of job times and the technological ordering (Wiest, 1964).

The group of software packages which facilitate project planning are known as advanced planning and scheduling systems (APS) (APICS, 2007). Problems at the strategic and tactical levels can be solved by the use of these software packages. These advanced planning and scheduling systems led to a decrease in the overall planned duration, when they were examined in various case studies. Moreover, there was better communication between the different functional departments and an increased control on costs and material flow was identified in the planning organization when these planning software packages were applied (Jonsson, Kjellsdotter & Rudberg, 2007). These tools and techniques provide a higher degree of added value for decision-support systems. The use of these decision support systems saves millions of dollars every year and provide scheduling support to the transportation systems (Gupta, Peters, Miller & Blyden, 2002).They also help in eliminating the losses due to customer deductions (Gupta et al., 2002).

3.1.2. Pitfalls of planning and scheduling

Even though, project planning and scheduling have a high impact on the project management and are useful for the successful completion of projects, they also have pitfalls associated with their use. It is seen that, often in projects more time is added than the last review on the status of the project and this slippage in the schedule of the project is sometimes very dramatic (Hulett, 2009). Thus, such delays in the projects can cause detrimental effects for the project owners. This can lead to a delivery of sub-optimal and sub-standard products with incomplete functionality (Hulett, 2009). Sometimes it leads to losses in the business as opportunity windows are missed and the associated equitable adjustments may be of the order of millions of dollars due to the delay claims (Hulett, 2009).

The commonly employed scheduling method for the baseline scheduling of a project is the critical path method (CPM) (Hulett, 2009). However, during the course of the project, the critical path might change. The critical path identified initially at the start of the project may not be same and may be completely different at the end of the project (Hulett, 2009). The previously slack path, i.e., the path with a total positive float may become critical due to the risks and uncertainties which come along the way of the project (Hulett, 2009).

The slippage of these schedules can be identified by the below-mentioned problems, encountered while project scheduling (Cashman, 1995):

- It is difficult to perform project scheduling: The people who are designated the responsibility of performing project scheduling find it demanding and difficult to master.
- The project scheduler lacks clarity on the rules of scheduling: The rules of scheduling such as assigning activity durations, use of resources, logic and constraints are unclear to the scheduler. Before the project schedules are put into practice, they need to be debugged as sometimes dangerous and improper project schedules can be developed due to poor scheduling practice.
- Unrealistic deadlines and milestones are demanded by the projects owner and the upper management: Sometimes the scheduler is demanded to produce schedules and deadlines which are not possible to be completed with the available resources.
- Single-point (deterministic) estimates of activity durations are used to produce project schedules: The CPM scheduling softwares do not take uncertainty of future durations into account because they are based on the single-point (deterministic) estimates. If the uncertainties appear during the course of the project, then the actual duration of the project schedule will be different to that calculated using the CPM scheduling software.

One of the major reasons for these schedule slippages is that, these scheduling tools do not take the impact of the outside uncertain world into account. The project schedules which are generated through the use of these tools are deterministic in nature, i.e., the time duration and its evolution can be estimated exactly for these type of systems (Howe, 2008). In scheduling, determinism means that (Hulett, 2009):

- it is assumed that the logic used for developing the schedule correctly represents the plan for execution of the project;

- It is known with complete certainty what the durations of each of the activities are;
- "the implication of the foregoing is that the dates computed for completion of activities, major milestones and project completion as well as the identity of the critical path are all accurate" (Hulett, 2009, p.10).

These deterministic tools and techniques do not consider the uncertainties which are pertinent to the project. As a result of this, the project schedule is bound to a state of the past. The schedule path durations are calculated by employing simple arithmetic to add the activity durations in accordance to the logic of the project in the CPM scheduling methods (Hulett, 2009). Uncertainties and vagueness in the estimation of the durations is not considered in the arithmetic calculations and they are assumed to be correct (Hulett, 2009). The completion date for the project is not always identified reliably with the CPM scheduling technique; this observation comes from the experience of project participants who work with CPM scheduling (Hulett, 2009).

Furthermore, the detailed design work required for engineering projects is not properly captured by the CPM technique as a limitation of the CPM is that it requires detailed description of the interrelations between activities, which is not present during the early stages of such projects (Oberlender, 2000). This shortcoming is also associated with the network analysis methods. It is assumed that all the relationships between the identifiable activities is thoroughly known and clearly defined upfront (Nicholas & Steyn, 2012). Planning for the activity durations and scope of the project is a problem with project planning because every project evolves as it progresses and hence, not all the tasks and work can be clearly defined in the beginning (Nicholas & Steyn, 2012).

While using the scheduling methods, like the network analysis methods, the point of separation is arbitrary and sometimes unclear due to which it is difficult to demarcate between successive activities (Nicholas & Steyn, 2012). Thus, two activities can overlap in their sequential order and it may so happen that the successor can start before the termination of the predecessor (Nicholas & Steyn, 2012). Hence, the shortcomings of project planning are transcended into the limitations of these network diagrams (Nicholas & Steyn, 2012). Another related problem is that the planning and scheduling methods and techniques are cumbersome because activities and durations in a schedule sometimes require regular modification; this may be due to the fact that the activities are not well defined or that there are a high number of activities in the network (Nicholas & Steyn, 2012).

Planning practices in project management have been deployed in the industrial practices over the last few decades. In doing so, there are various challenges which come into picture with regards to the planning and scheduling of the activities in the projects. The various types of time constraints between consecutive steps are not taken into consideration and scheduling research is missing for these problems (Mönch et al., 2011). This is because there are certain time restrictions between consecutive process steps. For example, time duration of three days should be there to start step B if step A. This implies that there is a better need to understand these nested time constraints between activities and its impact on the project schedule.

It is argued that, scheduling results from the academic environment are very often difficult to transfer to the shop floor (in the industry) (Mönch et al., 2011), i.e., the scheduling results which are obtained in practice are different as opposed to the academic results. This is partially caused due to some critical but practical constraints for which data problems are present and there is a lack of integration; problems that are not foreseeable/ considered in the academic environment (Mönch et al., 2011). Therefore, for better dealing with missing and distributed data, appropriate software representations of the scheduling algorithms are required (Mönch et al., 2011).

Even though, project planning and scheduling promise to aid project management, still there are areas within the project planning domain which need further attention. Notwithstanding the technical competencies required to operate the sophisticated tools and techniques for project planning, there exist practical problems while implementing it in the industrial sector.

3.1.3. Conclusion

This section dealt with the literature review on project planning and scheduling. Based on the literature review, the benefits and pitfalls for project planning were summarized.

When applied properly, project planning has various benefits. For the project to finish on time, i.e., on the targeted end-date then project planning can facilitate the same. If done properly, the flow of work is continuous and devoid of interruptions, thereby helping the projects to finish on time. Moreover, as multiple project parties are involved in the project, exchange of information is vital between them. A project plan plays a central role in this exchange of information and minimizes misunderstandings and confusion between the project team members. It also clearly defines the responsibilities and accountability of work between the project team members and provides a clear direction of the project end-goal. Furthermore, if project planning is sound and done with utmost scrutiny, then it can prevent delays and waiting-times during the project execution which ultimately leads to projects to finish on time. For the purpose of planning and scheduling, there are advanced methods and tools which are available that facilitate sound project planning. The network diagrams used for the purpose of scheduling clearly highlights the interrelations and interdependencies between the different activities of a project. Also, the critical path method (CPM) is used to generate the baseline schedule for the project and also facilitates in analyzing the trade-off between the cost and time for the project. The critical chain method which is based on the theory of constraints (TOC) is effectively used for buffer management in the project schedule. All the above mentioned methods and techniques used for the purpose of project scheduling and planning provide a higher degree of added-value for decision making in projects.

Although, project planning and scheduling have benefits for project management, there are also some pitfalls associated to the practice of project planning and scheduling. Project scheduling is difficult and not everybody is able to do it. Moreover, the rules of project planning and scheduling such as assigning activity durations, sequencing the activities etc., are not clear to everyone who performs project scheduling. Sometimes, unrealisitic estimates and project completion dates are demanded by the upper management which influences and hampers the project planning. In some cases, the critical path method fails to identify the project path which leads to the project end-date. This is because the project evolves throughout its lifecycle and changes it path during its execution. These changes are not captured by the CPM schedule because they are based on single-point estimates and are deterministic in nature. Also, it is seen that project planning and scheduling are cumbersome activities and involve a lot of time. Even if project scheduling is carried out properly, it is difficult to transfer the scheduling results from the academic findings onto the industrial workfront.

3.2. Project Uncertainties

This section talks about the uncertainties in projects. First, in section 3.2.1, the notion of uncertainty is established. Further to this, section 3.2.2 delves into the different types of uncertainties in projects.

3.2.1. The notion of uncertainty

Projects are carried out in an environment characterized by its ever-changing nature. The various activities and resources involved in projects frequently interact with the outer environment. It is this interaction of project with its environment that leads to the lack of complete certainty of pre-defined tasks and activities. Additionally, it was inferred from the preliminary interviews that, projects within the high-tech industry have high complexity and interdependencies in the activities. These projects can often span up to a period of 3-5 years. Due to this, there is a lack of certainty about innumerable factors involved in the project, at the time of project initiation. It can be presumed that such projects have a high level of lack of certainty during the course of their execution. This notion of lack of certainty would henceforth be referred to as, uncertainty. Sources both external and internal to the project can give rise to uncertainties in the project (Perminova, Gustafsson & Wikström, 2008).

Difference between risk and uncertainty

According to the PMBOK, project risk is defined as "an uncertain event or condition that, if occurs, has a positive or a negative effect on at least one project objective, such as time, cost, scope, or quality" (PMI, 2004, p.238). A typical way of describing a risk statement is:

Because of a cause, there may be an occurrence of a risk which can have an impact on the project (Hillson & Simon, 2007). Here, (Hulett, 2009):

- The component which is uncertain in this definition is risk: it is a future scenario and includes a word such as might or may.
- The cause is a fact and is confused with risk. A risk might not materialize if we do not have a cause. Quantification of the probability of occurrence of the risk and its associated impact can be inaccurate if the cause is confused with the risk.
- The project objectives such as time, scope, quality or cost have an impact. There can be a single value or a range of value for the impact of the risks.

A risk is quantified as the product of (probability of occurrence of an uncertain event) and (the impact of the occurrence of the event) (Ahmed, Kayis & Amornsawadwatana, 2007).

The description of risk in the PMBOK is based on the traditional view on project risk management. Here, risk is described as a phenomenon arising from an uncertain event. Hence, it can be argued that risk is an uncertainty. However, there exists a demarcation between risks and uncertainties.

"Project uncertainty is described by the project uncertainty management school as probability that the objective function will not reach its planned target value , or as an unknown probability of occurence of an event"(Jaafari, 2001, p.89). A distinction between risks and uncertainties is also made from the view point of economics. There are several arguments in the literature which state this difference. Keynes had such a view on risks and uncertainties."For him, uncertainty was a state in which individual actors find it impossible to attribute a reasonably definite probability to the expected outcome of their choice" (Nowotny, Scott, Gibbons & Scott, 2001, p.31). From this viewpoint, uncertainty is a situation in which, the probability of occurence of an event cannot be calculated. These viewpoints clearly showcase a distinction between the notions of risks and uncertainties.

In the context of project management, uncertainty has a relativistic connotation, i.e., different actors have different perspectives of uncertainties, where-in, they regard uncertainties in various aspects, or may, not recognize uncertainties as such. Thus based on this relativistic approach, uncertainty is defined in project management as: "an event or a situation, which was not expected to happen, regardless of whether it could have been possible to consider it in advance. In other words, uncertainty is when the established facts are questioned and thereby the basis for calculating risks (known negative events) or opportunities (known positive events) is questioned" (Perminova et al., 2008, p.77).

The traditional project management approach considers project planning, project control and monitoring as effective methods for successful project management as both research and practice show this (PMI, 2004). Apart from project planning and scheduling, risk management is also considered as an important discipline for managing projects. Planning for risk response and risk mitigation strategies, help in securing the project from a negative outcome. Identification and planning of risk response depends mostly on the experience and ability of the project manager to use the acquired knowledge from the past experiences to deal with situations that are uncertain and also on his ability to foresee potential challenges and dangers (Perminova et al., 2008).

However, not all risks can be documented and recognized before the initiation of the project. This argument leads to the conclusion that even though, project planning is necessary for project management, it is not sufficient in order to manage the risks and the uncertainties associated with the project. A project planner can plan only for what he knows with certainty and hence, this is another argument against

over exaggerated importance given to project planning (Perminova et al., 2008). In this sense, a project manager can apply preventive measures and mitigation strategies for the risks and uncertainties only if we can state that the uncertainties and risks are known with certainty (Perminova et al., 2008). On the contrary, uncertainties are unforeseeable and it depends on the project manager whether he/she can foresee these uncertainties. If the uncertainties are not identified, then suitable mitigation mechanism cannot be employed which can in-turn affect the project plan.

Thus, it can be concluded that, uncertainties play a prominent role in guiding the project outcome. Planning for risks does not indicate that the uncertainties are mitigated as well. Hence, even though the traditional project management tools of project planning and monitoring are effective in managing risks, they are insufficient for managing the uncertainties in the projects. In order to manage these uncertainties in projects, first, it is imperative to identify the different types of uncertainties and the sources of uncertainties in projects. These types of uncertainties are elaborated in section 3.2.2.

3.2.2. Types of uncertainties

As mentioned in the previous section, uncertainties surrounding a project play a dominant role in the project outcome. Managing these uncertainties is important for project management in order to have a successful project. "Uncertainty management is not just about managing perceived threats, opportunities and their implications. It is about identifying and managing all the many sources of uncertainty which give rise to and shape our perceptions of threats and opportunities" (Ward & Chapman, 2003, p.98). The project uncertainties are relativistic in nature, so identification and management of these uncertainties depend on the context of the project. In a given project context, identifying and understanding why and where the project uncertainties are important is key to sound uncertainty management (Ward & Chapman, 2003).

Starting from the concept initiation stage of a project to its finalization, the uncertainties play a dominant role in the project life cycle (PLC) and most of the project management activities are focussed on managing these (Chapman & Ward, 1997). In order to manage these uncertainties, identification and classification of these uncertainties on a broader level is essential. The recognition of the sources of these uncertainties also plays an instrumental role in this. In this section, these project uncertainties are categorized as follows:

Variability in the project estimates

Variability in projects is related to the project performance parameters such as the budget, time and quality. Uncertainties surround the quantification of these parameters for the project, as a whole and also the project activities. It is highly likely, that the size of effort required to accomplish the project activities may not be known exactly (Ward & Chapman, 2003). The causes of such uncertainties may include (Ward & Chapman, 2003):

- clarity on the required specifications is lacking;
- the particular activity is new and experience required for that particular activity is lacking;
- interdependencies between various factors in the project activities and a large number of these influencing factors affect the complexity;
- Project activities involve large number of processes and a limited analysis of these involved processes leads to uncertainty;
- Uncertain effect on project activities due to possible occurrence of specific conditions or events;
- During the project execution, unforeseen factors emerge which are not known at the initiation of the project (Atkinson, Crawford & Ward, 2006);
- Optimism in bias which is typically exhibited by estimators (Buehler, Griffin & Ross, 2002).

In the context of the high-tech industry, these causes of uncertainty may be present. Most of the sources of uncertainty are often not described as threats or opportunities and arise due to a lack of understanding of what is involved (Ward & Chapman, 2003). Also, employees may lack the requisite experience regarding new projects, which also might be plagued with lack of clear specifications at the conception of the project. It is possible that there are certain factors, which emerge during the project execution; i.e. during the project life-cycle. All such factors may not be necessarily accounted for, in the beginning of the project and may emerge in course of time. Such factors also have uncertainties surrounding them.

Uncertainties can also arise from the basis used by the project parties for producing the project estimates (PMI, 2000). The basis of such estimates is unclear and is mostly subjective. However, documenting these estimates provides an opportunity for scruntinizing them further. Uncertainty about the basis of these estimation biases depends on what form they are in, when and how were they produced, from what experience base and resources were they produced and who produced them (Ward & Chapman, 2003). It is difficult to adjust the biases in these estimates. These estimates can be optimistic or pessimistic estimates. When the estimates are adjusted deliberately, it can have long-term repercussions on the project. Uncertainties in successive estimates increases and gets amplified if the iterative process of cutting back and padding of these estimates goes unnoticed and unverified (Ward & Chapman, 2003).

Uncertainty about the project design and project objectives

Another source of uncertainty can arise from the alignment on project objectives and priorities. There should be clarity on the relative priorities of the project and the project objective so as to improve the project performance and acceptable trade-offs should be established between them (Ward & Chapman, 2003). This clarity on project objectives and priorities has to be well established before establishing project management techniques for the project. Even though there is uncertainty surrounding the level of achievability of the end product, the uncertainty related to the relative priorities in the project and the nature of these objectives should also be managed (Ward & Chapman, 2003). The interested project parties involved in the project might have different objectives with regards to the project output. This needs to be appreciated and accounted for, while aligning on the project objectives. This type of uncertainty can also have an influence on the variability associated with project estimates. The uncertainty about the amount of variability in the estimates and also about the basis of these estimates can be driven by the uncertainty due to the nature of objectives and priorities of the project (Ward & Chapman, 2003).

Also, at the project conception stage of the PLC, a fundamental and primary uncertainty is the process for producing the end product as well as the nature of the project (Ward & Chapman, 2003). In principle, during the course of the project, these uncertainties start to diminish as specifications about what has to be done begin to materialize. However, during the course of the lifecycle of the project, a large proportion of this uncertainty may remain unclear (Ward & Chapman, 2003). Such assumptions and associated uncertainty about the design and logistics may also have an influencing factor on some of the uncertainties about the variability of project estimates.

Uncertainty about relation between the project parties

There are a lot of parties which are involved in projects; people from various functional and business units may collaborate on a project. The relationship between such different parties can be quite complex and might not involve a formal contractual agreement between them. This may give rise to sources of uncertainty. There is ambiguity and vagueness in a project due to participation of multiple parties in a project with respect to (Ward, 1999):

- the roles and responsibilities of specific people;
- roles and responsibilities are perceived differently by different people;
- communication between the different functionalities and interfaces;
- the parties and their associated capabilities;
- effects and outcomes of the conditions of contracts between the parties; and

- the control and coordination mechanism which is used in the project.

While working on projects, such uncertainties can lead to ambiguity in the responsibilities and roles of different parties which are working on the project. Apart from the ambiguity in formal contracts between the various organizations, the aforementioned uncertainties should also be addressed (Ward & Chapman, 2003). These uncertainties associated to the contractual relationship between the project parties may further influence the uncertainty about project objectives and project priorities (Ward & Chapman, 2003).

3.2.3. Conclusion

This section dealt with the literature review on project uncertainties. Firstly, the notion of uncertainty is coined in layman terms as the lack of complete certainty. Uncertainty is different from risks as; in uncertainty it is impossible for the project actors to attribute probability of occurrence of events, i.e. the project actors might find it impossible to foresee certain situations from where uncertainties can develop. Uncertainties are unforeseeable and due to this, it is difficult to mitigate and prevent them. Uncertainties can be of various types and identification of these sources of uncertainties is also important for managing them.

The different types of project uncertainties are:

- Variability in the project estimates: Uncertainty around the quantification of project performance parameters such as scope, quality, time and budget.
- Uncertainties about the objectives and priorities: Uncertainty surrounding alignment of the project team members on the project objectives and priorities.
- Uncertainty about relation between project parties: Uncertainty between project parties where there are multiple parties involved and no formal agreements are there.

3.3. Impact of project uncertainties on project planning

This section focuses on the impact that project uncertainties can have on project planning. In order to develop a plan for a particular project, first it is important to identify and assess the priorities of the project, i.e., to identify the constraints and performance parameters which can influence the project plan. Establishing and prioritizing these constraints helps in the development of a sound project plan (which can cater to the requirements of the project). Hence, 3.3.1 discusses the triple constraints of project management, which are the project performance parameters. Sub-sections 3.3.2 through 3.3.5 dive into the reasons for project failures and the study is concluded in sub-section 3.3.6, where-in the reasons for project failure are correlated to the project uncertainties.

3.3.1. Triple-constraint

Historically it was said that, if the customers requirements and expectations are met, then the project is successful (Kerzner, 2015). This expectation is generally, a list of specifications and requirements which can be attributed to the dimensions of: project scope, the available time for delivering the product and the amount of resources which are made available for the project. This triple constraint is an important governing concept for project management and influences the project plan. It is represented as a triangle and shown schematically in the figure below:

Time, cost and scope are the three sides of the triangle and represent the three constraints (Kerzner, 2015). In some industries, it was highly improbable to complete the projects within the constraints of cost, scope and time (Kerzner, 2015). Hence, customer satisfaction (represented by the circle as shown in figure 3.1) was included to define project success as trade-offs were needed to finish the project (Kerzner, 2015).

In today's highly uncertain world, very few projects are completed with the pre-defined scope, time and budget. Trade-off is done between the triple constraints. The representation of the triple constraint

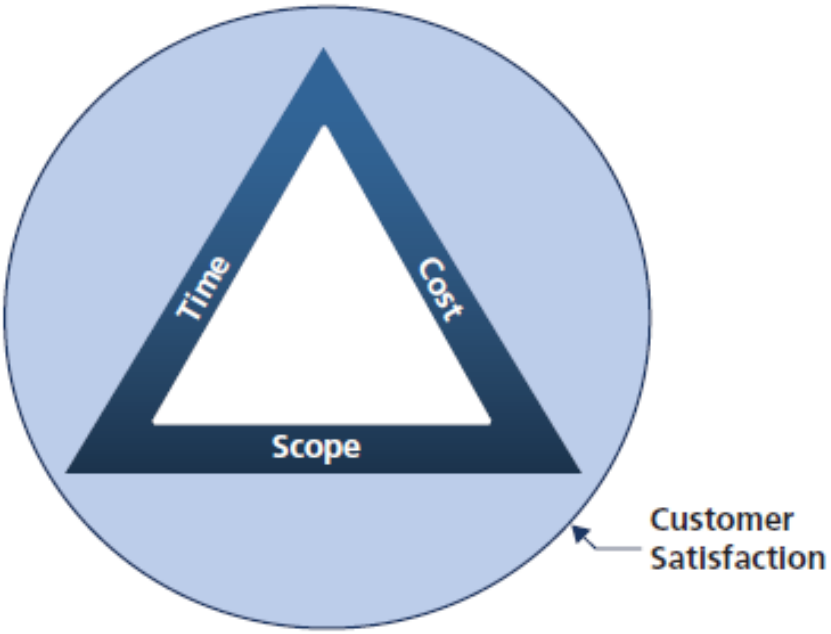

Figure 3.1: Triple constraint (Kerzner, 2015)

in the form of a triangle showcases that the three constraints are entwined and interrelated, i.e., a change in any one side of the triangle has an impact on the other two sides (Van Wyngaard, Pretorius & Pretorius, 2012). For example, if there is a change in the scope of the project, it has a knock-on effect on the time and project cost. The amount of impact on the project time and cost depends on the degree of scope change which is involved in the project.

Even if there is a trade-off between the project performance parameters, the project can be considered successful if it satisfies the customer. Therefore, if the final delivered product is de-scoped, has overrun the time and cost parameters, but if it is in the circle of customer satisfaction (refer figure 3.1), then it is considered successful.

However, even though the project management framework is established and practiced in the industry, some projects fail to meet the customer requirements. There are various studies and surveys which highlight this failure of projects. For example, a study conducted by Standish group shows that only 39% of the projects were successful and the remaining 61% were either late or over-budget or de-scoped (did not meet the required functions and performance) (Manifesto, 2013). Of these 61% of projects, 18% projects were cancelled prior to completion (Manifesto, 2013). The reasons for this project failure are aplenty and can stem out of different sources. A prime reason for project failure is project uncertainties.

Many proficient and experienced project managers have difficulties in dealing with the uncertainties, which are inevitable aspects of most of the projects (De Meyer, Loch & Pich, 2002). As a result of this, project may fail or end up with compromised and lower specifications (underperformance), budget and schedule overruns (De Meyer et al., 2002). In the domain of project management, it is imperative to study the impact of these project uncertainties on the triple constraint, i.e., project scope, project time and project cost. If not dealt properly, these uncertainties can lead to problems in the triple constraints in the project and thereby influence project planning.

3.3.2. Scope problems

Project scope can be defined as the work that must be completed in order to produce the deliverable with the requisite specifications and required functions (Kerzner & Saladis, 2013). This deliverable can be a product or service or any other result (Kerzner & Saladis, 2013). After clear definition of the scope, a work breakdown structure (WBS) is made. The WBS is used to divide the complete project into “pieces of work” which are called as work packages (Nicholas & Steyn, 2012). This insures that

every activity is clearly defined and identified and no activities are missed (Nicholas & Steyn, 2012). However, during project execution, the project scope might change.

Any change to the initially agreed upon scope of work is known as scope change (PMI, 2008). Adjustments and changes are required to be done almost everytime to the schedule and cost of the project in an event of scope change (PMI, 2008). This scope change is initiated through an official contract change notice (Lester, 2014).

In addition to scope changes, projects have a tendency to extend beyond their initial boundaries (Hussain, 2012). This tendency of a project to burgeon and extend outside its pre-defined boundaries is due to the phenomena of scope creep.

"Scope Creep occurs by adding features and functionality (project scope) without addressing the effects on time, costs, and resources, or without customer approval." (PMI, 2008, p.448). From this definition of scope creep, it can be concluded that addition of new features (increase in scope) to the project is done without consultation with the customer. This implies that scope creep is an unofficial change in the scope of work as opposed to scope changes which are carried out officially by change order requests. The uncertainties in the project impact the initially defined scope, which leads to problems of scope change and scope creep.

