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Norwegian University of  
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# Conflicting Objectives in Interfaces of Construction Project

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Safety, Health and Environment

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# MASTERKONTRAKT

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Oppgavetekst/Problembeskrivelse Companies today live in a very aggressive and competitive environment, which would motivate the decision makers only focus on short term financial and survival criteria rather than long term criteria concerning welfare, safety and environmental impact. An increased focus on efficiency and cost reduction that has been prioritized ahead of safety can consequently be seen as a root cause of the accident.  The objective of this master thesis is to study the conflict that can occur between safety and efficiency/economy in interfaces among different stakeholders in the construction industry. Based on the study of construction industrial experiences and relevant literature, recommendations on how organizations should handle conflicting objectives between safety and efficiency/economy will be given.	
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**Student:** Jeg erklærer herved at jeg har satt meg inn i gjeldende bestemmelser for mastergradsstudiet og at jeg oppfyller kravene for adgang til å påbegynne oppgaven, herunder eventuelle praksiskrav.

Partene er gjort kjent med avtalens vilkår, samt kapitlene i studiehåndboken om generelle regler og aktuell studieplan for masterstudiet.

Trondheim 02/04.2014  
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# Preface

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This master thesis is the final work in the two years' master programme in Health, Safety and Environment (HSE) at Department of Industrial Economics and Technology Management in the Norwegian University of Science and Technology (NTNU). The assignment is carried out in the spring semester of 2014.

With the background of Construction Civil Engineer, the purpose of choosing this study was an interest to learn more about safety management in the construction industry. Working on this study has made me to realize the complexity and challenges of HSE management. This work has contributed to extensive learning, and to an increased interest in this field of study.

I would like to thank my supervisor, Professor Eirik Albrechtsen, at the department of Industrial Economics and Technology Management at NTNU. I am very grateful to thank you for giving me many good and constructive advises and guidance during the writing of my master thesis, and spending time to read through my work at last. Words fail to describe how much I appreciate all the help you have given me. I also would like to also thank Eunike Sandberg, PhD candidate at NTNU, for helping me to contact with the construction companies and organize the interview.

Furthermore, I would like to thank everyone participated in the interviews. I am very glad, and thankful for all the valuable information and insight, which have contributed to great research material.

Finally, I would like to thank my family and my friends for helping me throughout this process. Especially I am grateful to thank my husband for supporting my work and taking much time to take care our baby.

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Trondheim, 11 June 2014

# Abstract

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As a high hazard industry, it is important to pay high attention to the health and safety of the working. Nowadays, with the fierce market competition and the complexities that construction projects face, the presence of multiple and conflicting objectives that needs to be achieved for the successful completion of the project objectives has been impact on safety.

This master thesis is a follow-up study on the project study in last year on the interface management. Considering the multiple interfaces in construction projects that would appear among various involved parties, the objective of the thesis is thus to study the conflicting objectives between safety and economy/efficiency in interfaces between different stakeholders in the construction industry. As guidance, three research questions have been conducted, which include what kinds of conflicting objectives can occur in construction projects, why the conflicting objectives occur and how to deal with them.

In the search of answering the research questions mentioned above, the existing theories have served as a tool to get deeper insight into safety and accidents, conflicting objectives that are usually described as a conflict between safety and production, and the approach to handle conflicting objectives. In order to acquire more knowledge and understand the current situation of the construction industry that how conflicting objectives impact on safety, comprehensive literature review is presented. Further, the empirical study is carried out by e-mail interview. The results are further analyzed and discussed based on the theory study and literature review. The finding shows that the five critical conflicting objectives are time, cost, quality personnel/interest, and safety. Combing with the knowledge of interface management, the causes of conflicting objectives are discussed in terms of the three types of interface problems, which are physical, contractual and organizational. With understanding of the causes, then the recommendations are introduced in both theoretical and practical way to handle conflicting objectives.

The conclusion suggests that conflicting objectives can be handled by following the theory and making good scheduling and planning, and also building a safety culture. However, to do a more comprehensive research on conflicting objectives needs to apply theoretical measures into the practical work, and conducting an in-depth investigation in the future.