Sometimes the client initiates changes in the project. Reduction in budget, changes to the requirements, acceleration and faster completion of the project etc. are demanded by the client and these cliental expectations may vary during the course of the project (Sun & Meng, 2009). Sometimes these changes and modifications in the design can also stem from the fact that the scope specified by the client is unclear (Le-Hoai, Dai Lee & Lee, 2008). Scope changes can also stem from the fact that the client fails to provide the necessary information required to carry out the work. This failure/ late delivery of information delays the decision-making and can also lead to scope changes (Chang, 2002). Further to this, it might happen that the client provides incomplete information/ incorrect information. This can also lead to changes in the scope of work (Chang, 2002).

Sometimes the original schedule is overly optimistic and unrealistic. This may be due to inaccurate and biased estimates or also due to some political decisions (example, pressure from the upper management) (Chang, 2002). Often mistakes in planning and quantity estimating can lead to errors, omissions and defects in planning and design and can lead to optimistic biases in estimates (Hsieh, Lu & Wu, 2004). Moreover, if the design specifications are inadequate or if the contractual interfaces have inadequate and inappropriate arrangement then they can serve as breeding areas within the project for the scope to creep than initially planned work (Hsieh et al., 2004). This may lead to problems of scope creep in the projects. Chang (2002) in his study observed that at the moment when the hours of work were originally estimated, the actual scope of work was not properly understood by the consultant (here, project manager) which led to scope creep in the project (Chang, 2002). This underestimation in the required amount of work and effort may lead to scope creep. Scope creep can also arise from conditions which are not foreseeable at the initiation of the project (Alp & Stack, 2012). Sometimes project managers tend to ignore the small changes that are occuring during the execution of the project. Many project managers ignore and accept the small changes as they concentrate more on the bigger and major scope changes that could further give rise to larger scope creep problems (Hussain, 2012).

Secondly, uncertainties surrounding the objective and priorities of the project can also lead to problems in the scope of work. The client may change the business case as the business that is to be supported by the project has changed its requirements in a way unforeseen at project intiation (unforeseen in the original contract) (Bröchner & Badenfelt, 2011). The stakeholders also play a prominent role in project execution. For specific projects, a detailed explanation and justification can be requested by the stakeholders who are external to the project (e.g., permitting agencies, community, etc.) (Chang, 2002). Failure to meet this expectations of the outside (external) stakeholders can also lead to changes in the scope of work. Inability of stakeholders (internal and external) to come to an agreement has a role to play in scope changes (Kerzner, 2015). If the stakeholders do not agree unanimously or do not reach a decision within a designated time, it can lead to changes in the scope of the project and

the project team might have to do more work or rework. Sometimes, the project manager can ignore the key stakeholders. Ignorance of the inputs of key stakeholders is also a reason for scope creep. If the key stakeholders are not involved initially, then their opinions and objectives would not be covered completed. If these key stakeholders are only involved when the project is underway, then it can lead to scope creep (Hussain, 2012).

Scope problems can also occur as a result of poor briefing at the start of the project. Sometimes there can be insufficient understanding of the cliental requirements and assumptions about the key aspects of the project can be wrong due to poor brief development at the project initiation (Sun & Meng, 2009). This wrong assumption is underpinning the work that the project team has to carry out and may lead to unnecessary work. Such a lack of communication is also seen in project teams. The flow of information between the project team members can be slow and also if the speed of decision-making between project parties is low then it can lead to changes in scope (Chan & Kumaraswamy, 1997). This speed of decision-making and information flow results in interim delays in the project. In order to curb these delays, additional changes to the project scope or modification in the work can be done. Another cause of rework and design changes is the poor communication between the project participants involved in the project (Sun & Meng, 2009). These design changes and rework can have negative effect on the amount of (official) work to be done and may lead to scope creep. Moreover, poor interdisciplinary communication may also lead to scope creep (Sun & Meng, 2009).

Further to this, bad management is also a prominent source of scope creep. Absence of scope control and management systems in addition to the improper management of changes may lead to additional (unofficial) work been carried out (Hussain, 2012). This also includes long waiting time for approvals. If the project steering committee (upper management) takes a long time to give approvals on matters which require immediate attention, then it may lead to delays in the project or may also lead to additional amount of (unofficial) work. Long waiting time for approvals for drawings, specifications or changes affects the project as the execution of the project may subject to more work and/or rework (Chan & Kumaraswamy, 1997). Another cause of scope creep is the inappropriate project organization structure (Sun & Meng, 2009). If the project organization lacks proper structure for dealing with changes, then project scope can expand without due accountability for work.

3.3.3. Time overrun

Project time is also a project performance parameter which is considered in the triple constraint. The project time, as the name suggests is the total time required to finish the project and produce the requisite deliverable with the pre-defined scope and amount of resources (cost). Time management of the project is defined as the process which is required to be undertaken to ensure timely completion of the project (PMI, 2000). Once the WBS is created, the time duration required to complete each activity is estimated in order to obtain the complete project plan.

Even though, the project plan is established before the initiation of the project, it is seen that projects fail to be delivered on the designated end-date. A cause of project failure can be attributed to the unrealistic expectations imposed by the upper management on the project plan. In a very little time, the project plan can ask for too much which can lead to schedule slippage (Kerzner, 2015). Also, if the project is not defined properly at its initiation, the project plan is inadequate and may lead to project failure. At the initiation of the project, if it is not defined adequately then it can lead to project failure (Black, 1996). This can also be due to insufficient/incomplete data, i.e., if project planning is done with insufficient data, then it may lead to inappropriate planning and might lead to project failure (Black, 1996). Also, if the project requirements are inadequate or incomplete, then planning would be misdirected (Kerzner, 2015).

If the project end-goal and objectives are unclear, then there can be delays and time overruns as it is very difficult to make a plan for such a project and follow a particular direction (Black, 1996). If these objectives and project goal change during the project execution stage, then it can affect the progress of the project and can be subject to project delays. In a survey by Black (1996), one of the most important reasons for project failures is poor work definition. This can be attributed to the overall project planning, for example, if the project milestones are not measurable (quantifiable), then it can

lead to more work/ rework which can lead to time overruns (Kerzner, 2015).

The project plan involves intermediate milestones. These milestones are to be met in a timely manner in order to complete the project on time. However, failure to meet the deadlines of these intermediate milestones coupled with lack of recovery plan may lead to project failure (Kerzner, 2015). In addition to this, the schedule can deviate and slip from its original duration due to a knock-on effect of schedule slippages, i.e., if the coordination of activities in the schedule is improper and if one activity fails to meet its deadline, then it can have repercussions on the next activities thereby causing such an effect (Black, 1996). Also, if the project schedule is not followed, then it can lead to schedule slippages, i.e., non-adherence to the project schedule (Black, 1996). If the schedule is not followed then the project manager may lose the track of the project (and the associated deliverables), which may lead to time overrun. Furthermore, if the monitoring of the baseline schedule is not proper and done poorly, then it may lead to delays in the project. These delays can be averted by timely interventions by the project planner. However, lack of replanning and awareness to act on delays can lead to project failures (Kerzner, 2015).

3.3.4. Problems with cost and resources

Project cost is the estimate of the total cost which is required to complete the project and deliver the end-product, i.e. all the features of the project which has a monetary aspect to it are considered in the total cost. This covers the budget of the project and the involved resources (example, labor costs, overhead expenditures etc.). For most of the project, the people who are working on the project, i.e., the project team members are assigned the largest percentage of total costs (Heldman & Baca, 2007). To ensure that the pre-defined (approved) budget is sufficient to manage the project, the practice of cost management is imperative (PMI, 2000). With the creation of the WBS, it is possible to estimate the total cost which would be required to complete the project. This includes the amount of resources which are also required for the particular project. Historical data, i.e., data from the previous projects can be used to gather inputs for the cost estimation (PMI, 2000).

Even though, there are prescribed methodologies for cost estimation and cost management, various projects fail as a reason of cost overruns and inadequate resource management (Black, 1996). If changes are implemented during the execution of the project, then it can lead to inflation in the cost (budget overruns). Moreover, if these changes take place towards the completion stages of the project, then there is a significant potential for the costs to increase and the cost of executing the project changes increase exponentially with time (Black, 1996). During the periods of inflation, if the costs associated with labor, materials and supplies are to be controlled so that they do not increase beyond its original budget then it is imperative that the project stays on the schedule (Black, 1996). Poor cost control can also lead to cost inflation. If the costs are not controlled and monitored properly during the execution of the project, then cost inflations can occur (Kerzner, 2015). This inflation is unforeseen and is caused by the lack of monitoring in the project.

Another major reason for project failure is the fact that there is a lack of resources for the work to be carried out in the project. Insufficient human resources in the project leads to an increase in the workload on the other members working on the project and as a result the project usually slows down (Black, 1996). Even if the project is assigned with adequate resources, lack of experience of these project team members (human resources) can lead to the project failure (Kerzner, 2015). Sometimes, resources are assigned too many projects at the same time. Assigning work to personnel on different projects at the same time can lead to long waiting times and delays in the project (McConnell, 1996). Over-assignment of resources to different projects can slow the process down (Black, 1996) and can have a knock-on effect on project cost and time. Another cause of project delays may stem from the fact that resources might lack motivation. If the resources are working on conflicting requirements or are fatigued during the project which may de-motivate the project team members (Kerzner, 2015). Studies give an evidence of this lack of motivation of project team members. For example, lack of focus and motivation of the project team members may lead to decrease in efficiency and productivity of the resources (McConnell, 1996). Motivational problems can also be due to lack of human resources as it will overburden the project team members which can lead to mistakes, poor work morale and eventually burnout of the people working on the project (Black, 1996).

Another reason for project failure can be due to the incompetency of the resource (who is) at the helm of the project, i.e., the project manager. To have a successful project, a competent project manager is required to lead and inspire the project team members and also help steer the project to success (Black, 1996). In a survey conducted for project failures, an important reason for failure of projects was associated to the incompetency of project managers (Black, 1996). Unwillingness of the project manager to make decisions and ignorance of problems by the project manager were also important reasons for the project to fail (Black, 1996).

3.3.5. Others

- Poor information management (Black, 1996; Kerzner, 2015; McConnell, 1996)- Information management embodies everything which requires a transfer and flow of information, i.e., flow from a daily routine report to high-end software packages and products. In the overall lifecycle of the project, communication and transfer of information on schedule, cost, inventory etc. is imperative. The project manager and all important stakeholders should be well-informed and up to date with the project's status and the project should be kept on track without having any deviations. This should be achieved by means of proper communication between these stakeholders and mitigative measures should be taken by them if and when needed.

- Insufficient risk analysis (Black, 1996; Kerzner, 2015; McConnell, 1996)- A project can be doomed and thereby fail if the risks which occur during the course of the project are not assessed properly. The environment in which the project is undertaken changes during the course of the project, as there are changes in the financial markets, businesses, technologies, culture and governments. Risk analysis has to be an important aspect for project planning. If the risks are not identified and analysed properly, then the project can fail. In addition to this, inability to manage and mitigate the risks can also hamper the project and can lead to cost and time overruns.

- Lack of management support (Black, 1996; Kerzner, 2015; McConnell, 1996)- Another reason for project failure is the lack of upper management support in the project. Support should be provided by the upper-level management by means of allocating the requisite resources to the project and should appoint a project manager who can effectively carry-out the project. However, sometimes the authority of the project manager to control the sub-contractors, customers, project team members etc. is undermined by the over-involvement of upper-level management. The project can sometimes go out of control if the upper-level management tries to over-control the project. Sometimes, minimal or absence of stakeholder backing (upper-management) can lead to project failures as without the backing of the key players in the project, the project can lose its direction and can misalign from the customer requirement.

3.3.6. Conclusion

There are various reasons for project failures. At first, these reasons may seem independent. However, these causes of project failure are interdependent and woven together (Black, 1996). If the time duration of the project is changed, then it not only affects the scope of the project, but the cost of the project and resources working on the project are also affected. There are problems of increased costs and schedule slippages due to poor information systems and ineffective project managers and may lead to dissatisfaction among the team members (Black, 1996).

These changes to the triple constraint of project management are due to the uncertainties which are pertinent to the project. The different types of uncertainties were mentioned in section 3.2. On mapping these different types of project uncertainties to the causes of project failures (mentioned in section 3.3), the impact of these project uncertainties on project management is obtained. This affects the planning of the projects. It is seen that, all the different types of project uncertainties impact the triple constraint and lead to alterations in the project time, budget and scope.

The table 3.1 below, shows the impact of the project uncertainties on the triple constraint of project management. Hence, in order for the project to be successful, these uncertainties have to be managed effectively.

Table 3.1: Impact of uncertainties on the triple constraint

	Scope problems	Time problems	Cost and resources problems
Variability in the project estimates	• Unclear requirements (Le-Hoai et al., 2008) • Optimistic schedule (Chang, 2002) (Hsieh et al., 2004) • Unforeseen conditions (Alp & Stack, 2012)	• Unrealistic schedule (Kerzner, 2015) • Poor work definition (Black, 1996) • Missed deadlines (Kerzner, 2015)	• Lack of experience (Kerzner, 2015) • Poor cost control (Kerzner, 2015) • Budget overruns (Black, 1996)
Uncertainty about the project design and project objectives	• Changes in business case (Bröchner & Badenfelt, 2011) • Changes due to stakeholders (Chang, 2002)	• Unclear end-goal (Black, 1996)	• Over-assignment of resources (Black, 1996)
Uncertainty about relation between the project parties	• Poor communication (Sun & Meng, 2009) (Chan & Kumaraswamy, 1997) • Bad management (Hussain, 2012) • Inappropriate organization structure (Sun & Meng, 2009)	• Non-adherence to project schedule (Black, 1996) • Poor performance tracking (Kerzner, 2015)	• Incompetent project manager (Black, 1996) • Lack of motivation (McConnell, 1996)

3.4. Chapter Summary

In order to develop an understanding of planning and project uncertainties, a literature review was conducted. The objective of this literature review was twofold:

1. To gain knowledge about project planning and scheduling. The benefits and pitfalls were noted. Further to this, literature on project uncertainties was also reviewed understand the notion of uncertainties and the different types of uncertainties. The key findings of project planning and project uncertainties are concluded in sections 3.1.3 and 3.2.3 respectively. These findings would be used to setup the interview questions for the semi-structured interviews at ABC Company.

2. To develop an insight into the impact of project uncertainties on project planning. The triple constraint of scope, time and cost is used as the driving factor for deriving project success or failure. The literature delved into the causes of project failure due to these triple constraints. Finally, it was seen that the project uncertainties play an instrumental role to doom a project. The phenomena of scope change, scope creep, time and cost overruns with other associated factors can be attributed to the uncertainties which are prevalent in the project. This is summarized in section 3.3.6 The findings from this section were used to develop the design solution, for the problem(s) faced by the ABC Company in project planning.

4

Interviews within ABC Company

This chapter forays into the current project planning practices in the ABC Company. To get an insight into the planning practices, interviews were conducted. Section 4.1 discusses about the interview protocol. Furthermore, section 4.2 provides an in-depth analysis of the data which was acquired from these interviews. In section 4.3 a causal analysis is done for the issues which are encountered by the project leaders during planning. Finally, section 4.4 provides the recommendations given by the project leaders to tackle the issues while planning under uncertainties.

4.1. Interview protocol

Interview questions

Interviews were conducted within the ABC Company, so as to get a real-time response of the planning practitioners about the planning practices within the company. For developing the semi-structured interviews, the findings from the literature review on project planning and project uncertainties were used to design the interview questions (Refer section 3.1 and section 3.2). As the interviews were conducted for a period of strictly one hour, owing to the packed schedule of the interviewees, the questionnaire was as concise as possible. The posed questions were such that they covered the holistic view of the interviewee. Moreover, the Project Leaders (PLs) were chosen as the panel of informants within the ABC Company. Before commencement of the main interviews, pilot interviews were conducted within the company (refer section 2.2.1). These three pilot interviews were of PLs belonging to the structural improvement department within the ABC Company. On the basis of the feedback obtained from these interviews, the interview questions were modified by the interviewer. Having established all these criteria, the interview questions were designed. Appendix A shows these interview questions.

Interview respondents

A total of 10 PLs were interviewed from different functional departments within the ABC Company. The interviews were conducted anonymously for confidentiality reasons. The table below shows the name of the interviewee and his/her corresponding department.

Table 4.1 gives an overview of the interviewees and the departments in which they work. PLs from five different functional departments were chosen to be interviewed. These departments are described briefly as follows:

- Structural Improvement: This department handles the project management activities within the ABC Company. All the IT tools which are required for supporting the core product are provided by this department. This department is cross-sectorial and helps the technical departments in managing their projects. The projects in this department are not directly related to the development of the core product.

Table 4.1: Overview of the interview participants

Name of the Project Leader (PL)	Department within ABC Company
A	Technical department-3
B	Technical department-1
C	Technical department-2
D	Technical department-3
E	Structural improvement
F	Technical department-1
G	Structural improvement
H	Information Technology
I	Technical department-2
J	Technical department-3

- Information Technology: This department works in association with the Sales and Marketing department as well as the Customer Support. It provides the services these departments need. As is the case with the structural improvement department, the projects in this department are not directly related to the development of the core product.
- Technical department-1: This department provides the hardware and software facility for the product, which is delivered to the customer. The aim of this department is to deliver product facilities such that they fit the customers production line.
- Technical department-2: This department develops the product which is manufactured by the ABC Company. This product is based on the current technology which is used within the ABC Company for manufacturing the product. Currently, the products from this department are shipped to the customer.
- Technical department-3: This department is involved in the development of newer type of product. The products which are to be delivered by this department are based on an upcoming technology. The production from this business line is still in its infancy within ABC Company.

The interviews were recorded by the interviewer and transcribed. While transcribing qualitative data, there can be problems of perceptions of what is said by the interviewee and (what is) perceived by the interviewer. Thus, in order to eliminate this bias, the interviewer sent the summaries of the interviews to respective interviewees to gather their feedback on the reporting of their interviews. The synopses of the interviews are presented in appendix B.

4.2. Data Analysis

On completion of the interviews, the data was analyzed. Since the volume of data which was generated from the interviews was huge, key issues from those interviews were scrutinized and obtained. This is in line with the issue-based analysis (refer section 2.2.2). Further to this, the cross-case examination was carried out. First, the category of link to the literature was used. Based on the findings from this category, a headcount of the issues mentioned in the interviews is done. This is the second category used in the cross-case examination.

In the first category of link to the literature, the issues in the interviews were fragmented based on the different types of project uncertainties. These types of uncertainties are mentioned in section 3.2.2. A cross-case examination of the interviews based on the different types of uncertainties was done. The issues raised by the PLs in the interviews were fragmented into the three different types of uncertainties; those of: variability in the project estimates, uncertainty about project design and objectives, and uncertainty about the relation between project parties. Appendix C shows three tables where-in, these issues are fragmented in the three different types of uncertainties.

Based on this cross-case examination, some findings are obtained for the three different types of uncertainties. The findings showed the issues while project planning under uncertainties. Table 4.2 shows

Table 4.2: Cross-case examination based on the different types of uncertainties

Interview	Variability in the project estimates	Uncertainty about the project design and project objectives	Uncertainty about the relation between project parties
Findings	• Escalations due to delays in plan as a result of scope changes and unforeseen challenges	• Scope changes by the management and the customer	• Lack of communication and role clarity may lead to scope changes and delays
	• Scope changes due to unclear and changing specifications	• Unavailability of the testing machine leads to delays and changes	• Delays due to external party
	• Escalations due to accepting risks and changes	• Escalations due to changing requirements and priorities of the customer	• Escalations due to poor information flow and lack of governance
	• Scope changes and delays due to optimistic planning	• Misalignment of the stakeholders caused delays	• Delays as people do not stick to the plan and do not monitor it
	• Complexity due to dependencies and development of newer methods leads to delays		
	• Scope changes (de-scoping) due to unavailability and transfer of resources		
	• Escalations due to inadequacy in budget		

these findings.

The variability in the project estimates had a significant influence on the planning of the PLs. It was seen in the interviews that, delays and scope changes occurred due to occurrence of unforeseen situations and also due to taking shortcuts in plans. As certain situations were unforeseen (like development of new tools, breaking down of a key component in the machine etc.), sudden occurrence of them delayed the project plan (which was not anticipated upfront). Optimistic planning was also identified as an area due to which delays and scope changes occur in the projects. The PLs also stated that they have buffers and contingencies in their plans to counter the prevalent uncertainties, but sometimes there are unforeseen events which come up during the execution of the project which go overboard the buffer-times, i.e., take more time than the buffer-time accounted in the project plan. In addition to this, as there were changing and unclear specifications and lack of clarity on the end-goal, it lead to additional work and rework which lead to scope changes and delays. Complexity due to the dependencies between activities also influenced the planning as due to improper management and understanding of this complexity, there were delays and scope changes. Furthermore, there were project escalations as well in the projects. These escalations occurred either due to scope changes or delays. Other causes for project escalations included inadequacy in budget, i.e., there was uncertainty about the budget estimate. The respondents stated that uncertainty surrounding the budget estimate was difficult to manage which later was seen to lead to project escalations.

Uncertainty about the project design and project objectives was primarily due to the stakeholder influ-

ence in the projects. The respondents stated that, there were scope changes and delays due to changes in the priorities and requirements of the customer. This also led to escalations in some projects. Some PLs also argued that there was misalignment of the key stakeholders involved in the projects, which led to delays in the project schedule. Unavailability of machines for testing the products was also seen as a cause which led to delays. As there were changes in priorities regarding the relative importance of projects, in a portfolio, the availability of the testing machine also changed as a result of that. This led to delays in the project plan.

Uncertainty about the relation between the project parties also impacted the project planning of the respondents. Scope changes and delays occurred as a result of lack of role clarity and improper/ lack of communication between the project parties. Top-down information flow as well as inter-disciplinary flow of information was inefficient which lead to these problems. Moreover, lack of role clarity of the people involved in the project team as well as unclarity of the roles of the upper management led to mismanagement of the project thereby leading to scope changes and delays. Due to this improper governance and lack of management support, projects had to be escalated as well. Other sources of delays arose from the fact that project parties were not monitoring and sticking to the plan. Sometimes, the external parties/ suppliers also failed to deliver on time resulting in delays to the project plan.

Moreover, the project leaders also highlighted issues with the practice of project planning within the ABC Company apart from the influence that uncertainties have on project planning. The interviewees stated that MS Project planning was not used appropriately within the organization. To make a project schedule on MS Project requires a lot of time and effort. They further said that, if there were any changes to the project baseline schedule, then it was very difficult for them to make changes to the schedule in MS Project. The PLs argued that the workshops conducted within the ABC Company were relatively easier in comparison to the work that they had to perform and stated that the planning workshops and courses did not help much. Some of them mentioned that they used Excel for scheduling as MS-Project requires additional skills. They also stated that the project plan which they developed was in conflict with the need dates and then they had to make necessary changes to the plan.

The project leaders also stated that there were issues with project planning due to inadequate support from the program level. A few PLs stated that the triple constraint management at the program level was poor which led to changes in the main constraint driving the project. They mentioned that the drivers of the project changed from a time-driven project to scope/cost driven later (or vice-versa) which affected their project planning. They argued for better triple-constraint management at the program level. Further to this, one of the PLs also stated that the masterplan is not maintained properly. He stated that uncertainties and dependencies in a project are visible more clearly at the program level which can give more predictability. He mentioned that this visualization of dependencies is happening very little at the program level.

The respondents stated that in the ABC Company, the project members are assigned to the next project, immediately after the completion of the previous project. As a result of this, they do not get sufficient time to develop there plan which leads to problems later. This view was given by one PL from the technical department. Also, the PL from the IT department stated that he did not do risk management for his project as he did not have time to assess the risks. This was due to the fact that he was appointed as a PL when the project was already under execution and he took over the project from another PL.

To gather a deeper insight into the issues with project planning, a headcount analysis of these issues was done. This is the second category for the cross-case examination (refer section 2.2.2). These issues were obtained based on the data analysis and the findings from the cross-case examination. Table 4.3 below shows the headcount of the issues inferred from the interviews. Appendix D shows the comments from the respective PLs which were used for obtaining the issues (shown in table 4.3).

It can be seen in the table 4.3, that scope changes and delays were mentioned by the most number of respondents (8 each). Following this, it was seen that project escalations had a headcount of 6, i.e., six PLs mentioned about escalations occurring in their projects. It was also seen that lack of governance

Table 4.3: Issues with project planning inferred from the interviews

Issues inferred from the interviews	Project Leaders (PLs) referring to the issues in the interviews									
	PL A	PL B	PL C	PL D	PL E	PL F	PL G	PL H	PL I	PL J
Scope changes	X	X	X	X	X	X	X		X	
Project delays	X	X	X		X	X	X		X	X
Project escalations	X	X	X	X			X	X		
Lack of governance	X		X		X		X	X		
Complexity	X	X			X			X		
Budget issues			X					X		X
Lack of communication	X	X				X				
Insufficient buffers						X		X	X	
Insufficient MS Project skills	X					X				X
Lack of role clarity					X	X	X			
Too detailed planning				X					X	
Poor triple-constraint management			X	X						
Lack of time to plan		X								
No time for risk assessment								X		
Insufficient masterplan	X									

and complexity of the projects were also impacting the planning practices of the PLs (mentioned 5 and 4 times respectively). The PLs mentioned that, if the complexity and the dependencies in the project are not managed properly, then it leads to scope changes and delays in the project. Also, if the governance is not appropriate, then it can lead to delays in approvals and change requests.

Further to this, each of the issues with project planning such as the problems with budget estimates, lack of communication, insufficient buffers, lack of expertise of MS Project skill and lack of role clarity were mentioned by 3 respondents. The PLs stated that, budget estimate was a difficult uncertainty that they had to deal with, and getting the budget estimate correct was difficult for them. Also, they stated that, due to scope changes, they had to get approvals for additional budgets. It was seen that there were delays in obtaining the approvals for these scope changes and providing additional budgets. However, there was very little mention of cost overruns in the project and its impact on the project outcome. In addition to this, lack of communication and role clarity were also mentioned by the interviewees. If there is a lack of communication between the parties involved in the project then it may lead to delays in the transfer of information and/or the information may not be transferred. This may lead to changes in the scope of the project. If the responsibilities and roles of the people involved in the project and also of the upper management are unclear, then it may lead to delays in approvals or lack of mitigating strategies in case of changes to the original baseline plan. The PLs include buffers and contingencies in their baseline plan in order to deal with the risks and uncertainties. These buffers are put-in mostly based on heuristics and experience of the PL. For projects, which are not time-driven, PLs may put significant buffers in their schedules so that there are no delays in the project. However, for time-driven projects, the buffers are relatively smaller. If there are any unforeseen circumstances, then the buffer-times may go overboard, i.e., as a result of the impact of these unforeseen challenges, the actual duration of the activity may be significantly more than the considered buffer-times and may lead to schedule slippage. MS Project is prescribed in the way of working of the ABC Company. However, the PLs argued that the workshops and teaching sessions which were provided in the company were not sufficient to learn the use of MS Project. Also, the skill-set required for operating MS Project was not sufficient.

Poor-triple constraint management and too detailed planning were mentioned by 2 respondents each. Poor-triple constraint management at the program level leads to changes in the priorities and objectives of the project, which may lead to changes in the scope as well as additional work/ rework in the project. Scope changes and delays also affect the detailed plan of the project. Making a detailed plan requires effort and time, and hence, if there are changes in the scope and priorities of the project, then it may result in re-development of the detailed plan. This dynamicity of these changes influences the detailed planning of the project leaders.

One respondent each cited the issues of lack of time to develop plan, lack of time for risk management

and insufficient masterplan. These three issues are process steps which should be done before the initiation of the project. Failure to do so may have detrimental effect on the project outcome.

In addition to this, from the analysis it was seen that, all the above mentioned issues contributed to project escalations. The projects are escalated so that they meet their targeted end-date. Hence, if there are issues which are influencing the completion of projects, then these projects are escalated in the end. Out of the 10 respondents, more than half of them (6) mentioned that project escalations have to be done in order to complete the project-on time.

The above mentioned issues were gathered from a sample set of 10 respondents. Since, these respondents belonged to the different sectors of the company; they had differing views on project planning. Hence, for further research, the top five issues which had the highest headcount are analysed. These are:

- Scope changes
- Project delays
- Lack of governance
- Complexity
- Project escalations

In order to develop solution(s) for these above-mentioned issues, a combined analysis was done. This was done to understand the causes for occurrence of these issues and to support the evidences obtained from the interviews. The combined analysis involved findings from both the literature and the interviews. This is further elaborated in the next section.

4.3. Causes of the issues with project planning

The main issues which were identified in the data analysis of the interviews were scope changes, delays, lack of governance, complexity and project escalations (refer section 4.2). Out of these identified problem areas, scope changes and delays (time overruns) are the problems with the triple constraint of project management. This was encompassed in section 3.3 of the report, where the general causes for scope changes and delays were identified (as found in literature). Further to this, based on the data obtained from interviews within the ABC Company, the causes for scope changes and delays are tabulated in Table 4.4.

Table 4.4: Causes for scope changes and project delays found in the interviews

	Scope change	Delays
Variability in the project estimates	• Unclear and changing specifications • Resource allocation problems • Unforeseen challenges and situations • Optimistic plan	• Resource allocation problems • Dependencies in the project activities • Insufficient buffer and optimistic plan • Unforeseen challenges and situations
Uncertainty about the project design and project objectives	• Changing customer requirements • Changes in design and objective by stakeholders	• Scope change discussions • Changing priorities of stakeholders
Uncertainty about relation between the project parties	• Improper communication	• Improper communication • External party • Non-adherence to plan • Approvals after scope changes

Table 4.4 shows the causes of scope change and delays identified in the interviews conducted at the ABC Company due to uncertainties. These causes were analyzed in combination to the literature review (refer

section 3.3). This was done in order to support the findings from the interviews and also to investigate whether there were some company-specific causal relations which lead to scope change and delays.

Causes for scope changes

1. Variability in the project estimates: It was inferred from the interviews that unclear and changing specifications lead to changes in the scope of the project. Also, it was seen in the interviews that the lack of information at the time of development of project plan leads to changes in the scope. This is in line with Le-Hoai (2008) where it is stated that scope changes may occur if the client requirements are unclear. It was also seen that failure to provide complete information at the initiation of the project can lead to scope changes (Chang, 2002). Secondly, it was seen from the interviews that, scope of the work was changed due to resource allocation problems. As the resources are moved and transferred from one project to another, it not only leads to additional burden on the other employees, but also may lead to changes in the scope of work. This is in-fact a problem of the triple constraint, as changes in resources is leading to scope changes. These reasons for scope changes and resource problems are interwoven and interrelated (Black, 1996). Further to this, scope changes may also occur due to unforeseen things and events. It was observed in the interviews that, scope changes might happen if, during execution, an unforeseen situation is observed, which was not foreseen at the initiation of the project. In the context of the ABC Company, projects involve developments of newer products and services which are not carried out before. Most of the PLs stated in the interviews that during the development of complex machines, certain unforeseen events come-up, which cannot be predicted at the beginning. This is due to novelty and limited experience about the process. Moreover, at the advent of such a situation, most PLs report to their upper management to get the changes approved. This is identified in the literature as a cause of scope creep, which may occur if things and situations are unforeseeable at the project initiation(Alp & Stack, 2012). However, scope creep is an unofficial change in the scope of work. Hence, if the PLs are communicating these unforeseeable things to the upper management and getting approvals for them, then it cannot be termed as scope creep. Finally, the interviewees also emphasized on the impact of underestimation of the work and optimistic planning. Scope changes can occur due to underestimation of the schedule estimate which might be due to estimation bias or pressure from the upper management (Chang, 2002).

2. Uncertainty about the project design and project objectives: The interviewees were of the opinion that, changing expectations and requirements of the customer leads to scope changes. The customer comes up with a set of requirements, when the project is underway. As the employees in the ABC Company aim for customer satisfaction, they have to change the scope of work. This also has implications on the time and budget of the project. The interviewees also stated that scope changes occur due to changes in design and objective of the stakeholders. A few interviewees mentioned that sometimes it is difficult to identify the stakeholders for the project. If this is not done at the initiation, then it can change the scope of work. This follows from the literature that scope changes may be due to changes in the business case of the client (Bröchner & Badenfelt, 2011) or due to variations in the clients expectations (Sun & Meng, 2009). Furthermore, stakeholders also influence the design and objectives. If the stakeholders expectations are not met, then it may lead to scope changes (Chang, 2002). These stakeholders can be external or internal to project. Failure to involve these stakeholders in the initial stages of the project may lead to scope creep (Hussain, 2012). Hence, if key stakeholders are not identified, then it may lead to misalignment of objectives and may involve additional work or rework to be done.

3. Uncertainty about the relation between project parties: Another source of scope change which was obtained from the data analysis of the interviews was improper communication between project parties. Some of the respondents commented that, upper management or marketing department commits certain deliverable to the customer, but it is not communicated properly to the PL. This leads to changes in the scope of work (rework or additional work) of the project. This is supported by Chan (1997) where-in slow information flow amongst team members was cited as a cause of scope change. Also, Sun (2009) observed that poor communication between the key partners of a

project can lead to changes and rework.

Other causes:
Apart from the influence of project uncertainties on planning, which led to scope changes; there were other factors which influenced the project planning leading to scope changes. Scope changes were caused as a result of poor triple contraint management at the program level. This follows from the findings of Black (1996) where the author mentioned that a lack of support from the upper management leads to project failure. Moreover, the PLs did not have sufficient skills for operating the MS Project software. Some of them attributed this to the lack of management support. Hence, the management support department in the organization, responsible for delivering the courses on the tools and techniques should further look into the ways of improving these courses. Another cause of scope changes in projects was due to insufficient risk analysis of the project. This argument is supported in the literature by Black (1996), where it was mentioned that insufficient analysis of risks and uncertainties leads to problems in the management of the projects.

Causes for delays

In the interviews, the reference to delays was not only about the time overruns of the overall project plan, but also included interim delays, i.e., schedule slippages. The causes for these delays include:

1. Variability in the project estimates: In the interviews, problems with resource allocation were seen as one of the causes for delays. Sometimes, adequate numbers of resources (project team members) are not employed to the project, or the team members are transferred to another project. This problem of resource allocation is entwined with time overruns and delays in the project (Black, 1996). Secondly, the complexity of the project due to the dependencies in the different activites of a project has an enormous impact on the project plan. The respondents stated that, the dependencies between different departments may lead to delays in the projects. This is because, if the dependencies are not handled properly, then delay in delivery of a sub-deliverable (milestone) might impact the further milestones. This is supported by the findings of Black (1996), where it is observed that domino effect in the slippage of schedules is seen if the coordination between different activities in the network is improper and there is a failure to meet the designated deadline by one activity. This has repurcussions on the successive activities causing the schedule to derail (Black, 1996). Furthermore, failure to meet the deadlines of these intermediate milestones coupled with lack of recovery plan may lead to project failure (Kerzner, 2015). In addition to this, insufficient consideration of buffer and optimistic planning was also seen as a cause of project delays by the interviewees. If very less time is alloted to the project plan and if it promises too much in that timeframe, then it leads to schedule slippage (Kerzner, 2015). As mentioned earlier, this optimistic planning may stem from estimation bias or due to the pressure from the upper management (Chang, 2002). Finally, as was the case with scope changes, the respondents expressed that, occurrence of unforeseen circumstances during the execution of the project may lead to delays and schedule slippages. As these unforeseen situations might impact the further progress of work, delays can be caused in the project.

2. Uncertainty about the project design and project objectives: One of the interviewees responded that scope changes and the discussions associated to it lead to delays in plan. As the stakeholders need to align on the objectives before the commencement of the project, it leads to delays in the plan. Discussions may also be due to the fact that the provided project data is insufficient. These scope changes amount to added work or rework which can hamper the project plan. This finding can be associated to the fact that long waiting time for approvals for specifications or changes by the stakeholders may lead to scope changes (Chan & Kumaraswamy, 1997). As these scope changes have repurcussions on the project plan, it may lead to delays and time overruns (Black, 1996). Also, inadequacy of data may lead to planning been misdirected (Kerzner, 2015). Furthermore, changes in the priorities of stakeholders (both internal and external) may lead to delays. These delays stem from the scope changes that can occur due to these changing priorities.

3. Uncertainty about the relation between project parties: Some of the respondents attributed scope changes due to improper communication as a cause of delays. It was seen that lack of communication between the key parties involved in the project, lead to delays in the project plan. As poor interdisciplinary communication may lead to scope creep (Sun & Meng, 2009), it may also hamper the project schedule. Furthermore, the capability of the external project parties also plays an important role in order to deliver the project on-time. However, from the interviews it was inferred that, delays in the project were caused due to late delivery of a sub-product by external party. Also, poor quality of work furnished by these external suppliers was also mentioned as a cause for delays. These delays in the intermediate milestones may further lead to time overruns and project failure (Kerzner, 2015). In addition to this, some of the PLs stated that, lack of monitoring of project plan and non-adherence to the plan lead to delays in the project. This is supported by (Black, 1996), where his study shows that non-adherence to plan leads to schedule slippage and time overruns. Also, lack of replanning and awareness to deal with the delays may have detrimental effects for the project (Kerzner, 2015). Finally, it was also inferred from the interviews that the upper management takes time to provide approvals after scope changes. This long-waiting time to act on approvals for budget and resources (due to scope change) can lead to delays in the project (Chan & Kumaraswamy, 1997).

Other causes:
Poor triple-constraint management at the program level also leads to delays in the plan. This is because since the drivers influencing the project changes during the course of the project, it has influence on the project plan thereby leading to delays in the project. Lack of support from the upper management and improper management and flow of information can lead to project failure (Black, 1996). Furthermore, lack of time to plan was also a reason for the projects to be delayed. As the project plan was not developed properly, it led to delays and changes during the course of the project.

Lack of governance

Lack of governance was cited as an issue with project planning by five PLs. Due to the insufficient/ lack of governance (on projects) by the upper management and the project management office (PMO) in the ABC Company, scope changes and delays may occur which can further culminate into project escalations. The PLs opined that if they go to the project board for help, then sometimes the necessary support is not provided. This is because the project board itself is not in a position of control. Since, the upper management has to manage multiple projects at once, they prioritize amongst the projects which they are managing. As a result, sometimes a particular project does not get the requisite attention. Moreover, as a large majority of the engineering projects (conducted in the technical departments) involve the use of technologies (which are in its infancy), the project board themselves are not in a position of control when an uncertain event occurs. The foreseeability of future outcomes is limited for these types of newer state-of-the-art technologies. Another issue which was mentioned by the PLs was that there was improper communication between the different hierarchical and functional domains in the organization, which affected their (respective) project planning. It was mentioned by a PL that the feedback loop in the ABC Company was poor. Sometimes, due to this, simlar mistakes can occur throughout the course of the project and the learnings from a completed project are not documented and communicated further. Further to this, another issue with project planning was that, there was pressure from the upper management. Due to this pressure from the upper management, the project planning is squeezed sometimes to adhere to the requirements of the project end-date (by the upper management). The project leader is sometimes required to produce unreasonable and unrealistic estimates due to the pressure from the upper management (Cashman, 1995).

Complexity

The impact of complexity on the projects undertaken in the ABC Company is gigantic. The PLs mentioned about the technological complexity in their projects. As mentioned earlier, the projects in the ABC Company involve innovative technologies, which are first-of-its kind. Due to this uncertainty in the development of these complex technologies, the PLs often encounter scope changes and delays in their projects. The respondents mentioned that, if a new technology has to be delivered, then the complexity of the project cannot be mapped. This is due to the fact that uncertainty surrounding the development

of these newer technologies is very high and significant. In the projects undertaken by the technical departments, there is complexity in the development of the engineering of a product. Intended quality of a component, pellicle problems etc., are some of the areas which are uncertain (while developing a new product). The PLs further argued that it is difficult to estimate the time duration required to complete a particular activity due to the complexity in the development of newer tools. Sometimes, the PLs fail to identify the complexity which is running in their projects and as a result, assign unrealistic durations to activites in their projects. The PLs mentioned that, they have requisite knowledge for developing a standard product. However, when a newer technology is to be introduced, the knowledge is scarce and limited. As a result of this, it is difficult to estimate the project performance paramaters. This complexity in the development of newer technologies is in-line with the technological complexity identified in various literature sources. Newness of the technology invovled in a particular project has a significant impact on the project complexity (Bosch-Rekveldt, Jongkind, Mooi, Bakker & Verbraeck, 2011; Vidal & Marle, 2008). Hence, if this technological complexity surrounding the development of newer products is not identified properly, then it may lead to scope changes and delays in the projects.

In addition to the technological complexity in their projects, the PLs also mentioned about the complexity due to the dependencies between various parties involved in the projects. The respondents mentioned that project planning is influenced by the dependencies between the different functional departments involved in a project. Failure in the timely delivery of a component can impact the subsequent successive activities in the project. The complexity due to the dependencies between the different activities in the project is also a cause of delays in the projects as shown in table 4.4 and is also discussed as a cause of delays in the projects (refer above).

Thus, better dealing with the project complexity can help in minimizing the scope changes and delays which occur during the course of the project.

Project escalations

Based on the data analysis, project escalation was also observed as one of the issues faced by the PLs while planning under uncertainties. However, on careful inspection it was seen that project escalations stem mainly from scope changes and delays in the projects. This was established based on the findings from the interviews. From the findings of the cross-case examination, it was seen that in majority of the cases, the reasons for project escalations was cited to be due to scope changes and delays in the project plan. ABC Company strives to meet the promised end-date which it has agreed with the customer. Hence, in order to meet this targeted end-date, the projects are escalated within the company, i.e., additional money and resources are employed on the underperforming (delaying) project such that, the project is delivered on time. Also, the project is de-scoped so that it is delivered on the required date. This inference was drawn by the interviewer based on the data analysis of the interviews. Changes to the project performance parameters of scope, time and budget leads to project escalations. The interviews of the PLs also support the fact that escalations are primarily caused by scope changes and delays in the plan. As these project escalations stem from scope changes and delays in the project, counteracting on the causes for scope changes and delays would lead to better management of these escalations.

Having established the problem areas and the causes for these problems, a design solution was developed. The starting point for this design solution was based on the recommendations provided by the PLs during their interviews. These recommendations provided by the PLs are mentioned in the next section.

4.4. Recommendations by the PLs

In this section, the recommendations to tackle the problems by the PLs are mentioned and are shown in Table 4.5 below:

It can be seen in table 4.5 that the recommendations are given respective ranks (from 1 to 16). It was seen in the interviews that one PL was of the opinion that project uncertainties are managed appropriately in the company. However, the experience of the PL was only restricted to the ABC Company as he did not have any prior work experience in any other organization. Moreover, the project he had undertaken did not encounter any major scope changes which had any influence on the planning. In order to develop a solution for the identified problems , the recommendations of standardized way of

Table 4.5: Recommendations by the PLs

Recommendations by PLs	Rank
Embedding risks into the planning	1
Want to import AIR issues into the plan	2
Masterplan and IRR to be maintained at project level	3
Need to improve risk management	4
Better tool than MS project is required	5
Need to have a clear priority setting	6
Need for change control management and stakeholder management	7
Resource allocation should improve	8
People should learn from previous plans and projects	9
Testing of the uncertainties should be done	10
Need more help from the project board	11
Governance support is required	12
Empower PLs to take decisions about their own projects	13
Need training in different planning styles	14
Need to have a standardized way of working in the company	15
Spotify engineering culture can be helpful	16

working and implementation of Spotify engineering culture (ranked 14 and 15 respectively) were not considered as they require change in the organizational structure of the company, and not particularly to the planning practices. This is because for implementing the Spotify engineering culture, the complete organizational structure of the company has to be re-organized and re-structured. Such a recommendation of change in the organizational structure is not in the scope of work of this research. All the other recommendations that were mentioned by the PLs were considered while investigating the relevant techniques and methods which could tackle the problems of scope changes, delays and escalations.

These ranking are provided based on the issues with project planning (identified from the interviews). The recommendations involving risk management practices and embedding risks into the baseline planning were given the highest priority (ranked 1 to 5) as it was seen during the data analysis that scope changes and delays occured due to emergence of unforeseen situations during the projects, dependencies between the project activities, optimistic planning etc. As these are sources of uncertainties which can influence project planning, they need to be minimized and mitigated. Therefore, in order to develop a solution, paramount attention was given to risk assessment and embedding the risks in the baseline schedule.

Following this, recommendations involving better stakeholder management and clear priority settings were considered as stakeholder influence was significant on the issues with project planning. Aligning on the stakeholders is important as it helps in minimizing the sources of uncertainties (uncertainties which can arise due to the stakeholders). Another recommendation (rank 9) from the PLs was that people should learn from the previous completed projects. This recommendation holds true for the complete lifecycle of the project, as previous experiences of working on similar types of projects may help to curb the uncertainties which arise in the projects. Finally, the PLs argued that support from the upper management is required and also argued for trainings in the different planning styles.

Based on the feedback and recommendations provided by the PLs for project planning under uncertainties, an investigation study was done on the relevant techniques and methods to counter the problems with project planning. This investigation study and design of the proposed solution is mentioned in the next chapter.

4.5. Chapter Summary

In this chapter, the current practice of project planning within the ABC Company was discussed. Semi-structured interviews were conducted to understand holisitically how the practice of planning is done within the company. The project leaders (PLs) were chosen as subject-matter experts and a total of ten

interviews were conducted. The obtained data was transcribed and further analysed. For the purpose of data analysis, cross-case examination of the ten interviews was done. Two categories were chosen in this examination. The first category was link to the literature, where the issues expressed by the interviewees were linked to the literature on project uncertainties (refer section 3.3). The three different types of uncertainties, i.e., variability in the project estimates, uncertainity about the project design and project objectives and uncertainty about the relation between the project parties were used and the cross-case examination of these interviews resulted in notable findings. In addition to this, other issues with project planning (which do not occur due to uncertainties) were also analyzed. Following this, the second category of cross-case examination was used, i.e., headcount of the issues with project planning (as mentioned by the interviewees). This was done to analyse the issues that PLs faced with project planning. The count of these different issues is shown in table 4.3 (refer above). A total of 15 issues were identified ranging from a count of 8 to a singular count. For further analysis, the top five issues were chosen. These were: scope changes, delays, lack of governance, complexity and project escalations. Here, scope changes and delays are problems with the project performance parameters which occur due to issues with project planning. Lack of governance and complexity of the project were major contributors to scope changes and delays in projects. The complexity in the projects not only involved the interdependencies between the different activities but also occured due to the newer technologies which were involved in the development of the products. Project escalations occur if the scope changes and delays are not managed properly.

Further to this, causes for occurrence of these issues were identified and examined. For this, a combined analysis was done, based on the inputs obtained from the interviews and also from the literature review (refer section 3.3). This combined analysis was done to support the findings from the interviews with the help of the literature. The causes for the problems of scope changes and delays are shown in Table 4.4 and the causes for lack of governance and issues with project complexity were also analyzed (refer above). It is these causes for which a solution was designed. A starting point for the development of the solution was to gather recommendations from the PLs on their preferred solution. These recommendations from the PLs are shown in Table 4.5 (refer above). Based on the feedback and recommendations obtained from the PLs on the problems with project planning, a solution was designed and developed in the next chapter.

5

Development of the solution

This chapter delves into development of a procedure to counteract the problems with project planning under uncertainties. Section 5.1 provides the investigation study on the relevant tools and techniques for the identified problem areas. This investigation is based on the inferences drawn from the interviews. A literature study for these tools and techniques is also conducted. Section 5.2 presents the designed procedure for improving project planning. And finally, section 5.3 discusses the results of the testing of this designed procedure in ABC Company.

5.1. Investigation of the relevant tools and techniques

In the previous section, the causes of scope changes, delays, lack of governance and complexity in the ABC Company were analyzed. It was also inferred that the project escalations in the company were primarily a result of scope changes and delays. Hence, relevant tools and techniques need to be employed in order to deal with these causes and the prevailing uncertainties.

As mentioned earlier in section 2.3.1, the investigation of the relevant tools and techniques is based on the inferences drawn from the interviews as well as from the recommendations given by the experts (refer section 4.4). Hence, based on the insights gathered during data analysis, the following inferences are obtained:

- A few PLs stressed on the importance of embedding risks into the project plan as it can lead to better management. The project board should also be aware about the impact of the risks on the time, cost and resources. It was further added that, practice of risk management needs to be improved. Even though, the IRR (Issue Risk Register) and AIR (Issue Resolution Database) are in place, the risks from the IRR and the AIR are not transferred to the project plan. The PLs argued that transferring the impact of the risks and the issues in the project plan would lead to better foreseeability. There was also a need for a better tool than MS Project (as mentioned by one PL). Furthermore, a respondent stated that good risk management can accout for scope changes in the project. Thus, proactively looking for risks can help minimize these scope changes as the uncertainties due to the unforeseen situations can be diminished. Also, the PL can show the impact of uncertainties on the time, cost and scope to the upper management. This should facilitate better management support.

  Hence, considering the recommendations provided by the PLs and also based on the inferences drawn from the interviews, the practice of schedule risk analysis was investigated (refer section 5.1.1).

- It was observed in the interviews, that scope changes and delays occurred due the changing priorities and expectations of the stakeholders. Even though stakeholder management practices are

available within the ABC Company, the interviewees argued that, there was misalignment on the priorities of the stakeholders during the execution of the project. In addition to this, scope changes and delays were caused in the projects due to ineffective communication between the involved project parties. Hence, effective communication and proper stakeholder management by means of aligning on the interests and priorities of the project team members is important. Also, respondents mentioned about the need for clear priority setting in the project. Lack of governance was also caused due to poor communication between the involved project parties.

Thus, from the above inference it was seen that aligning on the priorities and objectives of the stakeholders is imperative to minimize/ mitigate the issues with project planning which are caused due to misalginment of stakeholders. Section 5.1.2 deals with alignment of the stakeholders.

- It was inferred from the data analysis that issues with project planning were caused due to unforeseen things or due to novelty of the processes. Some of the respondents stated that the feedback loop within the ABC Company was not good, i.e., the experience and the knowledge gained from one project are not transferred to another. One of the respondents also stated that knowledge sharing is not done effectively within ABC Company. PLs while making plans for some newer developments, i.e., something that they have not done before, should take the help and view of others who are experienced in that domain. This would save on scope changes and time delays later in the project. Another recommendation from a PL was that people should learn from previous plans and projects.

  Even though, the ABC Company has the lessons learned practice in place, it is not been used effectively across the departments of the organization. Thus, section 5.1.3 deals with the practice of lessons learned and provides ways of documenting the knowledge acquired from previous projects.

5.1.1. Schedule risk analysis

In order to deal with the uncertainties and their impacts on the project schedule, the uncertainties should be embedded in the project plan. Williams (2005) provides extensive literature on overruns in projects and also on the failure of project management. He studied large and complex projects (which have high uncertainties) and questioned the use of deterministic CPM scheduling method for managing these complex projects. Delays (schedule slippages) and changes to the critical path (due to scope changes) of the project plan can be addressed by project risk analysis (Hulett, 2009). This is where; schedule risk analysis is introduced. Vanhoucke (2015) defines schedule risk analysis as,"A project management methodology to assess the risk of the baseline schedule and to forecast the impact of time and budget deviations on the project objectives. It can be easily performed on a computer using standard Monte-Carlo simulation runs based on user input on the uncertainty in activity durations and/or costs" (Vanhoucke, 2015, p.109). This practice of schedule risk analysis is an extension to the deterministic project scheduling techniques.

The prevalent uncertainties in the projects can be incorporated in the baseline schedule. As these uncertainties are unknown, schedule risk analysis explores how these can be applied to the project schedule (Hulett, 2016). Hulett (2016) categorizes these unknowns into four categories:

- Known knowns are events or conditions that are known to exist and to have an impact known with certainty. Known knowns are items that should be included in the plan, schedule, and budget (Hulett, 2016).
- Known unknowns for which the cause is known, but it is not known whether the risk will occur; and/or, if it occurs, its impact on activity durations (Hulett, 2016).
- Unknown unknowns are those risks that are not known today but it may reliably be expected that they will occur in the future. It is not clear that these risks are unknowable, because they have been experienced in many projects over time. Whether they could be known or not with further inquiry is an area of interest (Hulett, 2016).