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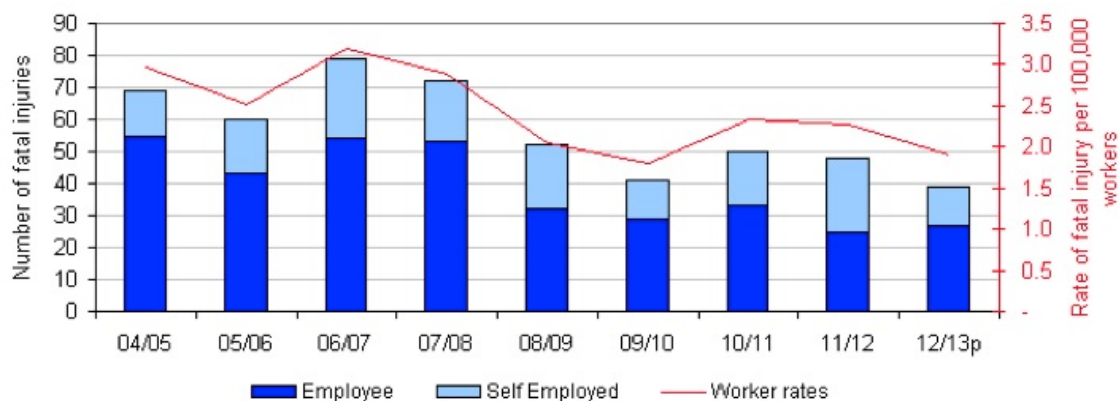
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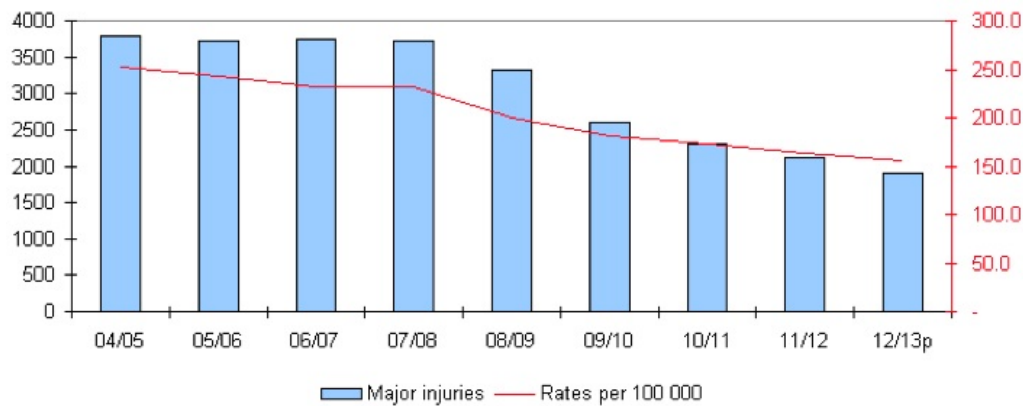
# 1 Introduction

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The construction industry, as one of the most important industrial sectors, contributes significantly to GDP and, on the other hand, it remains a high hazard industry that impacts on the health and safety of the working, even though there have been significant reductions in the number and rate of injury over the last 20 years or more (Health, Safety and Executive, 2013). According to Health and Safety Statistics for 2012/13 of Health, Safety and Executive (2013) shown in Figure 1.1 and 1.2, the rate of fatal injury per 100 000 construction workers was 1.9 in 2012/13p compared with a five year average of 2.3. There also has been a general reduction in the rate of reported major injury since 2004/05. The number of reported injuries has also fallen significantly over the last five years. However, in 2012/13p, 26% of all fatal injuries to workers were in construction and it accounts for the greatest number of fatal injuries of the industry sections. The fall in reported major injuries over the last two years is similar to that for all industries, but it was significantly higher in the previous three years (Health, Safety and Executive, 2013). In order to reduce the rates of accidents and injuries on the construction site, the labor unions, employer organizations and different governmental institutions need to pay attentions to the importance of the safety in the construction industry and spend a substantial effort to actively involve and make progress in this field.



**Figure 1.1: Number and rate of fatal injuries to workers in construction (Health, Safety and Executive, 2013).**

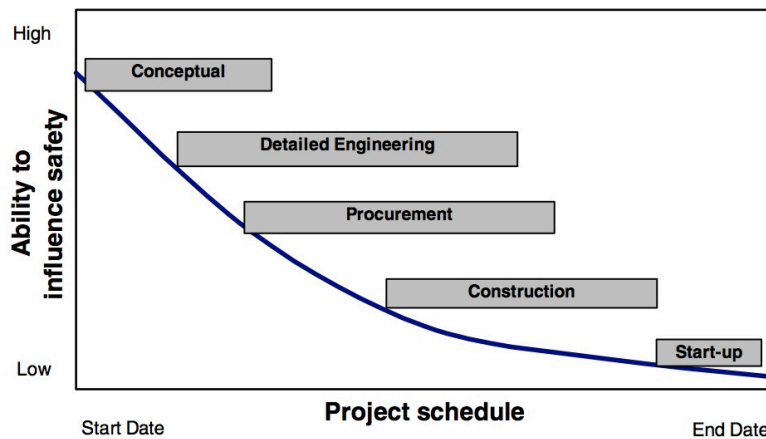


**Figure 1.2: Number and rate of major injuries to workers in construction (Health, Safety and Executive, 2013).**

In the construction industry, as well as in any high-hazard industries, the safety is always an investment that provides real benefits. A safe work environment helps to keep skilled employees on the job and projects on the track by reducing accidents that could result in injuries and schedule delays, while also reducing the risks of litigation and regulatory action. A strong safety record enhances a company’s reputation, makes it become more competitive and reduces the insurance costs over time. Fostering a successful safety culture, however, is a company-wide effort that requires commitment and participation from the chief executive to project managers, superintendents, foremen and individual workers on the job site. That commitment should also extend to the selection of subcontractors who also embrace a strong safety ethic, particularly when a company is using a construction wrap-up insurance program.

It is known that the projects start well before ground is broken. Safety should be part of the process right from the very beginning. As shown in Figure 1.3, Szymberski’s time-safety influence curve (Szymberski, 1997) illustrates how safety can be influenced to the greatest extent in the early phases of a project. To establish a safer workplace, construction companies could collect the extensive knowledge of risk management experts who are well versed in their industry. Project planners should also work with their insurers to plan and determine the most effective risk management strategies before a project begins and while it’s being constructed. Once a project begins, safety should be a part of every employee’s job, every day.

With the fierce market competition and the complexity of construction project, the conflicts between different objectives have been impact on safety. This chapter will give a briefly introduction on the importance of the study on conflicting objectives in construction industry, covering the background, aims, research questions and the structure of the thesis.



**Figure 1.3: Time/Safety Influence Curve (Szymberski, 1997). The ability to influence safety diminishes as schedule goes to end.**

## 1.1 Conflicting objective in dynamic construction Industry

According to the study by Chan et al. (2004), the construction industry is dynamic in nature due to the increase of uncertainties in technology, budgets, and development processes. Compared with the past situation, the present dynamic industry experiences some dramatic changes in the conditions of industrial risk management (Rasmussen, 1997). Changes may come in forms of new legislation and regulations, new construction technology, and the rapid development of information and communication technologies, which lead to a high degree of integration and coupled systems. Afterwards the effects of a single decision can have dramatic influences that propagate rapidly and widely through the global society. Moreover, companies today live in a very aggressive and competitive environment which would motivate the decision makers only focus on short term financial and survival criteria rather than long term criteria concerning welfare, safety and environmental impact. While an increased focus on efficiency and cost reduction has been observed recently, and question of whether this has negative effects on the prioritization of safety or not was also raised (Høyland & Aase 2008; Aase et al. 2008). The answer is actually “yes” and can be seen in the following two cases.