- Unknown knowns are those risks that are known that they exist and often their parameters (probability and impact) are known. The management does not want to discuss them in a public forum such as a risk workshop since they are sensitive or pessimistic, causing harm and even cancellation of the project (Hulett, 2016).

The known unknowns include the uncertainty about the inherent variability in project activities (Hulett, 2016). These arise because the people who are assigned to a particular project do not necessarily work according to the project plan (Hulett, 2016). Also, uncertainties surrounding the estimation errors and estimation biases are known unknowns (Hulett, 2016). It is quite likely that the management demands unrealistic estimates of the schedule and the planners can be pressurized by them. This leads to the plan being optimistic. Also, errors during estimating are also eminent sources of uncertainties. Furthermore, the risk events are also included in the category of known unknowns as these are the events that can be described and for which the specific cause is known. These, in turn, may or may not occur, or may be certain to occur, but in either case their impacts are not known with certainty (Hulett, 2016). These risks should be identified and documented during the risk identification workshops.

In order to see the impact of these known unknowns on the project schedule, these types of uncertainties are embedded in the project baseline schedule to see their impact on the baseline. Thus, in the schedule risk analysis, the activity durations are represented as probabilistic distributions. Some commonly used distributions are the triangular distributions, beta distribution, normal distribution and uniform distribution etc. (Hulett, 2009). These three point estimates are generally used to represent the probabilistic distribution of project activities (Hulett, 2009):

- The longest or pessimistic duration: While calculating this duration, all the factors which can go wrong are considered. If possible, these influencing factors are considered to go wrong simultaneously to calculate the longest duration. It is highly unlikely (nearly 1 percent chance) that the actual project duration can be longer than this duration.

- The shortest or optimistic duration: While calculating this duration, all the factors which can go right are considered. If possible, these influencing factors are considered to go right simultaneously to calculate the shortest duration. It is highly unlikely (nearly 1 percent chance) that the actual project duration can be shorter than this duration.

- The most likely duration: While calculating this duration, the most realistic scenarios of all the activities are considered. The obtained duration falls between the time periods of the shortest and the longest durations and it is estimated that this duration is more likely to occur than any duration. It should be noted that it is not necessary that the estimated duration of the activities in the schedule is the most likely duration.

Furthermore, unknown unknowns are those uncertainties which are not known. The significance of these types of uncertainties is unknown (Hulett, 2016). Hullet (2016), in his paper concludes from historical evidences that the knowledge of the magnitude and size of the uncertainties and of the risks is limited and that more risks and uncertainties will be revealed as the project proceeds through its lifecycle (Hulett, 2016). This results in a recommendation to repeat quantitative risk analysis periodically to identify the new risks, as well as retire existing risks. In other words, past experience of project managers tells that unknown unknowns exist that will potentially affect the project. They will become known in the future as events unfold, i.e., these risks and uncertainties are long-term uncertainties rather than the near-term uncertainties (which are mostly identified in the risk workshops). Therefore, the analysis on risks and uncertainties should reflect and highlight these long-term uncertainties as well (Hulett, 2016). While unknown unknowns have no known specific cause, it can be anticipated that they will be revealed as the project execution unfolds. To account for the long-term unknown uncertainties, the ranges of the near-term uncertainties can be widened (Hulett, 2016). The unknown risks and uncertainties can be accounted for in the future activities before one knows what they are (Hulett, 2016). The degree of widening the ranges (three-point estimate) in the far future for the project is obviously a judgment based on inputs from many and experience with benchmarking (Hulett, 2016). These judgements can be derived based on the experiences of other project managers and from the lessons learned from the previous projects. An example of the widening of these far uncertainties (for unknown unknowns) is

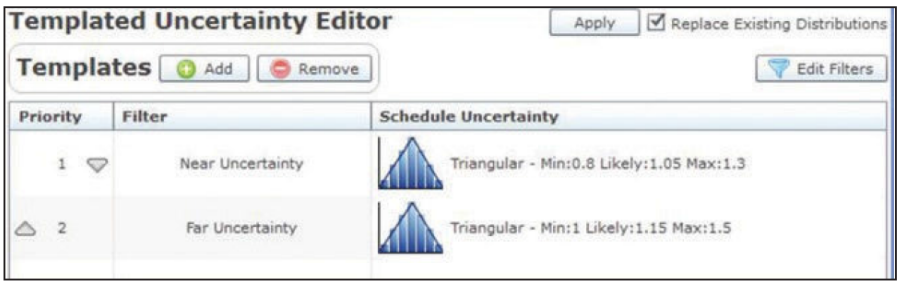

Figure 5.1: Example of widening of the activity durations for far uncertainties (Hulett, 2016)

shown in the figure below:

These three point estimates for both known unknowns and unknown unknowns are generally obtained by means of interviewing project participants and experienced project personnel. A project manager needs to restrict his attention on the analysis of the most important risks and uncertainties which can have a detrimental impact on the project schedule and thereby affecting the cost and budget overruns of the project (Vanhoucke, 2009). Focussing on these risks and uncertainties facilitates in managing the projects better and proper and accurate mitigation strategies can be employed which helps in increasing the overall project performance (Vanhoucke, 2009).

The schedule risk analysis is summarized by the four step procedure as shown below in figure 5.2:

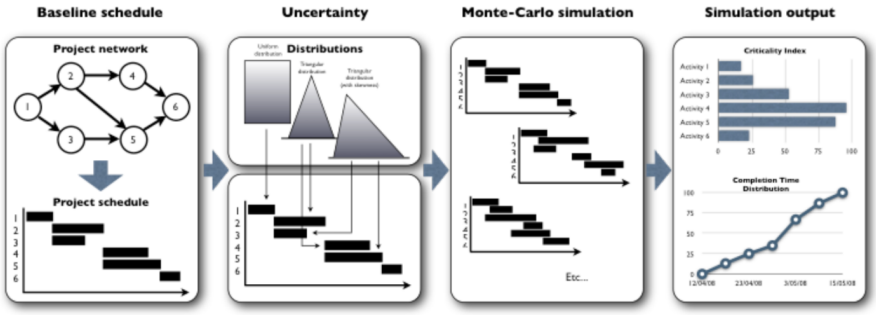

Figure 5.2: The 4 step procedure of SRA (Vanhoucke, 2012)

The steps in the schedule risk analysis are (Vanhoucke, 2015):

- Create the baseline schedule: The project baseline schedule is developed based on sequesntially arranging the activities and calculating the time duration taken for each activity. Information about the beginning and termination of each activitiy as well as the associated resources for them are shown by this baseline schedule. It is also central to the simulations which are carried out for the generation of the output (step 3).
- Assign the distribution functions to the uncertainties: The project baseline schedule is deterministic in nature and is influenced by the presence of uncertainties during the project execution. This leads to problems in the cost and time estimates of the project. Thus, the uncertainties should be defined and distribution functions should be assigned to these unknown time and cost parameters in the Monte-Carlo simulation.
- Perform the Monte-Carlo simulation: The distribution functions of these uncertainties are applied to the activities of the baseline schedule (steps 1 and 2). When the Monte-Carlo simulations are carried out, stochastic and variable values are generated for the uncertainties (defined in step 2). These Monte-Carlo simulations show the real uncertainties and risks which are prevalent in the estimates. Every other simulation run generates different outputs for the cost and time estimates and the critical path of the baseline schedule is also subject to change. All this data

is generated and stored in its memory so as to generate the sensitivity outputs on completion of these simulation runs.

- Analyze the sensitivity output: On completion of the simulation runs (step 3), the data is captured from these simulations and sensitivity analysis on the cost and time behavior of individual activities can be performed. The sensitivity metrics are used to perform this sensitivity analysis and to generate the output of the sensitivity of these activities on the outcome of the project.

The sensitivity metrics can be used for time-risk analysis. The time-risk analysis is used to investigate the expected impact on overall project duration due to changes in the activity durations (Vanhoucke, 2015). Each sensitivity metric facilitates in providing an analysis of the sensitivity of a particular activity towards the final project duration (Vanhoucke, 2015). This can help in taking corrective actions in the project so as to get the project back on track. Cumulative project duration graphs are also generated as an output of the SRA study (Vanhoucke, 2015). These graphs show the probability of a project to reach a certain specific end-date (Vanhoucke, 2015).

This also facilitates better management support. If the knowledge about the relative sensitivities of the project activities on the project goals and objectives is captured, then there can be better focus by the management (Vanhoucke, 2011). This also enables in contributing to the overall performance of the project as better and more accurate response strategies during the tracking of the projects can be applied (Vanhoucke, 2011).

5.1.2. Alignment of Stakeholders

Another cause of scope changes and delays in the project plan stems from misalignment of the stakeholders involved in the project. Hence, stakeholder management is important in-order to align on the objectives and priorities. The first step to stakeholder management is to analyze these stakeholders. The PMBOK (2008) states that,"Stakeholder analysis is a technique of systematically gathering and analyzing quantitative and qualitative information to determine whose interests should be taken into account throughout the project. It identifies the interests, expectations, and influence of the stakeholders and relates them to the purpose of the project" (PMI, 2008, p.248). Further to the analysis of the relevant stakeholders, stakeholder management strategy should be employed. An approach of minimizing the negative influence and impact of the key stakeholders and increasing their support for the project should be undertaken in the stakeholder management strategy (PMI, 2008). As stakeholders are important for the execution of a project; alignment of these stakeholders is necessary for managing scope changes and delays (Chan & Kumaraswamy, 1997). In a study conducted across 45 negotiating teams, which included teams from the manufacturing sector as well, four techniques for managing the interests between the project teams were identified (Brett, Friedman & Behfar, 2009):

- Plot out the conflicts: To create unity towards the end-goal and objective it is imperative to confront and deal with the diverging interests to clarify upon the team goals, dissolve interpersonal conflicts. Matrices depicting personal interests and priorities are created by managers to address the relevant issues at stake. For each issue, the project managers plot the priorities and influence of each of the stakeholders as well as their own interests.

- Work with the different functional departments: In a large organization, there are various functional departments which represent their own interests. Sometimes employees put the interests of their specific department over the interests of the company as a whole. In order to collaborate and deal with these different interests, it is imperative to present the holistic view on the facts and figures to these constituents so that they can see the bigger picture and show willingness to cooperate and reconcile.

- Mediate conflicts of interest: An external process manager or a mediator should be appointed if, despite the best possible efforts, the team cannot reconcile its differences. The mediator can ask the questions of why not and why to the key stakeholders to negotiate between the teams thereby acting as a sort of a buffer.

- Persuade the stakeholders with data: Conflict of interests can also arise if the team members dont have access to the same data. In the research by Brett (2009), it was seen that if the members

representing the negotiating teams are presented with facts and figures, then they are more willing to commit and cooperate if they can see that their efforts and work can have a positive influence on their departments.

Further to this, effective stakeholder management can be accomplished by means of proper communication. Hence, planning these communications is central to stakeholder management. Some stakeholders may not receive the requisite information due to Improper communication and can lead to problems such as delay in the delivery of messages (PMI, 2008). Thus, communication should be done by the means of proper channels so that it does not lead to rework or additional work in the project.

5.1.3. Lessons learned

Lessons learned is defined 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" (Harrison, 2002, p.2). This definition implies that, the knowledge accumulated from the experience of working in projects should be documented and shared with other actors, so that; learnings from the past experiences can be inculcated in the future works. In the context of the high-tech industry, where projects involve innovative and state-of-the-art technologies, most of the knowledge about the project is generated while working on the project. Hence, to avoid losing out on vital knowledge, it is essential to capture, share, and utilize the combined knowledge of the current workforce (Caldas, Gibson Jr, Weerasooriya & Yohe, 2009). This acquired knowledge should be properly documented and shared for further use.

Documentation and sharing of knowledge is a difficult process. This is because, while working on projects, most of the acquired knowledge about the project is with the individual at the helm of the project, i.e., it is in the individual's head. Managing this type of tacit knowledge is imperative and vital for the company so as to learn from the previous (completed) projects and be sustainable and competitive in the long run. However, there are problems with the practice of knowledge sharing. Problems such as lack of time for sharing of knowledge and the difficulty to covert tacit knowledge into explicit knowledge obstruct in fully acquiring and documenting the knowledge from the project manager (Stenmark, 2000; Woo, Clayton, Johnson, Flores & Ellis, 2004). Since tacit knowledge is based on an individual's observations and perceptions, it is difficult to communicate and formally document it. On the contracy, the explicit knowledge (about a particular project) can be easily documented and stored through the means of manuals, reports etc. for the purpose of further communication (Payne & Sheehan, 2004).

In order to convert and document both the tacit and explicit knowledge, theory of knowledge conversion is used (Nonaka, 1994). According to this theory, an organization creates, converts and transfers knowledge through a spiral process which includes four steps (Nonaka, 1994):

- Socialization: On-the-job trainings or mentoring sessions should be conducted to share individual experiences and to transfer the tacit knowledge.
- Combination: Mechanisms of meetings, workshops, information processing and technology should be used to transfer the explicit knowledge.
- Externalization: Questioning and reconstruction of the various decisions and perspectives should be used for the purpose of the conversion and transfer of tacit knowledge to explicit knowledge.
- Internalization: There should be learning and awareness of knowledge (also about the surroundings) to convert and transfer the explicit knowledge to tacit knowledge (Javernick-Will & Levitt, 2009).

Thus, lessons learned involve collecting and documenting the lessons (knowledge) learnt through experiences and sharing it further in the organization. Also, the lessons from the past projects can be re-used for future projects so as to establish the best practices for the project.

5.2. Design of the procedure for project planning under uncertainties

Based on the literature study and the findings from the interviews within the ABC Company, a procedure was designed to minimize/ mitigate the uncertainties which occur during project planning. The design procedure is shown in figure 5.3 below:

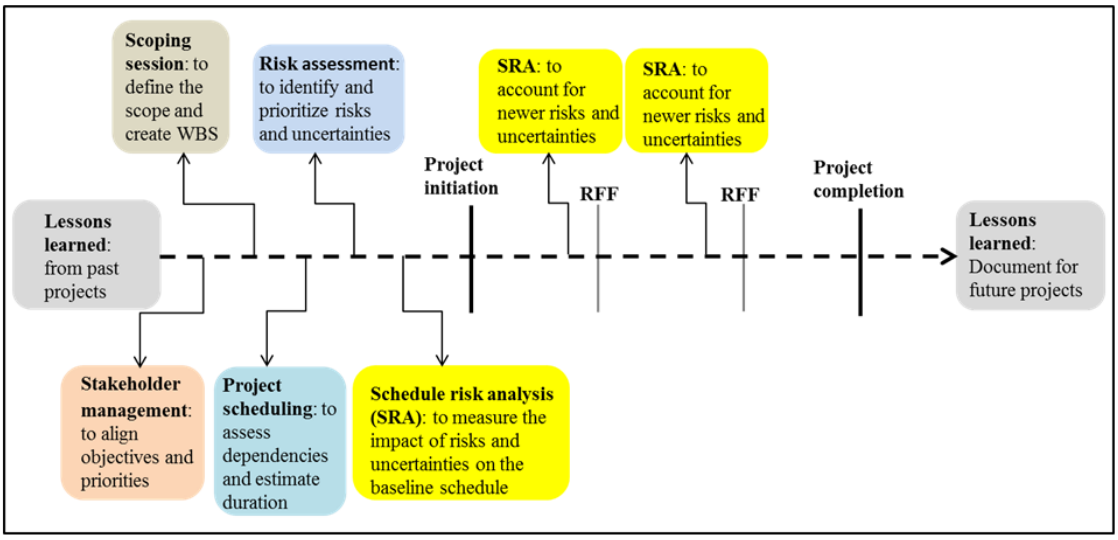

Figure 5.3: Procedure for project planning under uncertainties

The proposed procedure for project planning under uncertainties is developed by acknowledging root causes that lead to occurrence of scope changes, delays, lack of governance, complexity and project escalations in the ABC Company. The designed procedure can reduce uncertainties in project planning, but for it to work efficiently, it largely depends on the project managers skills (for example: technical skills, soft skills etc.)

The tools, techniques and approaches used in the procedure are explained below:

Lessons learned from past projects

Lessons learned should be used before the initiation of the project proposal. This should be used in the beginning so as to gather an understanding and perspective about the project (to be undertaken) from the previous completed projects. Using the lessons learned before the project initiation would help the project manager to acknowledge the uncertainties and risks which might be prevalent in the project. As the lessons learned are documented based on experience, it would provide better insight into the unforeseen things, i.e., known unknowns and unknown unknowns. It also enables the project manager to foresee things which he could not have considered in the beginning, such as both the technical and the non-technical challenges. Furthermore, the referring to the lessons learned before project initiation would help the project manager to establish the best practices for his upcoming project. The project manager can also learn from the past mistakes of other project managers, so as to establish the way forward. The past mistakes pertaining to project failures (due to project planning) act as key learnings for the project manager. Project leader can socialize and interact with other collegues who might have worked on such projects previously. Such a interaction during social meetings like the PM Day (conducted within ABC Company) can help the project leader to develop a better understanding of the project that he/she is undertaking. Another advantage of such informal discussions is that the other PLs, who are experienced in such projects, can contexualize their experience based on the requirements of the requestor (here the PL) (Javernick-Will & Levitt, 2009). This would further help the PL in managing the project planning problems that he may encounter later. Also, the knowledge acquired from the lessons learned document (about the project) can facilitate the project leader to deliberate

about the project objective and priorities with the stakeholders.

Lessons learned would help the project manager to have a clearer vision about his project and the uncertainties which can be associated with them. In addition to this, to acquire tacit knowledge as well (which might not be documented), the project manager should try and communicate with other experienced project managers who might have undertaken such projects in the past.

Stakeholder management

Having the knowledge about lessons learned in perspective, the project manager would have a clearer vision about the project while deliberating with the stakeholders. Stakeholder management is important and should be done to concretize the priorities and objectives of the project. By aligning on the priorities and objectives of the stakeholders, the scope changes and delays in the projects can be minimized. If documented properly, the lessons learned would give an insight into the problems caused in project planning due to misalignment of the stakeholders on the objective and priorities. Hence, while dealing with the stakeholders, the project manager can discuss about the importance of having a unified and clear objective with the involved parties. Clarity on the priorities and the objectives would help in minimizing the uncertainties which arise from these sources. This would lead to clarity on the project specifications and requirements before the project initiation and would reduce the changes and delays in the project plan which can happen due to involvement of the stakeholders (during project execution). Identification of the key players for the project and mapping their interests is particularly important for the project manager before the project commencement. The method discussed in section 5.2.2 can be used for negotiating between the project stakeholders.

In addition to this, proper communication and flow of information is important during the stakeholder workshops or meetings. Proper documentation and effective sharing of information is important during the course of the project. As improper communication may lead to scope changes and delays (later in the project), establishing a communication plan is effective for dealing with uncertainties which may arise due to lack of communication.

Scoping session

After the engagement and alignment with the stakeholders, the project manager should define the scope. Scope definition is important for the purpose of defining specifications and requirements for the product to be delivered and the tasks which are required for that. Stakeholder management and lessons learned from previous projects will facilitate a clearer and thorough definition of the work to be undertaken. By defining the scope of work, the product breakdown structure and the associated work breakdown structure can be obtained. Having a scoping session, i.e., a scope definition session with all the involved project team members would facilitate constructive discussion and clear definition and prioritization of the deliverables of the project. Once, the scope is defined, it should be communicated to the associated stakeholders. Based on the holistic views of the interested parties, the scope should be finalized. The method prescribed by the PMBOK for scope definition and scope management can be used (figure 5.4).

Knowledge Areas	**Project Management Process Groups**				
	Initiating Process Group	Planning Process Group	Executing Process Group	Monitoring & Controlling Process Group	Closing Process Group
Project Scope Management		**1. Collect requirements** **2. Define Scope** **3. Create WBS**		**4. Verify Scope** **5. Control Scope**	

Figure 5.4: Scope definition and scope management (PMI, 2008)

It should be noted that, the scope should also be controlled during the execution of the project.

Project scheduling

Once the scope is clearly defined, with the associated product breakdown structure and the work breakdown structure (WBS), the project scheduling should be done. Scheduling is done to sequentially order the project activities and to allocate time durations to those. Project scheduling should be done preferably through project scheduling software based on CPM scheduling, such as MS-Project or Primavera. The use of CPM scheduling would enable the project manager to identify the critical path and also the project completion time (deterministic). Since, lack of planning or shortcuts in planning, later lead to delays in the projects and scope changes, proper attention should be given to every detail of the activities in the project. Also, the CPM scheduling helps to identify the dependencies between different activities in a project, thus complexity of the project can be mapped and identified due to this scheduling technique and the delays and scope changes arising due to improper identification of the interdependencies between the activities can be mitigated . These project scheduling software packages also work under resource constrained environments, hence, problems of resource unavailability (unavailability of personnel or system etc.) can be controlled by using these. Also, having only one standard tool for reporting and monitoring of the project plan enables the project manager to have clear communication with the project team members and the upper management.

Risk assessment

Risk identification and management is important as lack of foreseeability leads to scope changes and delays in the project, which hamper the project plan. If not properly identified and mitigated, these risks and uncertainties can occur during the project execution. This impacts the project plan. Thus, identification and prioritization of risks and uncertainties helps in developing mitigating strategies for the project.

Even though the project leaders account for buffer-times and contingencies in their plans, it was seen that due to unforeseen events and challenges which occur during the execution of projects, the actual duration of the activity expands more than the considered buffer. Also, the contingenices and buffers which are taken by the PLs are based on heuristics and experience. For projects which are not time-driven, project leaders tend to take buffer times twice as much as the estimated duration, thereby accounting for the risks and uncertainties. However, for projects with an agreed-upon fixed end-date, these buffer times prove to be insufficient. Hence, rather than accounting for buffer times and contingencies based on heuristics, appropriate risk assessment study should be conducted to account for risks.

The project manager should pro-actively look for risks and uncertainties in the project. Having risk identification workshops with project team members can facilitate this. Moreover, knowledge about the risks and uncertainties from previous projects (documented in the lessons learned) should be used. By means of the lessons learned, the unknown unknowns (for the project manager) can be made known. This enables to increase the foreseeability of the project manager with regards to the risks and uncertainties in the project. During the risk identification session, the project manager should not only identify the technical risks, but should also focus on the non-technical risks and uncertainties which can impact the project. The widely used TECOP (Technical, Environmental, Commercial, Operational, Political) (Hillson, 2014) risk categories can be used as a starting point. In addition to this, the technological complexity of the projects is also a source of risks (Vidal & Marle, 2008). The risks which can arise due to the technological complexity of the project, such as risks due to novelty of the technology etc., should be identified during the risk assessment before the initiation of the project (Bosch-Rekveldt et al., 2011).These identified risks should be properly documented for further assessment and for the purpose of risk management. The figure 5.5 below shows the process of project risk management similar to one used in PRINCE2 (Arkesteijn, 2014). The risk identification and management process is iterative, hence, the project manager should be proactively looking for risks which can occur during the project and plan for response strategy.

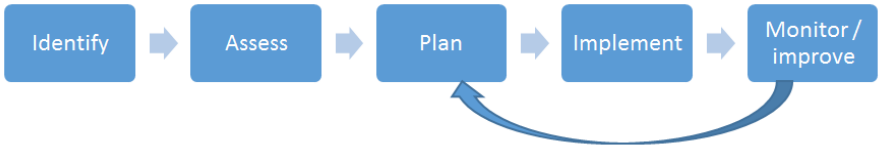

Figure 5.5: Project risk management process (Arkesteijn, 2014)

Schedule Risk Analysis

After the development of the baseline schedule and identification of the risks, the schedule risk analysis should be done. The risks and uncertainties should be embedded and applied to the project baseline schedule. The risks and uncertainties which are identified during the risk assessment workshop, should be embedded in the individual activity durations (which are been impacted by them). This enables the project manager to understand and realize the impact of these risks and uncertainties on the total project. The delays and scope changes (which might happen if the risks and uncertainties occur) can be foreseeable. This also includes the risks and uncertainties which might occur due to optimistic planning and estimation biases. Furthermore, based on the sensitivity analysis, the impact of these risks and uncertainties on the project dependencies would also be known. This helps in identifying the activities which might impact the critical path of the project (in-turn affecting the completion date). If delays are foreseeable, then corrective actions can be taken and employed by the project manager and the project planning can be adjusted and /or altered based on that.

In addition to this, the schedule risk analysis output produces a graph showing the probability of a project to complete at a certain deadline. If the project manager sees that the probability of the project completed on the previously agreed upon completion date is low, then the project manager can raise this matter in front of the upper management and the associated stakeholders (like customers etc.). As a result of this, the upper management and stakeholders would be aware about the project outcome before the initiation of the project. This enables in decision-making about the project end-date and the associated project parameters. The upper management can be in a better position to manage the project by keeping the requisite resources as a buffer. For example, if management wants to deliver on the agreed-upon end-date to the customer, then it can deliberate about the additional budget, resources and/or de-scoping the project beforehand (with the stakeholders and customers). Thus, the triple-constraint would be managed in a better way. This pro-active approach used for mitigating the risks and uncertainties enables in minimizing the scope changes and delays in the project.

However, even if all the risks and uncertainties are not captured and managed, the project manager and the upper management might be aware and prepared for the risks and uncertainties which can occur later and can lead to project escalations. In the event of such an unforeseen situation, the upper management can keep a contingency for additional budget and resources ready for the particular project, so that, long-waiting times and delays which occur due to getting the approvals from the upper management would be curtailed. This helps in better management of the escalations (if any).

This process of schedule risk analysis should be conducted on timely basis. This is because as the project execution start, more and more risks and uncertainties begin to be visible to the project manager. Hence, if there are any unknown unknowns in the project, they could be made known to the project manager. By updating the schedule risk analysis, the project manager can foresee the impact of these risks on the overall project time. This second-leg of analysis should be done preferably before the request for funds meetings (every half a year). In the request for funds meetings, the project manager can update the upper management about the status of the project and also tell the risks and uncertainties which might occur later. By this, the upper management is updated (which helps them keep their own contingency); and the uncertainties surrounding the approvals of budget estimates can be minimized.