In 1912, the sinking of the Titanic shook the world. It was great publicity surrounding the ship's first voyage and the company therefore wanted to surprise the world by having her arrive in New York on her maiden voyage two days ahead of schedule. As a result, despite the observation of icebergs, the vessel maintained record-breaking speeds, which obviously made it much more difficult to avoid the collision. Many people asked later the question of why an experienced captain allow such high speeds despite the risk. The answer probably depends on whether in practice the captain was in a position to say no. Under the commercial pressure, either explicit or implicit, the

captain has to undertake operations which may compromise the safety of the ship. In a competitive market, goods must be delivered efficiently and timely, and there would be the situations where complying with requests for delivery which will risk the safety of the vessel. So conflicts may develop at senior management level because of the perception that resources must be allocated on an "either/or" basis to conflicting objectives: production (i.e. delivery of services) and safety (i.e. considerations of safe operation).

In the Norwegian civil aviation transport system, conflicting objectives have shown to be part of the causal explanations of several serious aviation accidents. Analysis of accident investigation reports has revealed that in the Skagerrak accident (1989, 55 fatalities), pressure to uphold flight program due to a critical company economy was part of the accident picture. In the Namsos accident (1993, 6 fatalities), the investigation board recommended that the airline company's board of directors and top management clarified their principles for safety priority versus regularity, timeliness, and economy (Tjørhom & Aase, 2010).

Major accidents have been chosen to categorize as organizational- or system accidents (Reason, 1997; Hollnagel, 2004). To prevent these types of accidents, there have been a lot of researches on the significance of the so-called human and organizational factors (Reason, 1997). Conflict between production and safety is believed to be an important explanation (Reason 1997, and Rasmussen 1997). Although this issue has been a topic of accident research in general, it has not adequately been addressed in the construction industry. The study based on many investigations of major accidents in both construction industry and other industries shows that economic has been prioritized ahead of safety, which can consequently be seen as a root cause of the accident (Vaughan, 1996; Schiefloe & Vikland, 2007; Wackers & Coeckelbergh, 2008). Therefore, the issues of handling conflicting objectives must be taken on the agenda.

## **1.2 Purpose of study**

Nowadays, as one of the main complexities that construction projects face now, the presence of multiple and conflicting objectives needs to be achieved for the successful completion of the project (Burns et al. 1996). At the mean time, there are numerous parties involved, directly or indirectly, and multiple interfaces in construction projects would appear among various contractors, engineering teams and owners, as well as, contractors and manufacturers, contractors and subcontractors. Combining with the previous study of interface management, the present master thesis aims to investigate the conflicting objectives between safety and economy/efficiency in interfaces



between different stakeholders in the construction industry. Based on the study of construction industrial experiences and relevant literature, recommendations on how organizations should handle conflicting objectives between safety and efficiency/economy will be given. The main tasks of this thesis are therefore to:

- Review theory and literature on conflicting objectives in different interfaces in order to acquire basic knowledge on the study.
- Perform empirical case studies to identify and understand conflicting objectives in construction projects, and analyze the results.
- Compare the literature review and the empirical study, and make a discussion according to the findings and results.
- Give recommendations on how organizations should deal with conflicting objectives.

### **1.3 Research questions**

In the effort to improve job-site safety, the construction industry faces some headwinds from economic pressures as well as longstanding cultural issues. In a sluggish economy, competition to win projects has been enhanced, as increasing the pressure on pricing reduction and in the same to complete project within shorter time. However trying to decrease costs by cutting corners with safety is actually a false saving that one accident can far outweigh all of the perceived savings. This situation can be easily understood because we live in an open market economy. Risk control, risk management and safety performance often require considerable resources such as money, time, and competent personnel. When humans or groups are facing such a dilemma, they may make risky choices. Moreover, they may drift over time under the pressure of conflicting objectives. As written by Rosness et al. (2010), “*It is impossible to give a balanced view on organizational resilience without considering how organizations handle conflicting objectives*”. Above all, the research questions of the present Master thesis are extracted based on the previous discussions and listed as follows:

- *What kinds of conflicting objectives can occur in construction projects?*
- *Why do the conflicting objectives occur?*
- *How should we deal with the conflicting objectives between safety and economy/efficiency in interfaces between different stakeholders?*

## **1.4 Structure of the thesis**

This master thesis is divided in eight chapters including references. In Chapter 1, background, purpose of the study and research questions are introduced. Chapter 2 gives a description of the thesis structure and design, together with the different methods used during data collection. Chapter 3 will present theories relevant to solve the master's thesis research question. The theories are used as a foundation for the results and the discussion chapters. Chapter 4 reviews the relevant literature on conflicting objectives. This includes the current situations related to safety issues, the common conflicting objectives in construction industry and the underlying causes of conflict will be described. The results and analysis of the interviews are presented in Chapter 5. Combining with the literature review in Chapter 4, the interview results in Chapter 5 will be deeply discussed in Chapter 6. This discussion makes the foundation for the conclusion drawn in Chapter 7. Chapter 8 presents the sources used in this master's thesis.

## 2 Research Methodology

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Research methodology is those techniques and procedures used to collect and analyze research data (Saunders et al., 2009). The purpose of this chapter is to explain how this thesis was conducted. In order to increase the reliability of the work and make it possible for the reader to understand the work conducted, this chapter will focus on presenting research design and research approach including data collection which explains the choice of sources, and the interview process. Further, the data analyzed are presented, in addition to reliability and validity. According to the book of Bryman (2008), the research process of this thesis is illustrated as Figure 2.1.

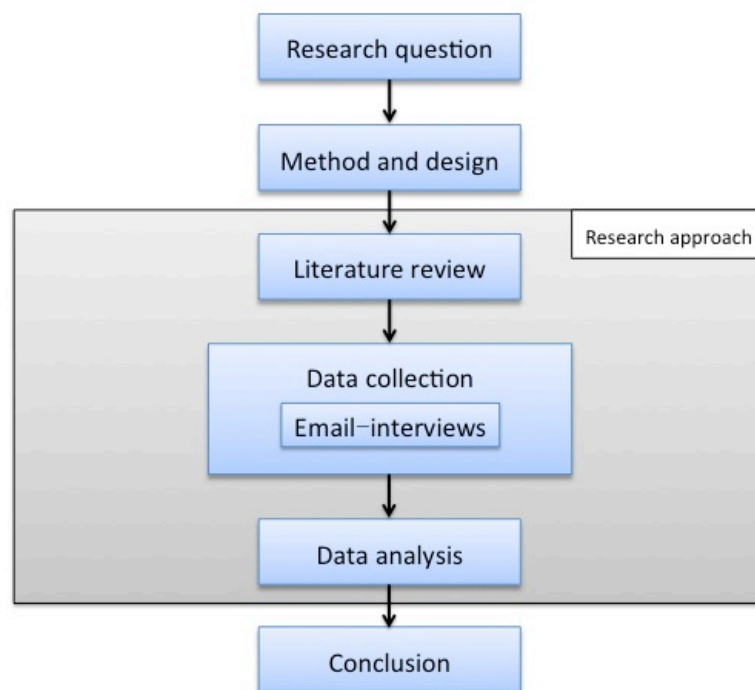


Figure 2.1: Research process of this study.

### 2.1 Research design

The research design is the general plan of how the research question is answered (Saunders et al., 2009). According to Ringdal (2009), a design is the researchers plan, or sketch for an investigation. There are many different designs, which can be used, dependent on the purpose of the research study. According to Goddard and Melville (2004), though each research study has its own specific purpose, research purposes may be grouped into four categories, which are exploration, description, diagnosis, and experimentation. The purpose of this study is to study the conflicting objectives

in the interface of construction stakeholders. This includes the exploratory and descriptive research studies. This part will give an introduction of the two research studies.