Document the lessons learned after the project is completed

The lessons learned should be documented after project completion. This is important as, it would help the project manager to learn from the mistakes that were conducted during the project. By means of documenting the lessons learned, other project managers and people within the organization an also have access to those. This would help them to learn from the mistakes which occurred in this project. Moreover, the documentation of the lessons learned can also be used to understand and use the best practices which are applicable to future projects.

5.3. Testing of the proposed solution

The developed model was tested within the ABC Company, to validate the model and also to gain insights into implementation of this procedure in the working culture of the ABC Company. A total of three interviews were conducted and five respondents were invited for the testing workshop. Three of these respondents were from senior management of the structural improvement department of the company. These three were interviewed together. Firstly, the testing members were asked to individually provide their views on the proposed solution. This was done so as to ensure that these testing committee members are not influenced by each other. Following this, a discussion was done on the validity and applicability of this solution within the company. The other two respondents were a PL and a team leader (TL) from technical department-2. The solution was presented to the workshop participants. A set of open questions was developed and the responses of the interviewees (who partcipated in the testing meetings) to these questions are provided in Appendix E.

From the feedback received from the participants, it is concluded that the proposed solution for managing uncertainties while project planning can be used within the organization. This way of working is confirmed by the employees from the technical department. Moreover, this proposed solution can also work for the projects conducted in the structural improvement department if the risks are proactively identified and good risk management is done. The lessons learned from previous projects can also help in identification of these non-technical risks in the projects. Also, if good risk management practices are established in the projects, then the risks can be identified and appropriate mitigating strategies can be employed.

Furthermore, the author modified the proposed solution based on the inputs provided by the respondents. The practice of stakeholder management is included after each SRA (in the model). Also, before the project initation, the results of the SRA are to be communicated to the stakeholders by means of a feedback loop. Moreover, during the project execution, each SRA is followed by a stakeholder management session. Stakeholder management is also included before the project completion. This is because, the stakes and priorities of the stakeholders are very high near the project completion and they should be managed before the completion of the project.

In the testing workshops, the author received differing opinions when the respondents were questioned on the limited use of tools and techniques for project planning. While, the managers from the structural improvement department stated that this is a golden question within the ABC Company and needs to be dived into deeper; the TL stated that some departments are already working towards this proposed solution. In addition to the the PL expressed that these tools and techniques have a limited use due to the complexity of the organization and also due to the stakeholders involved in the project. People have to adapt to the project and have to remain flexible. This limited use also depends on the background and the problems that a PL has experienced with his previous projects. Hence, they adapt and remain flexible in their way of working.

When inquired if there are any problems with project planning that the proposed solution cannot solve, the respondents stated that the problems outside the circle of influence of the project cannot be solved by the proposed solution. However, establishing proper risk management practices and aligning with the stakeholders during the different phases of the project can lead to minimizing the influence of external factors on the project. A manager from the structural improvement department mentioned that this procedure would not work at the portfolio level as there are a lot of dependencies between projects

at the portfolio level which cannot be foreseen. Management of the portfolios is different to the management of projects and should be further investigated.

Finally, the respondents from the technical department stated that the proposed solution can be implemented in the way of working of the ABC Company. They were of the opinion that this is a right step in a very long process and termed it as the beginning of a baseline for managing risks and uncertainties. The PL also mentioned that, further work needs to be done to implement this proposed design procedure into the organization, while the TL mentioned that some people in the design and engineering department of the company are already working towards this proposed way of working. However, the upper management employees from the structural improvement department stated that, risk management has to be established first before commencing with the practice of schedule risk analysis. Risk management workshops should be conducted. Once the risks are identified for the project, then separate sessions should be conducted to incorporate these risks into the schedule. Based on the above views, the author has provided recommendations for implementing the techniques and methods in the design procedure to the company (refer section 6.3.1).

5.3.1. Validated procedure for project planning under uncertainties

Based on the inputs provided by the experts (in the testing meetings), the procedure is updated as follows:

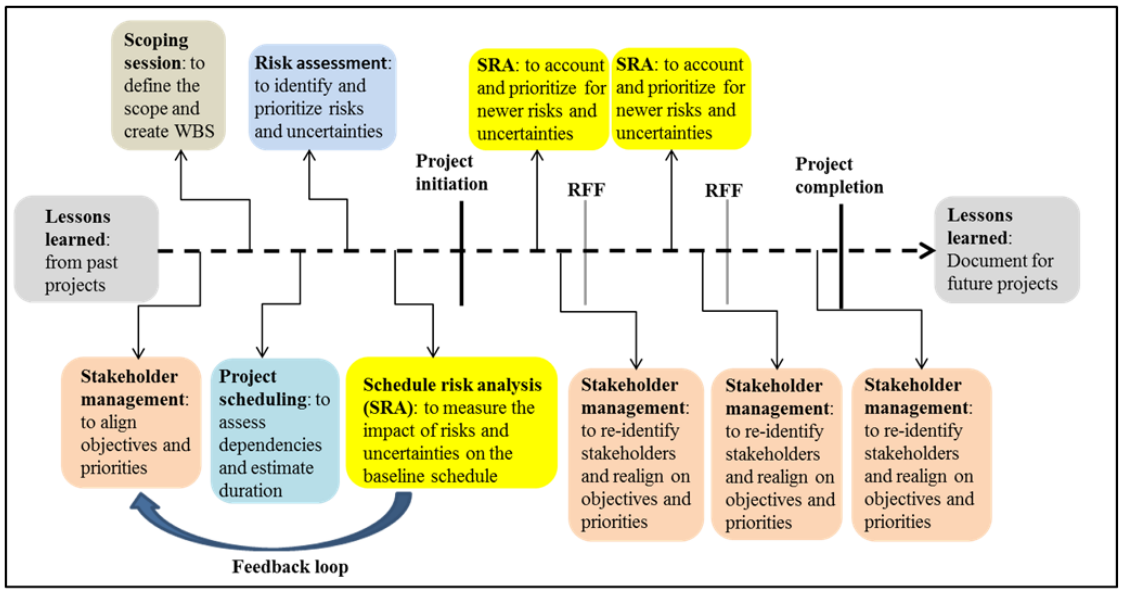

Figure 5.6: Validated procedure for project planning under uncertainties

Figure 5.6 above, shows the validated procedure for project planning under uncertainties. A feedback loop is introduced before the project initation between the SRA and the stakeholders. The results of the risk assessment and the schedule risk analysis should be communicated back to the stakeholders. This enables to make requisite changes to the objectives of the work before the commencement of the project (if required). The stakeholders should be updated about the risks and uncertainties which may occur in the project before its initation.

Before each request for funds (RFF) procedure, stakeholder management should be done. It was inferred from the respondents who tested the solution that stakeholders change during the course of the project within the company. Hence, re-identification of the stakeholders and re-aligning with them on the objectives and priorities (based on the output of the SRA) should be done. This enables proper and effective communication between the project parties and updates the key parties involved in the project about the newer risks and uncertainties. The SRA done before each RFF should also account and prioritize for the newer risks and uncertainties that occur during the execution of the project.

And finally, stakeholder management should also be done before project completion. Re-identification of the stakeholders and realigning on their priorities is imperative at this stage of the project (when it is nearing completion). The experienced senior managers mentioned that priorities of the stakeholders near the completion of the project have significant influence on the project outcome. Hence, stakeholder managememt is done here.

It should be noted that this framework of the validated procedure should be adopted depending on the type of project. Definitive timings for conducting these methods and techniques mentioned in the procedure should be assigned depending on the size and type of the project.

5.4. Chapter Summary

In this chapter, a solution was developed for the problems encountered while project planning under uncertainties. Firstly, an investigation study was carried out on the relevant tools and techniques required for mitigating and minimizing the problems of delays and scope changes. The recommendations provided by the PLs and the inferences obtained from the interviews was used as a starting point. In this investigation study, the techniques of schedule risk analysis, stakeholder management and lessons learned were identified as the relevant methods to encounter the problems with project planning.

Following this, a procedure for project planning under uncertainites was proposed (refer figure 5.3). The techniques of lessons learned, stakeholder management, scoping session, project scheduling, risk assessment and schedule risk analysis were applied in the aforementioned order in order to design the solution. Further to this, the solution was tested within the ABC Company. This was done so as to validate the proposed solution within the company. Testing workshops were conducted of employees belonging to different functional departments and hierarchical levels in the organization. Three upper management employees, i.e., two managers and a program manager from the structural improvement department were chosen to test the solution. Moreover, this solution was also tested by a PL and a team leader (TL) from the technical department-2 in the organization.

Based on the feedback received from the testing workshops, it was seen that the proposed procedure for project planning under uncertainties can help manage and minimize the uncertainties while project planning. Also, some changes were done within the framework of the proposed solution following the feedback received from the testing workshop. This validated procedure for project planning under uncertainties is shown in figure 5.6 (refer above). Stakeholder management was introduced before each RFF process and before the project completion so as to reidentify and re-align with the stakeholders. Hence, the validated procedure for project planning under uncertainties helps in minimizing and/ or mitigating the problems with project planning under uncertainties.

6

Discussions, Conclusions and Recommendations

This chapter provides the concluding remarks of the research. First, in section 6.1 the research is discussed. Here the research findings are scrutinized followed by the limitations of the research. After this, section 6.2 provides the conclusions of the research. The sub-research questions are answered sequentially, thereby providing an answer to the main research question. Finally, section 6.3 provides the recommendations to the ABC Company and section 6.4 gives the recommendations for further research.

6.1. Discussions

In this section the findings of the research are discussed along with the limitations of the research. The discussion reflects the influence of the limitations of the study on the obtained results and conclusions. First, the research findings are discussed, followed by the limitations of the study.

6.1.1. Research findings

This research was conducted to answer the following research question:

"How can project planning have an added value for project management in a high-tech company?"

In order to answer this research question, a literature review was conducted. First, the benefits and pitfalls of project planning and scheduling were discussed. Secondly, the concept of project uncertainties and the impact of project uncertainties on project management was studied in-detail. This was done as the research focused on improving the project management practices within the ABC Company by planning under uncertainties.

In the second phase, interviews were conducted within the ABC Company. The purpose of conducting the interviews was to get an insight of the current practice of project planning within the ABC Company. A total of 10 project leaders were interviewed from different departments within the company. This helped the author to develop a better understanding of problems with project planning as sometimes the literature may provide idealistic situations, thus demarcating theory from academic understanding. Based on the conducted interviews, the data was analyzed to get an insight of the problems faced by the project leaders within the ABC Company for planning under uncertainties. The majorly identified problems were those of scope changes, delays, lack of governance, complexity and project escalations. The author also noticed that there was a lack of standardization in the different departments in the way they performed project planning. While some PLs preferred to develop a detailed project plan, other refrained from the same and developed a high-level project plan with only the key milestones. The perception of project planning was different for different individuals. Also, the practice of risk management was not followed properly throughout the organization. Some PLs performed risk-based analysis of their project plan while a few others did not clearly identify the risks and uncertainties and

used ad-hoc buffers based on heuristics and experience to deal with risks and uncertainties. Another difference which was noticed was that, the PLs used different methods and tools for doing project planning. While some PLs used the MS-Project software for doing scheduling, which is prescribed in the way of working of the ABC Company, others used MS-Excel or PowerPoint presentations to make and monitor their plan. One interviewed project leader did not work according to the traditional project management practice but used the SCRUM-Agile technique for project planning. In addition to this, the technological complexity involved in the development of products also influenced the project planning. The author noticed that, even though, the project leaders were aware about the novelty of the technology which they were using, there were not many efforts taken by the PLs to identify and map this technological complexity (as inferred from the interviews). The PLs argued that, while working on newer technology and products, they did not have the requisite experience about it. However, the author is of the opinion that, if the complexity involved in the development of the new technology and tools could have been identified and mapped by these PLs (by communicating with the experts and conducting meetings with the team members to map the complexity etc.), a significant amount of complexity could have been identified and mapped in the beginning. This would have helped in their planning as the durations which they assigned to these developmental activities would have been more researched and thought-off and the buffers and contingencies could have been built-into the respective tasks in a better way.

Further to the problem identification, a root cause analysis of the problems was also conducted based on a combined analysis from the interviews and the literature. However, there was a striking difference between the problem areas found in practice and those found in the literature. There was no substantial mention of problems relating to cost overruns in the interviews, despite the fact that, there are multiple reasons for cost overruns observed in the literature. Also, the literature provides a clear distinction between scope changes and scope creep, the interviewees did not address the problem of scope creep. Even though, it was seen in the interviews that some causes lead to scope creep, the interviewees were ignorant about it. From the interviews, the author also gauged that there was a deliberate ignorance of uncertainties by the project leaders while doing project planning. They seemed to accept escalations in their projects. In addition to this, the causes which lead to delays in the projects (found in the interviews) were mostly related to the problems due to scope changes.

In the third phase of the research, a procedure was designed for performing project planning under uncertainties. The techniques and methods used for designing this procedure were chosen to be used based on the recommendations from the interviewed project leaders and an investigatory literature study. Further to this, testing meetings were conducted to test the solution in the ABC Company. While conducting these testing workshops, the author recognized that there was a difference in the objective and purpose of project planning within the company. From the testing meeting as well, it was seen that different people have different purposes for doing project planning and there was a lack of standardization on the purpose of the same. Further to this, the views obtained from the testing workshops differed between the departments. While the employees from the technical department-2 stated that the proposed solution can be implemented in their way of working, the employees from the structural improvement department stressed on the need to establish risk management first, before proceeding to the practice of schedule risk analysis. This difference may be due to the different ways of working in the different departments in the organization. Risk assessment and management is done in a far more-structured way in the technical departments as compared to the structural improvement department (non-technical). Even though, risk management is done by people in the structural improvement department, it needs further improvements and adjustments.

Hence, based on the formulated research question, it can be concluded that the conducted research provided a solution in the form of a procedure for minimizing/ mitigating the problems with planning under uncertainties. This research has extended existing knowledge in the domain of project planning at a high-tech company by suggesting changes to the existing methods and techniques in the company and also by proposing the introduction of the schedule risk analysis (SRA) technique in the way of working of the organization. However, it should be noted that using this procedure all by itself, would not make project uncertainties non-existent in projects as it requires proper implementation in the way of working of the projects and depends heavily on the expertise of the personnel (working with this

solution). This procedure provides a direction for managing the uncertainties which influence project planning. Furthermore, the procedure might show some problems if not implemented correctly. A good implementation strategy is required to properly implement this procedure in the organization.

6.1.2. Limitations

This section discusses the limitations of the research findings. It is important to address and acknowledge these limitations before using the findings from the research. These limitations are the following:

- The research was conducted based on interviewing the project leaders within the company. It does not take the view point of the clients (internal/ external) or project planners at different hierarchical positions for finding the problems with project planning under uncertainties. Incorporating these different perspectives would yield in developing a deeper knowledge on the problem of project planning under uncertainties. These different views were not taken owing to the time-schedule of this research.
- A set of ten project leaders from different functional department was interviewed to search for problems with project planning due to uncertainties. Even though, the author obtained a reasonable insight into the problem; it is uncertain whether interviewing more people would have led to different observations. By selecting interviewees from different departments, the author assumed that a wider perspective on project planning would be obtained. Moreover, the work experience, background and ethnicity of the interviewees were not considered by the author while analyzing the interviews.
- The research was conducted within one company. Hence, it does not directly imply that the problems faced in planning at this company would be the same across all the companies belonging to the high-tech industry. This is because; different organizations have different strategic goals. Also, there might be different standards and guidelines for project management practices in these companies.
- The focus of this study was only on the top five issues with project planning. This was done as the sample space was relatively small (10 interviews). If more interviews would have been conducted, then it might have resulted in recurrence of more issues.
- The techniques and approaches used for developing the procedure are not exclusive for addressing the problems of project planning under uncertainties. There can be different techniques and approaches which can yield better results. However, these techniques and approaches were used based on the inferences from the interviews supported by a literature study.
- The procedure was tested within the ABC Company by three employees belonging to the structural improvement department and two employees belonging to the technical department-2. The conclusions drawn from this testing meeting may vary if this solution is tested by a larger number of employees which belong to different departments within the company.

6.2. Conclusions

This section provides a conclusion to the conducted research. Here, the conclusions of the four research sub-questions are discussed. Based on the conclusions of the sub-questions, the main research question is answered. The sub-questions are answered and concluded in a sequential order to reach the solution for the main research question:

1. What are the added value and pitfalls of project planning?

   In order to answer this research sub-question, a literature review was conducted on project planning and scheduling. The benefits and pitfalls for project planning and scheduling were discussed. The purpose of this literature review was to facilitate the set-up of the interview questions for the semi-structured interviews which were conducted in the ABC Company.

   The benefits of project planning identified in the literature review can be summed up to the following:

- Continuous uninterrupted flow of work which helps projects to finish on time
- Exchange of information between parties which minimizes confusion and misunderstandings
- Accountability of work and clear direction to the end-goal
- Prevention of delays in work which leads to projects finishing in time
- Advanced methods and tools are available which facilitate sound project planning:
  - Network diagrams clearly highlight the interdependencies between activities
  - Critical Path Method (CPM) is used for generating baseline schedule and shows the cost-time trade-off for the project
  - Critical Chain method is effective for buffer management
  - These tools and techniques provide a higher degree of added-value for decision making

The pitfalls of project planning and scheduling identified in the literature review are:

- Project scheduling is difficult and the rules of project planning are not clear to everyone
- Management demands unrealistic estimates for project completion which may hamper the planning
- The project schedules are based on single-point (deterministic) estimate
- Sometimes, CPM scheduling fails to identify the project path which leads to the project completion date
- Project planning and scheduling are cumbersome activities
- It is difficult to transfer the academic scheduling results on the shop-floor (in the industry)

2. What are the different types of project uncertainties and their impact on project management?

   To develop an understanding of the different types of project uncertainties and their impact on project management, a literature review was conducted. This served dual purpose. Firstly, the study on the different types of project uncertainties was used to develop the interview questions within the ABC Company.

   These three different types of uncertainties identified in the literature are:

   - Variability in the project estimates: Uncertainty around the quantification of project performance parameters such as time, budget and quality.
   - Uncertainties about the objectives and priorities: Uncertainty surrounding alignment of the project team members on the project objectives and priorities.
   - Uncertainty about relation between project parties: Uncertainty between project parties where there are multiple parties involved without any formal agreements between them.

   Secondly, the literature review showcased the impact of project uncertainties on project planning. This study was imperative to understand the impact of these project uncertainties on the triple constraint of scope, time and cost used in the traditional project management. This study was further used to develop a procedure for project planning under uncertainties (in Phase-3). The impact of these project uncertainties on project planning identified in the literature is presented in table 3.1.

3. What is the current practice of project planning in the company?

   To get a deeper insight into the current practices of project planning within the ABC Company, semi-structured interviews were conducted. The project leaders (PLs) were chosen as subject matter experts for the purpose of the interviews. Based on the inputs obtained from a total of ten project leaders belonging to different functional departments within the company, the data was transcribed according to the issue-based analysis. In addition to this, cross-case examination of the ten different cases was also done. The categories used for this cross-case examination were: link to the literature (on project uncertainties) and headcount of issues (mentioned by the PLs

during the interviews).

It was observed that the PLs encountered issues with project planning. All the issues faced by the project leaders, pertaining to the practice of project planning were examined. The cross-case examination yileded findings (in the three different types of uncertainties). Based on these findings, a headcount of the issues (faced by the PLs while project planning) was done. The top five issues were used for further investigation. The study showcased that the issues with project planning were: scope changes, delays, lack of governance, complexity and project escalations. The project escalations were seen to stem from scope changes and delays in the projects.

In order to develop an insight into the root causes of these problems, a combined study was conducted based on the data gathered from the interviews and also from the literature review. The causes of scope changes and delays are summarized in the table 4.4.

In addition to this, causes for lack of governance and complexity were also examined. It was seen that sometimes, the upper management themselves are not in a position of control (with respect to the project) and problems with communication and prioritization (by upper management) leads to the lack of governance. The technological newness involved in the projects conducted in the ABC Company was a major contributor to the problems that the PLs encounter while dealing with complexity. Also, further analysis showcased that there were project escalations due to scope changes and delays. Hence, addressing the causes of scope changes and delays would further facilitate in managing the uncertainties.

The data analysis of the interviews within the ABC Company is elaborated in chapter 4.

4. What is the best practice that should be adopted so as to make project planning an added value for project management at a high-tech company?

The data gathered from the interviews was used as a starting point for investigating the best practices which are required to be adopted in order to manage the problems of scope changes, delays and project escalations. Based on the recommendations given by the experts and the inferences drawn from the interviews, an investigation was done into the literature to find the relevant techniques and methods. The following practices were obtained from the literature:

- Lessons learned
- Stakeholder management
- Scoping session
- Project scheduling
- Risk assessment
- Schedule risk analysis

These practices, when applied in the aforementioned sequential order were identified as mitigating/ minimizing the occurence of uncertainties in project planning. The proposed procedure for project planning under uncertainties is shown in figure 5.3.

A description of these techniques used for developing the procedure is mentioned in chapter 5.

6.2.1. Answer to the main research question

This study aimed at answering the following research question:
"How can project planning have an added value for project management in a high-tech company?"

On the basis of the literature review and the interviews conducted within the ABC Company, a procedure was proposed to manage the uncertainties while project planning. This proposed

procedure was tested by experts in the ABC Company. A total of five experts representing the different functional departments of the organization and belonging to different hierarchical levels tested the proposed procedure. Three of these experts belonged to the upper managerial level in the structural improvement department of the company, whereas a PL and TL from the technical department-2 also tested it.

Testing workshops were conducted to validate this proposed procedure. Based on the feedback received from the testing meetings, the procedure was adjusted so that it is in sync with the way of working of the ABC Company. The validated procedure is presented in the figure 6.1 below:

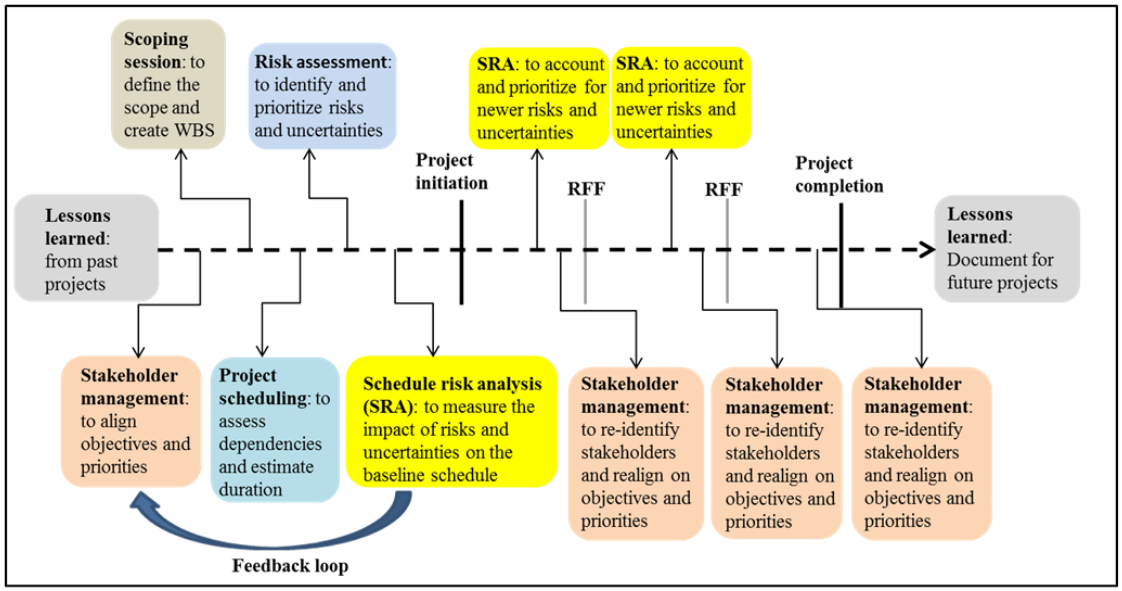

Figure 6.1: Validated procedure for project planning under uncertainties

The proposed procedure for project planning under uncertainties was adjusted to account for stakeholder management throughout the lifecycle of the project. Also, the SRA during the project execution should prioritize for the newer risks and uncertainties in the project. A detailed description of the testing workshop and the validated procedure is further elaborated in section 5.3 of the report.

Thus, from the feedback received from project management experts in the ABC Company, it can be concluded that the validated design procedure for project planning under uncertainties can help in managing/ mitigating the occurrence of uncertainties while project planning.

6.3. Recommendations to the ABC Company

In this section recommendations are provided to the ABC Company based on the undertaken study. Section 6.3.1 provides recommendations for implementation of the validated procedure, whereas section 6.3.2 gives general recommendations for project planning under uncertainties.

6.3.1. Recommendations to the ABC Company for implementation of the validated procedure

In this section recommendations are provided to the ABC Company on the implementation of the proposed solution within the organization. The solution is designed for mitigating the uncertainties which occur during the project. However, proper implementation of the proposed solution is required to be done within the organization in-order to minimize the occurenence of these uncertainties. Hence, these recommendations are provided for implementation of the proposed solution

in the way of working of the company. Since the model comprises of different tools and techniques, implementing them together at once would not be easy. Hence, based on the inferences received from the testing workshop and the interviews coupled with the culture of the ABC Company, following implementation techniques are suggested:

Improvements in Risk management

In the testing workshop, the respondents suggested that improving and adjusting the practice of risk management within the organization is the first step in the direction of implementing this complete design procedure in practice. Thus, risk management should be improved and implemented in the way of working of the ABC Company. Though, risk management practices are conducted with precision in some of the technical departments of the company, the practice is not done in a thorough and detailed manner throughout the organization. Also, following the recommendation from the testing workshop on: "How do we do risk management?", a risk management process is suggested in figure 5.5. Even though, there are various ways of performing risk management which are suggested by different project management orgnizations worldwide, this methodology is suggested for use owing to its general applicability to projects ranging from small to large size and is in-line with the PRINCE2 risk management methodology (Arkesteijn, 2014).

For the purpose of identification of the risks, a risk checklist is used (Franke, 1987). The Issue-Risk Register (IRR) should be used for this purpose. Following this, for risk assessment and response planning, the Delphi method is used (Franke, 1987). In this Delphi method, a risk workshop is conducted, where experts in the domain of risk assessment identify and assess the risks and uncertainties and their relative priority levels. The risks associated with the technological complexity and the uncertainty surrounding the newness of the technology should also be identified and assessed during risk assessment (Bosch-Rekveldt et al., 2011). The structural improvement department of the company should initiate and conduct these workshops.The risks and uncertainties are quantified and the response planning for mitigating and dealing with these risks is done (Franke, 1987). This assessment can be done with the use of the IRR and the associated response planning is done accordingly. Following this response planning, the identified corrective actions should be implemented and reviewed. As the projects in the ABC Company are highly complex projects with high uncertainties; risk assessment should be continued after the project initiation throughout the duration of the project. Finally, the lessons learned should be reported.

In the ABC Company, continuous changes occur during the project execution. In some departments, these are reported on a weekly or a bi-weekly basis, when the team meetings are conducted. However, in the technical department-1, such meetings are conducted everyday and there is daily reporting on the update of the work. This also facilitates in identifying the issues and risks at hand immediately. Then these risks are assessed to take corrective actions with immediate effects. The author suggests that, such daily reporting should be practiced in the other departments as well. Proactively looking for risks and uncertainties on a daily basis will increase the identification and detection of these risks and uncertainties.

Implementation of Schedule risk analysis (SRA)

Quantitative risk analysis or the use of Schedule risk analysis (SRA) to measure the impact of these uncertainties and risks on the baseline schedule and cost estimate should ensue as a next step to risk assessment and management. The investments in the tools and techniques required to perform SRA is quite high. Hence, it is suggested that these tools and techniques should be used in large and complex projects with high levels of risks and uncertainties. The tools and techniques for conducting quantitative risk analysis should be used where investing in them can be justified and result in value addition for the project (Hillson & Simon, 2007). Since, the projects in the ABC Company are characterized by high risks and uncertainties, SRA should be adopted. As this technique is new to the ABC Company, the first step would be to investigate more about this technique and inherit the requisite knowledge for the use of SRA. The project management office (PMO) belonging to the strucutual improvement department should be assigned this task.

Standardizing and formalizing the procedure for the use of SRA in the company is imperative. Following this, SRA technique should be communicated throughout the company by means of conducting meetings and workshops.

Improvements in Lessons learned

Even though, there is a formalized procedure for lessons learned within the organization, it has a limited use in the company. Only a minority of the interviewed PLs mentioned the use of lessons learned in their practice. In a separate study conducted within the ABC Company, an observation was made on the lack of use of lessons learned within the company (de Swart, 2016). Hence, this awareness of the use of lessons learned should be increased in the organization. This can be done during the PM Days which are conducted within the company on a timely basis. As the PM Day is attended by a majority of the project management practitioners in the company, the importance of lessons learned should be conveyed to them by means of a seminar. This would facilitate an increase in the awareness and use of the process. The formal procedure of lessons learned in the company should be extended to specifically document the lessons learned for the project management practices and should also document the risks and uncertainties. This should help to increase the identification of risks and uncertainties. Furthermore, the documented lessons learned should be made available throughout the organization and the database should be made user-friendly and easily accessible.

Improvements in Stakeholder management

Stakeholder management is prescribed in the project management practice of the ABC Company. To align and negotiate with the stakeholders, the method mentioned in section 5.2.2 of the report should be used. A process manager (external to the project) should be appointed to conduct these meeting within the stakeholders. The process manager (mediator) would facilitate negotiations between the different interested parties. The ABC Company should assign roles of the mediator to specific employees. The PMO from the structural improvement department should initate this process. Providing training to these mediators and formally documenting this procedure for stakeholder management in the company should be done. In addition to this, an improvement in this method was provided in a recent study by a Masters student in the ABC Company. An intervention for implementing stakeholder meetings was recommended (de Swart, 2016). The author suggests that the implementation plan for conducting the stakeholder meetings and managing them should be communicated throughout the organization.

6.3.2. General recommendations for the ABC Company

In this section, recommendations are provided to the ABC Company to improve project planning under uncertainties. The recommendations are enlisted below:

- It was seen in the interviews that the project leaders argued about lack of standardization in practices within the company. Hence, the company should further probe into ways of standardizing the practice of project management within the organization.
- Workshops and seminars on project management practices should be conducted within the organization and standard guidelines for performing project management should be communicated.
- It is recommended that the upper (senior) management should have more control over the projects which are executed. This recommendation stems from the comments and views expressed on better governance by the project leaders.
- It was inferred from the interviews that project escalations are acceptable within the company. However, these escalations often lead to cost overruns and resource allocation problems (within projects). Hence, it is recommended that the organization should investigate into better management of project escalations.
- The project leaders argued about a lack a skill/ competence to use the scheduling software-MS Project. It is recommended that, the project management organization should devise better workshops and facilitate the process of scheduling in projects in a smoother way.

- There should be workshops conducted at the company to increase awareness between the project leaders about the techniques and methods which facilitate in managing the uncertainties while project planning.

6.4. Recommendations for further research

In this section, recommendations for further research into project planning within uncertainties are provided. These recommendations encapsulate the aforementioned research limitations:

- Further research should be done on ways of implementing this designed procedure within the organization of the ABC Company. As different departments within the company have different objectives and practices for project planning, further work should be done to look into implementing these practices within the organizational setup.
- In this research, a total of ten project leaders were interviewed. Hence, in order to get a holistic view, more project leaders should be interviewed. In addition to this, analysis should also consider the work experience, ethinicity and background of the interviewee, before deriving conclusions.
- Further investigation should be done into looking for different techniques and methods which are available in the literature which can tackle the problems faced in project planning due to uncertainties in a high-tech company apart from the techniques used in this research.
- Further research should be done to investigate the limited use of project planning tools and techniques within the ABC Company.
- As the solution was tested by only five employees within the company, further research should be done to test the applicability of this proposed solution in the organization. This includes testing the solution by a larger number of employees who represent the different functional competencies within the ABC Company.
- This research focused on the traditional project management practices to deal with project uncertainties in planning. An interesting area for further research should be to look into the different ways of project management (such as agile project management) to understand whether these project uncertainties can be managed in a better way. The research should also include a study on the use of different types of project management practices based on the type of project to be undertaken.
- Further research should be done to investigate the extent of generalizability of the proposed procedure. The solution should also be tested in other industries which are also characterized by large projects and high uncertainties, such as the oil and gas industry, construction industry etc. to look into the extent of generalizability of this model.
- The solution was proposed based on the practice of project planning within the company. Further research should include ways of improving this method and investigate its applicability at the portfolio level.

6.5. Reflection

In this section, the author reflects upon his graduation research that he conducted at the ABC Company as part of his study programme at TU Delft.

The author worked on this research topic from January to August, 2017. In the seven months that the author worked on this research, he encoutered various challenges. To begin with, the domain of high-tech industry was completely new to the author as he had very little knowledge about the high-tech industry. Coming from a background of civil engineering and having undertaken courses related to construction management and engineering, the author was fascinated with the ABC Company which operates in the semiconductor sector. When the author got an opportunity to work in an area which he had not explored, he found it challenging. In the initial days, the author tried to meet as many colleagues as possible in the company, to acquaint himself with the company. In the dynamic case of the ABC Company, it was very challenging to understand about the kind of work that the company does

and various business lines which the company had. The author had limited idea about how the company delivered the products and services which they did with utmost precision. Another challenge for the author was that he had to shift from Delft to Eindhoven, which was in the vicinity of the company. This shifting of accomodation was out of the author's comfort zone. Also, as the distance between the university and the workplace was quite large, initially it was difficult for the author to manage the meetings at these different locations. However, with passing time, he was better able to manage his calendar.

Having talked to various colleagues, the author realized that they experienced some problems while doing project planning and it was mostly to do with the innovative approaches that they were undertaking to furnish-out their end products. Hence, the author, in consultation with his committee members focussed on investigating the problems with the planning practices within the company. The author conducted qualitative interviews within the company for performing the research. This type of research technique was completely new to the author and he encountered innumerable challenges while conducting the interviews. Firstly, the preparation phase of the qualitative interviews took more time than what the author had estimated in the beginning. For preparing the interview questionnaire, the author conducted literature review, which was difficult. This was because, the right set of questions had to be asked to the interviewees to extract as much information as possible from the respondents. Also, as these interviews were to be conducted strictly for one hour, the interview questions and interview structure had to be precise. This required a large proportion of time as there were multiple iterations which were done to finalize upon the interview protocol. Furthermore, another major challenge which the author encountered was that, when he conducted the pilot interviews, he realized that the interview protocol had to be restructured as it was not a suitable fit with the kind of inforamtion which was required. The author had not anticipated this issue at all in the beginning, and hence, another fortnight was required to finally streamline on the interview questions. One more major challenge which came forward was that, when the author was planning to conduct the interviews, during that period, most of the project leaders were supposed to take a leave owing to the holiday period then. The author tried to squeeze-in his schedule and had to go to different locations (the company had offices in different locations) to conduct the interviews. This part of the process was very hectic.

Furthermore, transcription and data analysis of the interviews was very difficult. As the company has different business lines, and the project leaders working in these different departments had different goals and objectives, channelizing and integrating these different views and opinions for the purpose of data analysis was difficult. The bulk of generated data was huge and the author found it really challenging and difficult to interpret and integrate the data. It is during this period that the chair committee member and his first supervisor helped the author by providing guidance on how to interpret and later produce the data.

In addition to this, one of the major challenges that the author faced was to structure the report and report-out on the findings. The author, coming from a different academic environment (which he had in his home-country) found it really challenging to compile a scientific report (something which he had never done before). In the initial months, the author was not able to communicate the story of his research through his report. Particular chapters, sections as well as sub-sections seemed to be frgamanted with very little connection between them. During the review meetings with the committee members, the author was time and again told to improve upon the structure of the report, but he was not able to make significant improvements in the way he was delivering the report. This inability was frustrating the author as he had to do multiple iterations and had to also do additional work and rework to produce the report. Here, the author would like to state that without the help and guidance of the supervisors, he would not have been able to furnish his end-report as he is able to do right now. The author's second supervisor helped the author significantly in framing the structure of the report. He introdcued the author to the concept of freemind mapping, which helped the author to streamline his thoughts and finally structure the report. Another massive contribution in this area, was of the author's first supervisor, who used to read the completed parts of the report on a weekly basis and used to discuss it with the author. This helped the author to make massive improvements in the report in a relatively shorter duration.

Further to this, the author thinks that, if the tools of schedule risk analysis and MS Project would have

been available for use during the research, then the results might have been different. At the initiation of the research, the author and his supervisors tried to obtain access to a computer-aided tool which could perform schedule risk analysis like the Primavera P6 or CrystallBall. However, even after persistent efforts, access to such softwares was not obtained. Had the software been available, then the author would have also had practical knowledge about the use and operationability of the software rather than only having the knowledge from the literature. This would have helped the author in understanding and gauging the problems with project planning under uncertainties better, as he would have been aware of the practical constraints as well. Moreover, while the proposed solution was tested within the company, the author could have shown the use of such a software to the employees, thereby gathering better insight into the applicability of the software in the organization. The author would also have been in a position to conduct a study on a particular project with the help of the software, thereby investigating the applicability and implementation of the software on schedule risk analysis in the organization.

If given a chance to perform the research again, the author thinks that he would have made certain changes. Firstly, the author would have gathered as much background information about the company and about the working of the company as possible, so that, the initial days which went into acquainting with the company would have been more productive. The author would have tried to do online courses or would have tried to gain access to softwares before the start of the research. In addition to this, the author feels that, if he would have done a bit more of background and literature study on project planning in a high-tech industry, then the initial period could have been better utilized to meet the requisite employees and colleagues. This would have helped in framing the research proposal as well as the research in a better manner. Finally, as the author had many problems with structuring and writing the report, he should have been better equipped and acquainted with the knowledge of writing scientific reports. If given a chance again, he would do courses relating to report writing and go through documents on the same, to be in a better position to write the scientific report.

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A

Interview questions

I am conducting this interview as part of my graduation thesis project within the company. The underlying objective of my master thesis is to inspect the added value of project planning for project management in a high-tech company. The research for my project comprises of two parts: namely, a literature review and an interview protocol with the Project Leaders within the company. Based on the findings from these two parts, I would design a solution in line-of-sight of the objective of my master thesis.

In this interview, I will ask you about your project and planning activities involved in that. I would like to ask your permission to record this interview, so that I can comprehend your inputs effectively. Moreover, this interview would be anonymized and your identity would not be disclosed. Thanking you in advance for your time and help.

Profile questions:

- What is your educational background?
- Can you tell me briefly about the experience that you have of working in projects?
  - How much experience do you have of project planning?
  - Did you also work with risk management in this occupation?

Planning/ scheduling questions:

General planning questions

- What is your view on project planning with regards to managing projects?
  - Are there any pitfalls to planning that you encounter?

Case-specific planning questions

- Can you walk me through the planning process of a recent (finished) project that you worked on?
- Was the project: time-driven, quality-driven, budget-driven or scope-driven?
  - How did this constraint influence your planning?
- Were there any factors that infleunced your planning? How did you deal with them?
- What was the impact of the complexity of the project on your planning?
- What kind of pre-requisite input information did you need and/ use for development of your schedule?

  - How detailed did you plan and why?
  - How did you build your schedule? (Top-down/ bottom-up)?
- What tool did you use for planning and why?
- How did you deal with changes and deviations in the plan along the way of the project?
- Did you encounter any delays in your plan? If yes, then why?
  - How did you deal with these delays?
- How did you make sure that the plan was realistic?
- Are there areas within planning that further need to be improved so that it would have an added value for your project? If yes, then which ones?
- Was everybody aligned on the project objective and project priorities? If no, then why not?
- How did you deal with the uncertainties along the way of your project?
  - What kind of uncertainties did you find difficult to deal with?
  - Did you build-in contingencies (buffer-time) into your schedule?
- How did you define responsibilities and accountability of work in the project?
- How did you identify the risks in your project?
  - What was your response strategy for these risks?
- What would you like to see happen in order to deal with these uncertainties?

B

Interview responses

The responses of the interviewees are presented in this Appendix. The highlights from the interviews are summarized below:

1. PL A from Technical department-3

   - Graduated from Italy and working in the Netherlands for the last 20 years in the high-tech industry. Involved in project management throughout the career.
   - Project plan is made when you know what you want to do. At ABC Company, they take a lot of shortcuts. You make a project plan for three months and it changes after that as there are a lot of uncertainties.
   - After 20 years of experience, I know that we have to be sharp on expectation management and requirement management. Use of dependencies in the plan is important.
   - Project planning suffers from the uncertainties which occur along the way (which lead to scope changes). Sometimes, you can plan aggressively or very conservatively. Be very clear on the expectations. Everyone wants to have a plan but the timelines are very soft.
   - The current project is an integration activity. Original plan was 6 weeks but it is taking 13 weeks (to conduct a test). The reason is uncertainties. The specifications are unclear. We are working on a completely new thing which we do not know about.
   - The project had 3 main constraints: having the product, having a sufficient quantity of raw material for the product and testing of the prototype. These dependencies were the most important constraints for the project (more than the triple constraint). I had engaged with the stakeholders beforehand to keep them updated about it.
   - Planning was influenced by- Availability of a sub-product, capacity of production in the ABC Company, 24X7 testing was not possible as the testing machine was occupied by other projects as well. This led to changes in the plan.
   - Impact of complexity is gigantic. If it were a standard product, then you can plan it with a little bit more knowledge. Complexity has been completely running in the project which brings a lot of stress on the team and the management. You have to be kind on your planning. I am very strict to keep my baseline. I had to re-organize my planning due to complexity.
   - Pre-requisite information that I needed was to know the requirements / specifications and what are the tests required for these specifications and requirements. Requirements and specifications are very liquid in the daily operation, i.e., they can change quite often. You have to be very careful with the way you deal with that.
   - I kept high as possible planning to specifically deal with complexity. I try to keep focus in the team and try to keep working the team in the same direction; of course we can change the direction. I ask my team to detail their own planning. In ABC, people require very detailed planning at every specific situation. For each of the different steps I have a potential backup plan. If my team knows better what they do, then they tell me what they do. I put it in a top level plan.

- Project schedule is a mix of both: top-down planning and bottom-up planning. Tried to ask it top-down so as to know the project end-date. Asked also because the information was a bit vague (according to me). Then created a bottom up and top down check and double check. Then I have a couple of review meetings with all the teams. Then I give my proposal and to the upper management and ask them if they need something else.
- I used Excel to make a project plan than MS Project. I tried in my previous project to make the schedule on MS Project, but we realized that we were making more logistical and not technical dependencies. The more you deal with known things with foreseeable activities then MS Project is good. But when you dont have an influence to change other things, then it is easier in Excel, as some things are happening which are not under your influence.
- I communicate about changes and deviations bluntly to my customer and to the management. I have a weekly meeting with the customer where I tell the progress to the customer. I also take feedback from the customer about my worries and incorporate it into the plan.
- I experience delays almost every day. You have to be very flexible and transparent. If we plan to skip some tests for some reasons then I inform it to the customer. In ABC, people are shy about telling delays, but you should tell what you are doing to the customer. I try to build a very transparent plan with the customer.
- Uncertainties hit you badly as you cannot identify them. You have to deal with them as they come. There are technical challenges which are uncertain and one of the ways is to test (the product). Sometimes we know only a tenth of potentially what could happen. ABC Company is the biggest escalation company of the world. You have to able to deal with the uncertainties that come along the way.
- I fill the Issue-Risk register (IRR) with my lead architect to identify risks. If the IRR is used at a higher management level, then you can prioritize amongst the risks.

Recommendations by the PL:
Better dealing at the program level than the project level. The masterplan and the IRR should be maintained at this level, because uncertainties are more visible at the higher level. If you dont deal with uncertainties on a weekly basis or dont consider the risks in the IRR, then there are escalations. Escalations are very important and should be properly taken care-of.

To deal with uncertainty- Change control management and stakeholder management is important. If you can take the acceptability of the escalation away, then there are better ways to manage them.

2. PL B from Technical department-1

- Mechanical Engineer by profession and 8 years of experience with project management.
- Project planning is a big challenge within ABC Company, as with such complex systems it is difficult to make a plan with the given time and guarantee the highest quality in the given cost. You have to focus on triple-constraint management. This is very challenging because you cannot make a complete plan which will succeed.
- Given a certain target, we make a plan, I start calculating back from the end-date. I need the amount of time for that to qualify. It (Planning) is mainly based on experience from the previous products. Specifications and the numbers change but the tests that are needed to be done do not change.
- You have list and priorities. When we actually get there (integration of the product), there is an assessment to be done as to how much time it will take. If you set priorities beforehand, based on risk assessment, i.e., risk based testing (risks either technical or business). We consider that if some changes from the technical side are not working then what the impact on the business is. I do risk based testing session and make the plan for the alpha testing (final testing). Everything has to be done before that.
- Main problem is the availability of the system (required for testing the product). I try to optimize the testing plan based on that (as it can cause delays and changes in the plan).
- Most of the times, you dont have time to prepare before you start working on your project (integration plan). First, I visualize the dependencies and translate the dependencies into a plan. Using risk assessments you can see how much time you need for what. Next to that is that when we start integration we start work and then things do not work, that is you have an issue on the system right now which blocks the system and cannot go further (delays the plan). If you are blocked you cannot make progress and it can have impact on the end-product.
- I prepare a plan with the end-date. I try to steer the project so that they (project team members) work on the current things. I look at what is the impact of the total integration plan on the end-date (shipment date). If we have an issue (unforeseen thing) at hand, I see if we can do some other things which are not blocked by the issue (if not, then it delays the project).
- Time to market for this product is very important for the customer needs, because if we are not on time then the competitor takes the market share.
- Difficulty in project planning with the preparation phase. The projects do not have the details yet as to how much time it will take so they take an estimate. They (Team Leaders) make an estimate of the A4 specification. But, when they actually start writing down the work that has to be done, they realize that they did not consider certain sub-steps in their process (and the time required for that). This impacts my project planning. It may also lead to escalations in the end.
- Time driven project. Week (X) is holy, we need to ship it. Either I need extra systems or you see the system availability for testing is the bottleneck. I need to plan in 2 shifts. First, when I planned, I saw it wasnt fitting the timescale, so it was a no go, it wasnt a realistic plan. We had to reshuffle again and look at the scope and then came up with a feasible plan. We need to have flexibility for the people so that they can test in the evening hours as well. We have weekends as the buffers for the baseline testing plans. We have work planned on processes that we use for integration.
- Sometimes people from this project are involved in other projects and if there is an escalation coming from a customer then a resource from this project can go there. As a result of this, people for this project deliver later, i.e., these are the external factors that can have an impact on my planning. I have to translate the impact of the change in delivery or timing. You choose this i.e. (customer first). This impacts the plan and we are asked to make impact analysis report of certain external interventions.

- This product is based on another product which is not completely new. In this case, hardware wise there is a complete new module and that also is designed to be built by a supplier and that supplier is not up for it. First (X) modules of the part were built there. Now we are building it here as the work center is here. This influence of the complexity of the hardware and the (backing-away) of the supplier impacted the plan.
- Preparation work (for the project) is done separately, but planning, timings and dependencies are shown in MS Project. Excel is used for daily reporting.
- To deal with changes and deviations in my plan, I tried to make an impact analysis as to what does it mean for my plan, i.e. I can absorb it, or I find a way that it does not affect the end-date. Then people have to work longer or the shipment date is delayed. At the moment the specifications are made; they are clear and unchanged. There can be some scope changes during the integration project due to dependencies. If we are not really able to deliver what was agreed upon, then we agree upon lesser scope or later delivery. i.e., Delivery with limited functionality.
- Changing priorities due to the fact that there are escalations from the customers (this is difficult). Marketing team is also talking to the customer, sometimes marketing promises additional functionality with time before asking it to the respective teams. This is unplanned work or scope change. Then we need to make an impact analysis, this might impact the integration plan. You should be very clear in priorities and planned work else it stays vague and all changes that are (to be) absorbed in the projects are not doable.
- Most difficult uncertainty for my scope, in the integration is the dependencies, like working on more than one system in parallel. To look at: what is my planned and what are the dependencies. It is difficult to define the next action or what is the way forward. Have to see if there a dependency on the other system and things like that. Testing activities on hourly basis is very difficult.

Recommendations by the PL:
System integration planning is always difficult. Approach where you do the system integration in the most effective way should be risk-based. Then you can prioritize and value them. Make sure that highest risk items are tested as soon as possible. If it a high-risk issue like for software, then it does not need to be tested on a machine. Basically identify issues and risks so that we can work around it.

Stop promising things to the customers before aligning with the engineering teams. We know the roadmap for what is coming on the high level or the program. But what we deal with is that there are a lot of extra requests coming in. Too many changes (come in) for the amount of people. Pressure is very high on everybody; still new requests from the product team are coming in. More scope changes are coming in- but we are given lesser resources (money, people).

What would help is a clear priority setting. Escalation should not be necessary if you have a clear priority setting. More structured planning over a longer period of time is required.

3. PL C from Technical department-2

- Mechanical designer at ABC Company (18 years experience). Did mechatronics designs, and then moved to lead engineer/ MDO (Main Deliverable Owner). I have 7 years as a PL, responsible for flow and temperature projects.
- Planning is key factor to deliver projects on time. We start always with a master plan from the program, connected to that we have milestones (which are quality checks). Under a PL, there are TLs or MDOs. MDOs plan PBS (Product Breakdown Structure). MDO makes sure that the PBS is delivered to on-time to projects. I start (to plan) bottom-up. Apart from the master-plan you have to have a good quality product. You want a good plan where all the risks are mitigated. It is most of the times in conflict with need-dates. Then we manage the risks. Sometimes it is okay to take shortcuts. We Roll-up from MDO to Project plan to master plan. At a certain moment, if all the plans are correct, we freeze the planning and work towards it.
- Most of the times, you have an incident, design failure or stakeholder whose specifications are changing/ need to re-design (this affects the plan). Also, during integration phase of testing (not planned in details), there are iteration loops. You take a shortcut and at a certain moment you make a new mistake. You are not looking at the FMEA items, the specifications, the design and thats where it (planning) mainly goes wrong.
- While making a plan, me together with other PLs did some iteration loops and did some learning. If we make a new product, what is necessary to make a good-quality product? We have a checklist and verification list; mainly milestones. All the hardware and software are in one-list. We created the list and every MDO has to fill it. They have their plan and they have to link it to the major milestones. Before we start we have the 3 in a box: architect, PL and GL. For every PBS we review the verification list. We agree upon the quality of the PBS and everything needs to be planned. We have the quality of the plan, where timing aspect is important. You have PBS, checklist and detailed plan. We review if the plan is good quality (timing-wise) and then we freeze it. We use verification list with MDO and check if the dates are matched.
- We never do triple constraint decisions correct in the program. At this program, the timing is always fixed. We see more discussion about scope and budget. If the timing and the budget is fixed, but we cannot deliver the performance agreed to the customer then it is okay if we do it the right way.
- Scope changes and scope discussion influence my planning and can cause delays. We started as a complete machine (X), but we de-scoped it later (which is my current product now). For this, we had multiple iterations which were done during execution of the project. People are working on and spending budget on items which are learnt to be de-scoped in time. This is not good! We now have the whole quality initiative. We took some shortcuts in the past and have some backlog. We have to see whether the quality is right. The backlog is to be done in this machine but budget is not there. Although we need to ship it in next few months we have additional requests coming. These requests for scope change are not only from internal (system engineering and program) stakeholders but also from stakeholders outside the project.
- Complexity is that there are so small delays on each item that you do not change your plan. But if you count them, there are so many that it leads to weeks of delays.
- I really like EP (MS-Project) for planning. Important is to have one standard way of working, in the end to track and to get the reporting; you have to report to line management and program. I want to have one single truth. If we have the right reporting tool, then they have the right information to share. Everybody has access to the program.
- If the changes are within the need-dates within the program, then it is okay. I see whether these changes are manageable or acceptable? Also for the KD (key-decision) moment I have to agree upon how much risk I should take. We agree on this KD moment and comment on the risk for the go or no-go moment. We need to escalate in the end.

- We are not good at the feedback loop. We do not see after the project, as to what happened and how did we do? We are not very efficient. Because we have to switch work (lot of times), there are small delays in that. We forget to mention it and forget the impact (Thats something we need to improve).
- To deal with uncertainties, we talk within MDOs to see whether we can exchange a resource from one MDO to another to see if everybody is on track. Can he solve it himself? Can the MDO fix it? No, then PL, then upper management, to see who will manage it? Most difficult uncertainty is budget discussions. We have time pressure and on top, upper management tells that they do not have budget and they escalate very fast. Also, we shift time to front, i.e., we have to pull-in a plan! We have an integration step in week X, but we try sometime earlier. The uncertainty here is high.
- To deal with risks, we have a PL and a project meeting. We get input from Architect and MDOs and update the IRR. We have FMEAs. We have critical design reviews. We discuss about the performance of each PBS and see where the risks are. In the MDO sheet I put the risk in. At multiple levels it is very difficult to have a track of the project or the risk. I try to do my best to talk about issues and risks. I talk to the MDOs to catch all the risks which are necessary. I see what the risks are and what the additional risks that we have to consider are.

Recommendations by the PL:
We need to have a standardized way of working within ABC Company. If we have standardized working, then I think we are doing well. If everybody works as we are working now, then risks and uncertainties are managed well with the IRR. Key is to deal with the risks (deal with the risks, accept the risks etc.). You need to make your stakeholders aware about this. As long as everybody is using this way of working, manage the risks and issues well with manageable escalation level, then we are doing well.

As a side-activity, I am working towards this, i.e., to get everybody on the same way of working. I have to serve multiple projects, i.e., interface management and communications are difficult. It is important to have a standardized planning because if we dont have (it) then we are lost.

4. PL D from technical department-3

   - I did a PG in Computer Science. 20 years of work experience. I have been a PL several times.
   - Project planning helps but it is not so crucial. It helps in the sense of organizing, giving insights to the people in the project about the environment. It is not mandatory to do proper planning. I used Excel. Its not about the tool but about the mindset. Logic and sequence behind the planning is crucial.
   - One of the pitfalls of planning is the plan being too detailed. Daily and hourly plan should be properly aligned. Another pitfall is if only the project leader is following it and others are not. People should understand and believe in the plan otherwise it is not going to work.
   - I only have the milestones in my plan. Activities are planned in the team plans. I dont want to see some things of the team plans into my own plan, hence I select some important milestones and put it into my plan. In the team meeting (3-in-the box), we always go through the highlights. These are the deliverables which are there in the plan but I am not going to go through the plan. People give feedback and we adjust to it. For planning, alignment on the priorities is important. Every week there is a weekly highlights and the lessons learnt meeting. Within ABC Company we have the Request for funds (RFF) meetings about how much budget you get for your project
   - Managing the triple constraint is difficult. Initially, it is about what is in and out of scope. If you have delays, then you have to deal with it by changing the scope. If they (stakeholders) define new deliverable, then I say that I do not have people or cost. If I get cost then I can give it to external parties or outsource it. At the end of last year, we decided how much people and budget we get. Resources and budget, including time are fixed which leads to scope (in or out scope). We had to accept two additional tasks. Some tasks are de-scoped based on the business case. Once you are clear on the budget and resources then you have to execute.
   - I develop my plan; both top down and bottom up. First collecting data, bottom up and the planning is top down.
   - There are various things which influenced my planning. One person went to customer support. This was an action decided within the program and I did not get a replacement. There were other significant delays in hardware developments. Also, the final delivery was delayed because hardware supplier had 10 weeks of delay. During testing we realized that the solution was not enough, you have to do an extra iteration. You never know how many iterations we need!
   - I do weekly tracking with the TLs. If there are smaller changes then we leave the plan unchanged. After about 6 weeks if there are major changes then we replan. More difficult is to find dependencies between plans. I try to prevent dependencies in the plan (dependency should be functional dependency).
   - To encounter delays, we try to use lessons from previous mistakes into the next project. If a single person is delaying then I have open discussion with the person and the TL. I do not blame him but try to prevent it for the next time. If there are unforeseen delays, if there is a problem in the field (highest priority), then it is escalated! It should go via the PL/ TL. If two people get the change requests, then later you discover that they have done the same work. You should follow the path from the TL/ PL. (During escalations).
   - To make sure that my plan was realistic, we reserved a significant part of the people which are not counted for these activities (in the plan). If there are new issues, I need the people and I dont know what is their exact deliverable and list, but I need capacity for people for things which are not planned. This is how it is possible to deal with change requests. If there are unforeseen tasks then people are needed. Creating a buffer for unforeseen work is important.
   - Everybody within my project was aligned on the objectives and priorities. However, not everybody outside the team was aligned. System engineering has different ideas which are not

properly aligned. The real customers are aligned, but bottom up planning is not influenced by marketing team (which may lead to misalignment and changes).

- We have new requests for activities in planning (which is documented in the AIR). For each work (we accept) we have two phases. I dont know what to do so cannot plan it right now (plan it with the correct priority, feasibility phase). When we know what to do then it is adopted in the plan. The other uncertainties which are there (always there), I sit together with the people who have the knowledge (architects and engineers) and then it is to find the solution the best way forward. Most difficult uncertainty to deal with is where the architects and the technical people have totally different opinions. The more self-confident the people are, and then we have the solution.

Recommendations by the PL:
We should improve upon risk management and contingency. 3-in-a-box does not do it properly and need to improve on that.

Furthermore, I do high-level planning and in the end escalation is identified in the AIR issue. I want to have the AIR issues up to date. During escalations the AIR issues need to be up to date. I should be able to import the dates from the AIR issues to the plan rather than importing dates from the plan to the AIR (which is the current practice).

You get a certain budget and people allocation. There is still a problem that during changes, I have to go several people for all the approvals etc. (which tends to delay the work). You dont have the freedom as a PL to spend your budget in the most efficient way. You need double approvals. This is something which should change. You should empower the PLs to take decisions about their own project.

5. PL E from structural improvement

- Bachelor in Computer Science and Masters in Technical Business Administration. Since graduation, I have been into IT projects or post improvement projects. PL at ABC Company for 3 years. I have always worked in project planning. I am technical minded and I know how the project is divided into technical packages.
- In terms of planning , as long as you have all the constraints and dependancies within your projects and if you are not dependent on someone else to give you something then the planning is very efficient. But a pitfall is that in every project there are dependencies and I am unable to manage them. Often we are pending (delaying) on a particular input/item and cannot continue without it and then we are stuck. Also it is good to let the other person know your dependancy so that if that guy delays then your work also gets delayed.If one dependency is not delivered then the whole plan starts to shift.
- I came into the project when it was on hold (was stuck). Already lot of time and money was invested. I investigated what work was supposed to be done, which deliverables are open and got a clear understanding of the priority. Once clear with the above things, I started looking at what are the steps to deliver this product. I then made a product breakdown structure and the work breakdown structure. Based on the feasibility of the plan we create a baseline plan and held it up to a PowerPoint that we can share with the team.
- The project was mostly scope driven. There were fewer items to be done and in those less items if one is not done then we could not close the project. So the main constraint was how much time we need to invest to get the product delivered. There are lot floating of requirements and as long as you find out (what has to be done) there are more requirements which you cannot postpone and you really need it. So what happens is you immediately change the scope (and the time and resources also need to be increased). So this project particularly extended from the time frame. The project keeps slipping because in most cases we dont know what we are going to deliver.
- Because you add new stuff which you didnt plan for, then you have to replan for those things. Sometimes you also have to undo things (previous work). So it is like you did a lot of things and invested a lot of time and it goes waste.
- The impact of complexity was pretty significant. The project was challenging and complex in few areas for e.g. technical challenge and complexity that it involved was to get everyone to understand how it works. The other thing is to do the change management. We are usually very optimistic in making such plans. So if the first thing goes wrong or you underestimate the complexity then you need more time to level-up things and it takes more time.
- Sometimes it is pretty difficult to make a detailed plan with very little information and this is the reason why often we get it (plan) wrong.
- In this project we had functionalities to be delivered so we planned at day-level. However, due to complexity some things were finished soon and some things took longer. For handover (to support) and for subsequent deliverables we had planning at week-level.
- Initially it (plan) was top-level plan and we had built it top-down. But once we made the detailed plan (bottom-up), we again updated it in the top-level plan. So at the time of approval of the plan they were both in sync. I developed the plan in MS-Project because I was struggling to make the plan in Excel (previously but couldnt do it). Also the previous project lead had an Excel file which he maintained. I could not really do that in Excel because it didnt give me the insight that I needed. The main reason to do it in MS-Project is that I had lot of dependencies and I couldnt oversee them in PowerPoint or Excel.
- To deal with changes, you update the plan. So some times the duration will take longer. Sometimes new tasks need to be added,new deliverables need to be added. I always (on a weekly basis) went through all the activities and items. The MS Project gives the status of all running tasks. Task that is done is put as 100%. Running task is categorised as 50% and anything which is to be done and not yet started will be highlighted in red.
- The plan delayed mostly all the time because we had dependencies in all the departments. There were so many external factors involved that it was actually more for luck than planning

that I actually managed to get the project closed. I had done the plan but never knew if the plan would actually fit and work and in the end it actually didnt fit. So we extended the time frame and we tried again.It was more trial and error and we were more lucky.

- Dependencies in all the departments of project were very critical. Uncertainities about delivering of the dependencies is most difficult to manage. If these uncertainties become tedious, I start managing them pretty closely and it is also sometimes gut feeling.
- In terms of overall the responsibility in the team, it was pretty much clear. At the project board level it was unclear and they did not really understand their roles. At the director level and the senior mangement level the roles are pretty unclear. You can only influence them and cannot directly tell them what has to be done because they will always remain a higher authority to the project lead.
- To identify and manage risks, we discuss in team meetings about what is going on, and then questions come up from the team. I dont feel the need to go through the risk-register every week. I rather focus on whom to make responsible in managing this risk. Also believe on gut feeling and past experiences help in identifying the risks.

Recommendations by the PL:
Project dependencies and resource allocation need to improve within ABC Company. Allocation of who do you have in your team and who is assigned to what, should be known. It is difficult to handle if someone works for a duration lesser than that alloted or planned and you have to deal with it all the time. Also people should restrict the number of projects they are working on simultaneously so that full time can be dedicated to all the tasks of the same project and coordinate with all the teammates of the same project.

Also, to deal with uncertainties, the most important thing is to be able to escalate serious issues regarding dependencies and uncertainities. If I am stuck with something or to get a task done; if I ask for help then I dont necessarily get help. They just let you keep giving options instead of getting help directly. If the project leader is unable to handle the task then he should have the say (to go and tell) the project board directly about the situation and get help out of it.

6. PL F from technical department-1

- I did electrical engineering and have a work experience of 11 years. I have been a PL for 8 months.
- I am not using MS project, it is horrible. Courses did not help; you get stuck in the program. PMO also get stuck in the program.
- In the feasibility type of projects (which I am doing) - there are a lot of uncertainties and big scope. You just make an estimate and start with it. Every 6 weeks I have reviews and the whole project shows progress technically. It is much more difficult to manage because of the uncertainties to manage. At ABC Company priority changes fast. What is important now might not be important later. 6 weeks later half of the plan is burnt to another thing, because we have a request to change the requirements or scope.
- Some of the pitfalls to planning are that people are always positive and they underestimate the work. Not taking enough buffers, for coffee breaks, lunch breaks etc.; small questions from colleagues (to help them) take a lot of time as well, may lead to delays in the plan. Also, people working too long on a topic which is not relevant anymore. We stop this study and (we go to this direction), but still people make a report to wrap it up.
- First (this project) was a very small scope and clear project and I had to prepare a specific tooling. I supplied all the effort estimates. I sat with the architects and listed down the main topics that we think need to be done, which risks and unknowns are there, which design items do we need to make, which implementation topics we need to make. Feasibility study would be some work (say 2 months). Once you know the feasibility is done then we have the design and implementation phase. We need customer support, need to support software team (roughly 80 days). Go to product manager and ask for resources, if we dont get resources then we de-scope or change the timeline.
- The project was first scope driven, and then later it became time-driven due to the customer. The Product manager had to make choices on how to allocate people. But still you need to de-scope which is never going to meet.
- Many factors influenced my planning and there were unforeseen tools (which I had to build). Making design tools took much more time than anticipated. We needed more access to the customer and we got more requirements. To mitigate this, you communicate with the Product manager to ask for more people and deliberate about it.
- A major complexity was that there were a lot of stakeholders and they had early access in the project. The only way to manage scope-less projects is to have experienced technical people, who oversee the product and the risks. If you are lost (in the project) then you cannot act in time. After that it is a matter of time to have very short iterations and be very sharp on scope and priorities. It is always about the input and the output, and you have to be really sharp on things. All the projects that I have done are complex! Easier projects for me are the execution projects; it is more predictable for me.
- Work with Excel, put all the tasks and activities in Excel, then I go to MS Project to get the timing. I use MS Project later because doing it upfront, if I have to add and delete tasks then it is very complicated.
- If there is a deviation, I first assess the priority and how much time it takes and together with the Product manager make the trade-off. How can we buffer it, or can we off-load tasks to the customer support? Some of the reasons for changes are: Request from marketing (indirectly request from customer). What you are making is not enough. Typically (request) starts at the customer; the other side is when you encounter technical issues (then you have changes).
- I encountered delays because of unforeseen items as scope changes and unexpected items. No planning finishes on time, takes twice as long (typically because of added scope). Then I changed the planning, putting new priorities and communicating back.
- In the beginning everyone was aligned, but the misalignment comes later. You start deviating and the misconceptions come in later, about the priorities of work. Priority calls are made

quite often at the correct level. Sometimes people make decisions unconsciously. But in general, priority of work is there when taking a decision.

- Most difficult uncertainty is: Development work. Creation of development tools take longer than expected. You run into problems for the promises made to customers. Then you do micro-management! Every two days you have to sit together to see how it is working. If it happens towards escalation, then you have to work more to manage it back.
- Even though, buffer time was built, but once it starts delaying then it goes overboard the buffer. People think that it is insane and you dont want to do it. You cannot take all the buffers for the unforeseen. Sometimes you dont scratch the buffer but the scope.
- To identify risks: Thinking upfront, where do we see uncertainties? (Lessons learnt- high risk item). I try to schedule-in extra feasibility study to see if the risk is really concrete or not. In the weekly meetings, we get data from customers and people analyze it to see if there are unforeseen items. If you can see what is happening and if it can impact your final thing (deliverable), then start thinking about it.

Recommendations by the PL:
Better tool than MS Project is required.

Role clarity and communication should also change. Sometimes, you are not informed as a PL; even if new requests are coming-in. PDM commits something without informing the PL which leads to scope change and delays. At ABC Company everybody is very technical; nobody plays a role for the full definition of the project and the project plan.

As with uncertainties, I think they are just there in the project and they are tackled correctly. We tend to take uncertainty as risk and then park it until it materializes, which is not wise. But it is a triple constraint decision. ABC Company is strong with concurrent engineering and that is how we mitigate uncertainties. We have technical views and reviews on planning to adjust the scope and planning.

7. PL G from structural improvement department

- Education in industrial engineering. I have 4 years of experience of project planning.
- Issue with planning (pitfall) is that- At the beginning, you really plan with Product breakdown structure, and then you start adding activities (it is too detailed). When you start executing, it is never kept and monitored along the way. But when you have a scope change (by the management) then you dont change the plan. It is done on experience and ad-hoc! It is not a team activity to go into the details.
- Most important constraint for planning in the project was scope. We had some fixed module which we had to implement. Standard (time duration) was that it does not go more than 1 year, but more important was that the modules are implemented. The focus was whether we are getting the scope and quality right.
- I had some resource-dependencies which influenced my planning. One super-key user was needed for all activities (there was a big dependency on him). Local resource commitment was needed (as the product was been launched at different sites). Because some activities were not done with the same quality, there was delay and the planning got delayed. If I have a problem on the critical path, then I go to the project board and escalate.
- I did a bit of both, top-down and bottom-up planning. I built bottom-up (got information from the team). Had a top-down as well, because I knew this scope has to be delivered at this time. Then I saw if it is acceptable from top management. I did detailed planning in MS-Project because you have dependencies and you can allocate resources.
- One major change in my plan was a decision at (X) location to put the work out of scope. At such times, you have to make sure that your resources are aware about it, you have to phase out. But it changes the plan; you have to adjust the planning. Closed all the activites in planning I that planned there.
- There were delays in location (Y) due to an external party who had to do process stuff, but there was a problem with adaptation. I had to check how all this would affect my planning, but I kind of delayed with the plan. During such times, you try to check the impact on the total schedule. I tried to make sure that the process descriptions were delivered as soon as possible. It took us a three week delay and it was acceptable in my planning.
- To align everybody on the objective and priorities: we have toll gates, during my ready-to-plan and ready-to-execute (toll gates), I delivered my plan and everyone was aware about the fixed scope and the required time.
- Most difficult uncertainty is where there is no one responsible for it. If there is a functional problem then functional guy solves it. But, the areas where we do not know who is going to manage that, it is the toughest. I have a general contingency post, but not specifically for uncertainties. I scheduled some uncertainties for the general contingency post.
- To deal with uncertainties, sometimes you check to mitigate the uncertainty. Those are actions along the way. Sometimes you have ad-hoc uncertainties or issues. Sometimes you have to escalate and you have to see how managers adapt along the way.
- Sometimes it is obvious to define responsibility and accountability of work. But when you dont know who is responsible, and then we put everybody on one table and make people responsible. (When time is short). Everyone who could have the role in the issue comes around the table and then we discuss the topic right away and make sure that the action is done.
- I maintain the IRR to identify the risks. Then I see what are the main issues and risks and try to control it. I mention it in the bi-weekly meeting and have my response strategy.

Recommendations by the PL:
Couple of things-

- Embedding risks into planning, start slow with it. Put top 4-5 risks which are there in the planning. Project board should also be aware and they should ask what it would be impact

on your planning, impact on time and budget. We have an IRR but it is not embedded in the planning. In general, our projects are delivering less scope; are overtime and overbudget. We dont account for what risks have an impact on your planning and budget . If we can show that to the project board then we know what is the budget and the time we need. Project board should know what has to be done. It should have a better governance. The main focus should be on orange and green projects, because they need assistance on how to manage risks and how to do things. The PMO should help in that: do you have risks visible on your project? Do you have mitigation measures? What are you going to do about it? We should account for big risks and adjust that in the planning. Right now, we plan on happy flow plus little bit of contingeny, but we should plan for happy flow and big risks and include it into the planning. If there is any, then you can go to the project board, and they can allocate.

- Scope change and stakeholder management is very important. If you do good risk management then you can account for scope changes. Scope changes appear where you do not foresee it. Make sure that you proactively account for risks and plan for risks and also governance bodies should have contingencies for these.

8. PL H from IT department

- I graduated in aerospace engineering and have been in project management since 1999. Mostly worked on IT projects. I have been a PL for 8 years.
- When you deliver a plan (top-down), I do it quickly. I also do a bottom-up plan (which takes time). You often see surprising things. The main way to tackle that is not to plan for risks. You dont know the main risks that affect your project so you cant plan for them. When you make a top-down plan, you know whether this is a risky project, so you can keep a buffer of priorities and estimates! Really minimize the dependencies that you have (as low as possible). You have to prioritize the goals of your project. If you know your priorities then you can revolve your planning around that. Most of my projects focus on quality. If you go for time, then quality can be hampered (I dont want to keep fixing things later by focusing on time). Time is really slipping and is always relative (it is always about quality)! As long as it functions properly, then it is okay.
- I took over a project. My predecessor said yes to the project (said yes to small amount of time and money). When I got involved then I realized that it was undoable. When people go to the stakeholders or executives, main discussion to counter (the time and budget they are getting) is to say that this (amount) is the time and money that I am going to do it in. Not saying yes too quickly (otherwise you are in fix).
- People put buffer-in, and they remove the buffer to say that we finish earlier (you cannot do that because we have risks). Best way is to think conservative and not optimistic.
- I did a project which was cancelled. Everybody was pointing to each other. I was IT project lead and there was a business (quality) PL. The other PL was not good at planning and said that lets do it in 3 months. We did a scoping session with the core team (architects, TLs, PMO and PLs). He just said to make a WBS and make something (document) called in and out of scope. You always dont need to make a detailed planning! We did it in AGILE way (scrum-agile). You do a top-down estimate! You have a really quick overview of what the plan and time would be. You focus on these prioritized (critical path) activities and this is where you focus plan. You make a top-down plan which works, which is better than detailed planning; because people know what to do (you divide points in the timescale). This is the agile way of working.
- The business PL was driving it as a time-driven project but it actually wasnt a time-driven that is why it failed (he was asking for more and more budget). We squeezed it, which didnt happen. If it was cost or quality driven then it would not have been cancelled. I presented another scenario to the management, but he pushed for the time-driven scenario only! He didnt want to sell the scenario of cost or quality driven (he was pushing for 20 weeks).
- The complexity of the project was that analytics engineering (which we were trying to build); the architecture did not take time for that. There was a lot of disagreement for the best solution (customization and things like that).
- I stepped in December last year (the project was my predecessors portfolio). I was asked to escalate work on my predecessors behalf. The business PL was making everybody angry and was making a fight. There were a lot of requirements added all times. The discussion of all the requirements started from things! I dont see them as changes; I did not know what we were looking at (to find a good solution). We were just planning for that. There were escalations as people were just pushing all the time (they were unavailable as well). The change was on triple-constraint. People are not available and I need these people before we could start. This was the scope and timing change.
- I did not encounter delays as such because from my experience I put in contingencies thats why no delays. I filled up buffer of double the time (in my plan).
- Everybody was aligned on my plan but the Business PL and the sponsor was an issue (quality department). The people in the factory knew what to do, but the PL from the quality was in disagreement with the factory people. Project governance is a main issue at ABC Company. If they would replace this PL a year ago, then this scenario would have changed.

- To deal with uncertainties- main thing that we use, in agile planning is that, in every sprint, after everything we see if we have to change anything. At the end of the week, we have a short meeting (weekly and monthly) (weekly- team meeting, monthly- planning meeting). When something big comes up then you foresee it (you change the plan then). Main thing is to do meetings and then I handle the stuff which comes out of the meeting. The really strict agenda is to know what we did yesterday and what to do tomorrow?
- Most difficult uncertainty is stakeholder management. Findings out who the real stakeholder is for the project (with whom you have to deal with), how they are influencing it and organizing it. If somebody does not agree with what you are doing and what your team is not doing then it hampers your plan.
- We did not have time to properly identify risks. We did not have a good risk roll.

Recommendations by the PL:
Support! (Governance) is one thing which is lacking. If you are in trouble, you have to go to the project board for help. But they are also not in control and cannot help. They cannot get the timing right. Accountability and responsibility is not laid down properly and if you deliver then people dont care much. In the Dutch companies, it is always the same; we are not good in hierarchy, which is our strength and weakness as well. Germany is already different, they are not so flexible when things happen and we are a lot flexible (including who is responsible).

The main thing is to see if you can handle the change process. It is always about handling changes, how to work together and handling changes all the time. Spotify engineering culture can be helpful to deal with changes.

Also, the scheduling session (within ABC Company) is old fashioned. Its like creating a false session to show you are in control, they should focus on agile planning. Lot of PLs do not use MS-Project. Funny thing is that when there are changes, it is very difficult to change the plan and it is not flexible. If the PLs get some training into different planning styles (like agile or planning poker) then it would be good.

9. PL I from technical department-2

- Graduated in aerospace engineering. I have a work experience of 12 years and have been PL for 6 years.
- Emphasis on planning is mixed. Also, risk management is heavily dependent on the project you are running. It was not done in a real structured way as it was in its infancy. In the last 3-4 years there is a much more emphasis on risk management (depends on the phase of the project and on the risk profile of the project itself, but still requires improvements).
- Biggest pitfall of planning is to go into too fine detail of planning. I think that project planning should be a guideline for what you are doing and the intermediate milestones where you have to reach. More detailed plan is not of added value for me. I see added value for bigger work packages (milestones). In dynamic case of ABC Company it gives false security. You can write (work to be done) on the plan but people wont do it tomorrow.
- My project was for 3 years, where we had to develop new generation hardware. The first part of the project is risk management. It is the most important part (in conceptualization) the risks and decisions that you take has the highest impact on your project. The issue solving is a goal than to finalize it, and then the detailed project management is more important.
- The main constraint was time. Scope over the 3 years did not change that much. There was a bit of scope creep. We freeze our resources every half year and only at the end there was a real squeeze on the resources (did not get the desired number of resources). But in the first phase, we couldnt do everything what we wanted to do. I needed 20 people in the first half-year, but we got 15-17 (almost the entire claim was got). But in the later stages (you want 15 but got 7), which leads to cutting down on scope.
- The project was a cross-sectorial and cross-competence project (hardware and software). This was the biggest complexity. Making a plan as a PL for such a team is not possible by yourself, you dont have all the knowledge and experience and you need the input from the people in that team. These people sit together to see what needs to be done (I record it and summarize it and go to the team) and then we agree if we execute what we agreed upon.
- The timing constraint is very nice for project as you can plan back, you can calculate back from now. If the end point is floating, then you dont know how hard to push for progress, but timing is important. Also, you need to know what you need to do, i.e., scope of the project. But for planning it is important also because at some point you come into resource discussion. If you dont have your scope discussion then the resources are unclear. If the scope is unclear, then delegation is difficult for the management.
- In the beginning I used MS Project (EP). Then you can have the links between your project and the other projects in the program. Once you have passed the bottom of the V curve, ABC Company starts using AIR (Issue resolution database). On the top-left side you use EP, down the curve you have EP and IRR and also a bit the project navigator and if you go up on the right hand side, then most milestones are already reached and EP starts to lose its benefit and work you are encountering is more issue driven (AIR).
- We wanted to implement this (X) module and it has a lot of interfaces. Initially we proposed to operate it at one fixed setting. So our entire integration phase was directed in a direction for one setting. We got our result and decided for single setting and delivered it to the filed. Then after a month a customer came and wanted to operate it at a different setting. The implementation is a lot more work for that. Initially it was not in the scope of the project.
- For the scope change process, getting the information and making the decision was pretty fast. But the first steps after this about the budget and the people is usually is a bit more troublesome (if new people are involved, getting these people up to date with the subject) they may have some work left for the old project. Other generic thing is the RFF project, where every half year you get the project. You go through the RFF and you think that you have the budget; then suddenly somebody says later that we are going to do it differently, this spoils the relation between you and the customer and one week before you start you say that I dont have money for you. This causes delays.

- Sometimes you get really angry! Usually, if there is uncertainty in the direction of the program, for instance whether to continue the project? Or sometimes you are doing more than one generation on the project (and then you know at the high level to stop or continue that activity). There are risks involved, and you need to see whether you are in-time. You have to be honest. If you are going to delay, you need to tell people (to enable) to help you. They also can inform their stakeholders and it is always better to be the first one to signal it yourself than to confront it from other party.
- The most difficult uncertainties are the ones that have to do with people on the personal type of thing, the other one is if you are suddenly confronted with a situation, when you know that you are too late. Some issues you can see them coming and you can do the early signaling. By the time that the project gets to know that you have a problem you are already too late! You do plan with buffers, but there are always exemptions that can occur.
- We used the IRR process (to identify risks), we made it together with the function architect. You set up a list with all the risks and you start putting the mitigating actions in the plan! For the high level risks, for the real difficult ones, you need to see whether to do contingency or to mitigate the risk? What if this module doesnt work, you go to the program management for help.

Recommendations by the PL:
In ABC Company, scope is highly dynamic, that creates a problem to get some sort of stable base for project planning and resource planning and it also creates a difficulty. Suppose you as PL (you) are a very detailed planner, you start off with the project objective. Making a detailed plan costs a lot of effort. But in 2 months, there are scope changes, for which you have to change the plan and you have to throw it away. The dynamic planning is demotivating the detailed planning. We make fast changes to technical directions (good thing). We are very quick to address the issues that come, we remain flexible. But if there are 30-40 people work in that project, then changing that direction is very difficult.

However, I think we are dealing quite well as a company! People think that scope changes and scope creep are not uncertainties and it is embedded in peoples way of work. In ABC Company, scope changes are a rule and they are there. You have to deal with it.

10. PL J from technical department-3

- Graduated in mechanical engineering in 1995 and started at ABC Compay in 1997 as a mechanical designer. From 2001, became a project lead. So 16 years of experience as a project lead.
- It is very important that you have a good insight in your critical path as it should be given more attention. You should have a good view on what is next to critical path (as well). If you plan as soon as possible, then it gives you more time. There are lots of uncertainities and risks in development phase. Make sure all risks are mitigated at the earliest.
- Pitfalls to planning are that we plan too optimistic, this may lead to scope changes. So we usually think that things will take certain time and in practice it takes longer. If things take longer than planned, these things will become automatically your critical path - so we know where to give extra attention to. Sometimes we need to plan a bit more realistic.
- I sit together with lead engineering and architects and discuss how much time we need to deliver certain milestones. We write it down on wallpaper or excel sheet and see what activities are there and how much time we need to perform these activities successfully. It gives us a certain timeframe which we want to stick to. So we review it from time to time and adjust it a little bit to see if were on track with what we estimated.
- The project was mainly time-driven. But if it doesnt work, were not successful. So scope was the most important parameter. There should be a balance between scope, timing and resources. Dependency between all the three is needed to deliver a successful project. For this project, time frame was half a year. So we need to process things as parallel as possible. Such as 50 sequential (like in parallel manner), to make sure that all scope is delivered in a shorter time frame. In effect, what youre doing is planning engineering.
- There are always uncertainties and risks that can hamper your project. We have to think immediately how to repair or save or plan as best as possible. We have to think about how to deal with setbacks. Accept them and solve them as soon as possible. Uncertainties such as - if a design/module performs the specification it should perform. One of the risks is if the expected performance will not be met or if there is a reliability issue or if the design has service-ability issue.
- Complex project needs to be made simpler. Same goes with the plan. Things can be made simple by taking away dependencies - also in planning. Plans have a lot of dependencies. For example, if were integrating modules then we test the whole system. If the system doesnt work we cannot individually check the modules. So test independently by creating an environment which does not depend on the whole system. Complex project needs multiple competencies. If there are less people, then there is less communication and the process is faster.
- I did not plan with so many details. It doesnt help if you have lots of details in the initial plan. In the beginning you just need a rough plan. Find your critical path and then spend more time on that part. Planning for more detail takes more effort. I used Excel (for planning) and the reason is it is user-friendly and that is very important. If you need a lot of skills to use a tool then we will need a lot of time for that tool. Even for complex projects planning in excel is helpful.
- Changes are a fact of life. So accept them and see what the effect/impact will be on your total plan.
- There were delays because things were not foreseen. Plan was too optimistic. Halfway we found that it needs more time and resources to work. Adjust your plan and communicate to the outside world. Communicate why youre delayed.
- We make sure that everyone is aligned by having a certain view of the project plan with some high lines and low lines. Everybody can see it and we update it every week. Project plan is continuously updated and it should reflect reality. Aligning via meetings, emails and presentations, discussions and telephone calls.

- To deal with uncertainties, we first make an overview of uncertainties or risks and rank them based on priorities. Pick up top 3 or top 5 and think about coming up with a test or analysis to check if the issue will become a risk. I built-in buffer time for high risks, i.e., what if it doesnt work, what do we do then? I try and answer that up front.
- The most difficult uncertainty to deal with is the budget estimate. If you estimate too low youve to ask for extra budget which is not easy and it may lead to delays. And if its too high they youre left with too much. Say what youre going to do and do what you say. Estimating the right budget is important.
- I identify risks by reviewing the concepts, design and specification and ask the specialists/technical people which risks do you see and then they write it down. Then, we usually rank them and see if we can contain them and how to mitigate it. We define it up front. If it occurs, we look back and see what we agreed in the past and if its still good we implement it.

Recommendations by the PL:
If you have a new development, something that has not been done before, you can always learn from your previous plans and from other people. Show it to other people so that they can help you and accept input from other people. Instead of using a certain tool, ask people. This practice is currently not employed within the ABC Company effectively.

Moreover, to deal with uncertainties, testing should be done. If you have an uncertainty or risk, best way to find out is to test it. I have my specification and I have to make my design fit the specification. The only way to meet the specifications is by testing, i.e., pilot testing, volume testing etc.

C

Cross-case examination

In this section, the cross-case examination of the interviews is done. The interviews are examined based on the three different types of uncertainties.

Table C.1: Cross-case examination based on variability in the project estimates

Interview	Variability about the project estimates
A	Take shortcuts in plan
	Scope changes due to unclear and changing specifications
	Complexity (due to dependency)
	Newer technical challenges lead to escalations
B	Changing specifications
	System blocked (delays) due to issues(unforeseen things) during work
	Only make A4 specs (shortcuts) leads to changesin plan and need to escalate
	Delays as transfer of people (due to otherescalations)
	Scope changes during integration due todependencies
	Complexity (due to dependency)
C	Plan in conflict with need-dates
	Delays due to complexity
	Accept risk and escalate in the end
	Budget bias leads to escalations
	Pull-in the plan (shift time to the front)
D	Take shortcuts in plan
	Transfer of a person without replacement
	Insufficient solution
	Complexity (due to dependency)
	Escalations due to unforeseen delays
E	Complexity (due to dependencies) delays the plan
	Did not know what to deliver
	Optimistic planning leads to delays
	Limited information for planning
	Resource allocation problems
F	Underestimation of work leads to changes in the plan
	De-scope due to unavailability of resources
	Scope changes due to unforeseen items
	More work for changes during escalations(unforeseen)
	Delays go overboard of the buffer-time
G	One person was needed for each activity (delays due to this dependency)
	Escalate when delays in the plan
H	Do not plan for risks
	Project was undoable in the allotted time andbudget (optimistic plan)
	Did not make a detailed plan
	Complexity due to development of a novel tool
	Escalations due to unavailability of people
	Plan change due to unforeseen things
	Did not have time to properly identify risks
I	Risk management not done properly
	Dont do detailed planning (take shortcuts)
	De-scoping due to unavailability of resources
	Confronted to unforeseen situations
J	Too optimistic plan leads to scope changes
	Did not make a detailed plan (rough plan)
	Accepting changes (as they come)
	Delays due to unforeseen things
	Difficult to deal with budget estimate
	Planning for newer developments is not proper

Table C.2: Cross-case examination based on uncertainty about the project design and project objectives

Interview	Uncertainty about the project design and project objectives
A	Lack of clarity on expectations influences planning
	Availability of the testing machine leads to changes
	Requirements change regularly
B	Availability of the testing machine influences planning
	Escalations from customers due to changes in priorities
C	Design changes by stakeholders
	Scope change discussions influence planning and can cause delays
D	Change in the design/ objective
	Tasks de-scoped
	Additional tasks
	Outside stakeholders not aligned
	Difference in opinions of team members
E	New floating requirements
	Continuous scope changes
F	Priorities change fast
	Scope changes due to marketing
	Project from scope-driven to time-driven (due to customer)
G	One location was put out of scope
	Scope changes by the management
H	Lot of requirements were added
	Did not know about the end-objective
	Business PL and sponsor was an issue
	Stakeholder influence hampers the planning
I	Customer expectation led to scope change
	Delays and spoiling of relations with customer due to change in priorities (internal)
	Scope changes make planning and resource allocation difficult
J	Lack of design to meet specifications

Table C.3: Cross-case examination based on variability about the relation between project parties

Interview	Uncertainty about the relation between project parties
A	Information flow was a bit vague from the upper management
	People are shy about telling delays to customers
	Improper dealing with uncertainties lead to escalations
	Teams fail to consider functional dependencies
B	Supplier backed away
	Scope change by marketing (unplanned work) without communication
C	Main drivers of the project changed continuously
	Poor exchange of information
	Upper management escalates very fast
D	Project team does not follow plan and can lead to delays
	Poor triple-constraint management
	Supplier delayed delivery
	Difference in opinions of team members
	MS Project is horrible
E	Delay in the delivery of a sub-deliverable
	Lack of role clarity on director and senior management level
	Resource allocation problems leads to changes in plan
F	People make decisions unconsciously
	Lack of role clarity
	Lack of communication leads to scope change and delay
	Planning courses do not help
G	Plan is not monitored
	Plan is not changed while scope changes
	Delay as an external party could not adapt
	Role clarity for responsibility is difficult to manage
	Project board does not know what has to be done, which leads to escalations
	Delays due to lack of quality
H	Misalignment on the main drivers of the project
	Everybody was pointing at each other as project was cancelled
	Project governance is a problem as they cannot provide proper help
I	People might not work according to plan
	Delays in obtaining budget and resources after scope changes
J	Used Excel as MS-Project needs more skill

D

Inference of the issues from the interview responses

For the purpose of data analysis, the interview responses were transcribed and documented. Based on the inferences drawn from the interviews, issues were obtained. The issues are inferred from the responses and comments received during the interviews. Some of these comments used for deducing the issues are as follows:

1. Scope changes:

Table D.1: Comments on Scope changes

PL	Comments
A	"Project planning suffers from the uncertainties which occur along the way which lead to scope changes" "Requirements and specifications are very liquid in the daily operation, i.e., they can change quite often"
B	"There can be some scope changes during the integration project due to dependencies" "Marketing team is also talking to the customer, sometimes marketing promises additional functionality with time before asking it to the respective teams. This is unplanned work or scope change"
C	"Most of the times, you have an incident, design failure or stakeholder whose specifications are changing/ need to re-design (this affects the plan)"
D	"Some tasks are de-scoped based on the business case" "If they (stakeholders) define new deliverable, then I say that I do not have people or cost"
E	"There are lot floating of requirements and as long as you find out (what has to be done) there are more requirements which you cannot postpone and you really need it"
F	"Request from marketing (indirectly request from customer). What you are making is not enough. Typically (request) starts at the customer; the other side is when you encounter technical issues (then you have changes)"
G	"One major change in my plan was a decision at (X) location to put the work out of scope"
I	"I needed 20 people in the first half-year, but we got 15-17 (almost the entire claim was got). But in the later stages (you want 15 but got 7), which leads to cutting down on scope" "Initially we proposed to operate it at one fixed setting. Then after a month a customer came and wanted to operate it at a different setting. The implementation is a lot more work for that. Initially it was not in the scope of the project"

2. Project delays:

Table D.2: Comments on Project delays

PL	Comments
A	"The current project is an integration activity. Original plan was 6 weeks but it is taking 13 weeks (to conduct a test). The reason is uncertainties." "In ABC Company, people are shy about telling delays, but you should tell what you are doing to the customer."
B	"They (Team Leaders) make an estimate of the A4 specification. But, when they actually start writing down the work that has to be done, they realize that they did not consider certain sub-steps in their process (and the time required for that). This impacts my project planning."
C	"Scope changes and scope discussion influence my planning and can cause delays" "..there are so small delays on each item that you do not change your plan. But if you count them, there are so many that it leads to weeks of delays"
E	"Sometimes it is pretty difficult to make a detailed plan with very little information and this is the reason why often we get it (plan) wrong" "The plan delayed mostly all the time because we had dependencies in all the departments"
F	"Not taking enough buffers, for coffee breaks, lunch breaks etc.; small questions from colleagues (to help them) take a lot of time as well, may lead to delays in the plan" "I encountered delays because of unforeseen items as scope changes and unexpected items. No planning finishes on time, takes twice as long (typically because of added scope)"
G	"There were delays in location (Y) due to an external party who had to do process stuff, but there was a problem with adaptation"
I	"You go through the RFF and you think that you have the budget; then suddenly somebody says later that we are going to do it differently, this spoils the relation between you and the customer and one week before you start you say that I don't have money for you. This causes delays"
J	"There were delays because things were not foreseen. Plan was too optimistic"

3. Project escalations:

Table D.3: Comments on Project escalations

PL	Comments
A	"If you don't deal with uncertainties on a weekly basis or don't consider the risks in the IRR, then there are escalations"
B	"Changing priorities due to the fact that there are escalations from the customers (this is difficult)"
C	"Also for the KD (key-decision) moment I have to agree upon how much risk I should take. We agree on this KD moment and comment on the risk for the go or no-go moment. We need to escalate in the end."
D	"If there are unforeseen delays, if there is a problem in the field (highest priority), then it is escalated! It should go via the PL/ TL. If two people get the change requests, then later you discover that they have done the same work. You should follow the path from the TL/ PL. (During escalations)"
G	"If I have a problem on the critical path, then I go to the project board and escalate" "Sometimes you have ad-hoc uncertainties or issues. Sometimes you have to escalate and you have to see how managers adapt along the way"
H	"There were escalations as people were just pushing all the time (they were unavailable as well)"

4. Lack of governance:

Table D.4: Comments on lack of governance

PL	Comments
A	"..the information was a bit vague from the upper management(according to me)"
C	"We are not good at the feedback loop" "We have time pressure and on top, upper management tells that they do not have budget and they escalate very fast"
E	"If I am stuck with something or to get a task done; if I ask for help then I don't necessarily get help"
G	"Project board should know what has to be done. It should have a better governance" "..governance bodies should have contingencies for these (risks and uncertainties)"
H	"Project governance is a main issue at ABC Company" "Support! (Governance) is one thing which is lacking. If you are in trouble, you have to go to the project board for help. But they are also not in control and cannot help"

5. Complexity:

Table D.5: Comments on complexity

PL	Comments
A	"Impact of complexity is gigantic. If it were a standard product, then you can plan it with a little bit more knowledge. Complexity has been completely running in the project which brings a lot of stress on the team and the management"
B	"This product is based on another product which is not completely new. In this case, hardware-wise there is a complete new module and this influence of the complexity of the hardware impacted the plan"
E	"The impact of complexity was pretty significant. The project was challenging and complex in few areas for e.g. technical challenge and complexity that it involved was to get everyone to understand how it works"
H	"The complexity of the project was that analytics engineering (which we were trying to build); the architecture did not take time for that. There was a lot of disagreement for the best solution (customization and things like that)"

6. Budget issues:

Table D.6: Comments on budget issues

PL	Comments
C	"Most difficult uncertainty is budget discussions"
H	"I took over a project. My predecessor said yes to the project (said yes to small amount of time and money). When I got involved then I realized that it was undoable. When people go to the stakeholders or executives, main discussion to counter (the time and budget they are getting) is to say that this (amount) is the time and money that I am going to do it in. Not saying yes too quickly (otherwise you are in fix)"
J	"The most difficult uncertainty to deal with is the budget estimate. If you estimate too low you've to ask for extra budget which is not easy and it may lead to delays. And if it's too high they you're left with too much"

7. Lack of communication:

Table D.7: Comments on lack of communication

PL	Comments
A	"In ABC, people are shy about telling delays, but you should tell what you are doing to the customer" "Tried to ask it top-down so as to know the project end-date. Asked also because the information was a bit vague from the upper management(according to me)"
B	"Marketing team is also talking to the customer, sometimes marketing promises additional functionality with time before asking it to the respective teams"
F	"Sometimes, you are not informed as a PL; even if new requests are coming-in. PDM commits something without informing the PL"

8. Insufficient buffers:

Table D.8: Comments on insufficient buffers

PL	Comments
F	"Even though, buffer time was built, but once it starts delaying then it goes overboard the buffer. People think that it is insane and you don't want to do it. You cannot take all the buffers for the unforeseen. Sometimes you don't scratch the buffer but the scope"
H	"People put buffer-in, and they remove the buffer to say that we finish earlier" "I did not encounter delays as such because from my experience I put in contingencies that's why no delays. I filled up buffer of double the time (as it was not a time-driven project)"
I	"By the time that the project gets to know that you have a problem you are already too late! You do plan with buffers, but there are always exemptions that can occur"

9. Insufficient MS Project skills:

Table D.9: Comments on insufficient MS Project skills

PL	Comments
A	"I used Excel to make a project plan than MS Project. I tried in my previous project to make the schedule on MS Project, but we realized that we were making more logistical and not technical dependencies"
F	"I am not using MS project, it is horrible. Courses did not help; you get stuck in the program. PMO also get stuck in the program"
J	"I used Excel (for planning) and the reason is it is user-friendly and that is very important. If you need a lot of skills to use a tool (MS Project) then we will need a lot of time for that tool."

10. Lack of role clarity:

Table D.10: Comments on lack of role clarity

PL	Comments
E	"At the project board level it was unclear and they did not really understand their roles. At the director level and the senior mangement level the roles are pretty unclear"
F	"Role clarity and communication should also change"
G	"Most difficult uncertainty is where there is no one responsible for it. If there is a functional problem then functional guy solves it. But, the areas where we do not know who is going to manage that, it is the toughest"

11. Too detailed planning:

Table D.11: Comments on too detailed planning

PL	Comments
D	"One of the pitfalls of planning is the plan being too detailed. Daily and hourly plan should be properly aligned"
I	"Biggest pitfall of planning is to go into too fine detail of planning. I think that project planning should be a guideline for what you are doing and the intermediate milestones where you have to reach. More detailed plan is not of added value for me. I see added value for bigger work packages (milestones). In dynamic case of ABC Company it gives false security. You can write (work to be done) on the plan but people won't do it tomorrow"

12. Poor triple-constraint management:

Table D.12: Comments on poor triple-constraint management

PL	Comments
C	"We never do triple constraint decisions correct in the program. At this program, the timing is always fixed. We see more discussion about scope and budget."
D	"Managing the triple constraint is difficult. Initially, it is about what is in and out of scope. If you have delays, then you have to deal with it by changing the scope. If they (stakeholders) define new deliverable, then I say that I do not have people or cost. If I get cost then I can give it to external parties or outsource it. At the end of last year, we decided how much people and budget we get. Resources and budget, including time are fixed which leads to scope (in or out scope). We had to accept two additional tasks. Some tasks are de-scoped based on the business case. Once you are clear on the budget and resources then you have to execute"

13. Lack of time to plan:

Table D.13: Comment on lack of time to plan

PL	Comments
B	"Most of the times, you don't have time to prepare your plan before you start working on your project (integration plan)"

14. No time for risk assessment:

Table D.14: Comment on no time for risk assessment

PL	Comments
H	"We did not have time to properly identify risks. We did not have a good risk roll"

15. Insufficient masterplan:

Table D.15: Comment on insufficient masterplan

PL	Comments
A	"Better dealing (with uncertainties) at the program level than the project level. The masterplan and the IRR should be maintained at this level, because uncertainties are more visible at the higher level. For many reasons it is happening too little"

E

Testing workshops

The proposed solution was tested by five people belonging to different functional departments and different hierarchical levels in the organization. 3 testing meetings were conducted. One program manager and two managers from the structural improvement department were invited together to test the soltuion (in one meeting). Two other meetings were conducted of a PL and a TL belogning to the technical department-2. The respondents were asked questions for validating the proposed solution. The responses of the participants are shown below:

1. Can you confirm whether each of these techniques are solving the problems and helping manage uncertainties while project planning?

   The PL and TL confirmed that the proposed way of working can help manage the uncertainties while planning.

   From the discussion between the three senior managers from the structural improvement department it was seen that this way of working is suitable to the engineering types of projects but they expressed their queries on the use of this model for the organizational development projects. One of these three respondents mentioned that engineering and technical risks are easier to recognize in comparison to the risks that can occur in the organizational development projects. The organizational development projects involve the non-technical risks. They also stated that, different departments have different projects and different ways of working. Hence, it has to be investigated how this framework can be adapted to each project.

2. Should something be introduced/ removed and/or changed within the boundaries of the proposed procedure? Would you re-structure it? If yes, how?

   All the respondents stated that stakeholder management should be done after each SRA, i.e., before the inititation of the project and also before each RFF process. They also stated that stakeholder management should be done just before the project completion as the influence of the stakholders near the completion of the project is very high. They stated that in the ABC Company, the stakeholders may change during the execution of the project. Hence, identifying the stakeholders and communicating the status of the project before each RFF is imperative. Moreover, the stakeholders should also be aligned just before the completion of the project, to agree-upon the final deliverable. This is because, the stakes and priorities of the stakeholders are very high near the project completion and they should be managed before the completion of the project.

   Furthermore, the PL also stated that lessons learned should be documented twice a year (before going into the RFF) so that newer developments can be known to the project team members as

well as the upper management. Documenting these lessons learned at each project phase facilitates in aligning on the scope and the objectives of the project.

3. The techniques mentioned in the proposed solution are not new as they are present in the academic literature, then why is there a limited use/ are not used by the practitioners themselves?

   The managers from the structural improvement department stated that this is a golden question within the ABC Company and needs to be dived into deeper. They stated that the use of risk management and SRA is an eye-opener and needs further investigation.

   The PL from the technical department-2 stated that these tools and techniques have a limited use due to the complexity of the organization and also on the stakeholders involved in the project. People have to adapt to the project and have to remain flexible. This limited use also depends on the background and the problems that a PL has experienced with his previous projects. Hence, they adapt and remain flexible in their way of working.

   The TL stated that some departments are already working towards this proposed solution. In the ABC Company, people always try to do these things faster and in a shorter timespan. This hampers the quality of the end product. Patience is required for using such tools, and if used properly, then it can provide excellent results.

4. Are there any parts of the problems that this proposed design procedure cannot solve?

   The respondents stated that the changes outside the circle of influence of the project have to be accepted. The proposed design solution would work at the project level, but not outside the boundaries of the project. If there are internal scope changes and delays then this design procedure can solve it. But changes and requests that happen due to the customers and upper management (later in the project) are prioritized and should be looked into. A manager from the structural improvement department mentioned that this procedure would not work at the portfolio level as there are a lot of dependencies between projects at the portfolio level which cannot be foreseen. Management of the portfolios is different to the management of projects.

5. What would you recommend to reduce and manage the uncertainties while project planning, in addition to the proposed design solution?

   The PL and the TL from the technical department mentioned that this design procedure should be adopted properly into the way of working and did not recommend any further changes. People should pro-actively look for risks and uncertainties and try to put them in their process of work. The TL further mentioned that people should do their jobs more seriously and that the PL running the project should be an expert in that particular domain of work.

   Two of the senior management employees from the structural improvement department did not mention about any additional changes to the proposed model. However, one manager from the department mentioned that cross-sectorial alignment of projects at the portfolio level should be done upfront to account for the risks and uncertainties.

6. Do you think that the current working culture within the ABC Company is suitable for implementing this model? If not then, then why? What would you recommend to be done beforehand to implement it within the ABC Company?

   The upper management employees from the structural improvement department stated that, risk management has to be established first, before commencing the practice of schedule risk analysis.

Risk management workshops should be conducted. Once the risks are identified for the project, then separate sessions should be conducted to incorporate these risks into the schedule.

The PL from the technical department-2 stated that this solution can be implemented in the way of working of the ABC Company. He stated that this is a right step in a very long process and termed it as the beginning of a baseline for managing risks and uncertainties. He further mentioned that, further work needs to be done to implement this proposed design procedure into the organization. The PL also pointed out that according to him, this design procedure should be implemented in phases, starting with lessons learned and stakeholder management. He argued that lessons learned from other projects are not readily available to everybody and it is very difficult to find lessons learned from different projects on the company portal. He further mentioned that only the technical knowledge is documented in the lessons learned practiced within the company and mentioned about the need of having project management lessons learned in the company as well.

The TL mentioned that some people in the design and engineering department of the company are already working towards this proposed way of working. He mentioned that if everybody executes this proposed solution in their way of working, then the identified problems can go down.