*Exploratory research* might involve a literature search or conducting focus group interviews (Goddard & Melville, 2004). The exploration of new phenomena in this way may help the researcher's need for better understanding, may test the feasibility of a more extensive study, or determine the best methods to be used in a subsequent study. For these reasons, exploratory research is broad in focus and rarely provides definite answers to specific research issues. When the explorative study is carried out, the describing part of the study is put into action. As its name suggests, *descriptive research* seeks to provide an accurate description of observations of a phenomena (Goddard & Melville, 2004). The object of the collection of census data is to accurately describe basic information about a national population at a particular point in time. The objective of much descriptive research is to map the terrain of a specific phenomenon.

Since the study on conflicting objectives between safety and production of construction projects in Norway is not something which has been studied to a large degree earlier, this needs to start with an explorative research study to be able to get an overview on this field. This was performed by a literature review. After completing these literature reviews, with qualitative research approach which investigates the why and how of decision making, e-mail interviews with experts in construction company were carried out to get more in the field about the theme.

## **2.2 Literature review**

Robinson and Reed (1998) defined a literature review as “*a systematic search of published work to find out what is already known about the intended research topic.*” A literature review serves many important purposes, including establishing the need for the research; broadening the horizons of the researcher; and preventing the researcher from conducting research that already exists. Aitchson (1998) supports the view that a literature review allows the researcher to find out what has been done in terms of the problem being investigated - to ensure that duplication does not occur.

The literature review for this thesis was carried out to provide the information relating to conflicting objectives that impact on occupational health and safety, and handling of conflicting objectives. Most of the literature was discovered on the Internet through different type of sources. In order to obtain different journals, books, scholarly literature different search tools and databases have been used, Google, Google Scholar, NTNU University Library and Science Direct. Articles and books from

attended courses mainly *Safety Management* has been taken into account, as they have given background material for this assignment. Supervisor has also recommended relevant literature on occasions.

## **2.3 E-mail interview**

According to Bless (2000), the main types of qualitative data collection methods include non-participant observation, participant observation, interviews and questionnaires. The decision to use interviews as a data gathering method was influenced by Ely et al. (1991), who maintained that “*qualitative researchers want those who are studied to speak for themselves, to provide their perspectives in words and other actions.*” Interviews are very useful because highly specific data can be obtained in a very short space of time. The interview is also useful in providing a general overview of people's thoughts. Nowadays, however, researchers have identified challenges associated with the observation and in-depth interview methods, including cost, time, and limited access to research participants (Denzin & Lincoln, 2005; Gubrium & Holstein, 2002; Miles & Huberman, 1994; Kvale, 1996). Challenged with the task of identifying new methods or tools for conducting more effective research while retaining or improving quality, researchers started to explore using the Internet for carrying out qualitative research.

According to Meho (2006), the types of Internet-based qualitative research methods can be divided into online synchronous interview, online asynchronous interview and virtual focus groups. The study of this thesis uses online asynchronous interview. Online, asynchronous interviewing is usually conducted via e-mail, which it is also called e-mail interview. This part will present the reason of choosing e-mail interview and how the interview was conducted.

### **2.3.1 Reason for e-mail interview**

There are many benefits using e-mail interview as a qualitative research method (Meho, 2006). One of the main reasons that I choose it is that the e-mail interview allows both interviewers and participants who do not or cannot express themselves as well in talking as they do in writing. Another reason is that e-mail interview costs considerably less to administer than telephone or face-to-face interviews, since this study was conducted with participants who worked in different cities. Interviewers can invite participation of large or geographically dispersed samples of people by sending them e-mail messages individually or through listservs, message boards, or discussion groups, rather than making long-distance telephone calls, using regular mail, or traveling to the location of participants. The use of e-mail in research also

decreases the cost of transcribing (Meho, 2006). Data from e-mail interviews are generated in electronic format and require little editing or formatting before they are processed for analysis.

E-mail interviewing offers an opportunity to access, in an interactive manner, participants' thoughts, ideas, and memories in their own words. It allows the recording of many anecdotes that participants share to enhance the accounts of their experiences. It also allows participants to construct their own experiences with their own dialogue and interaction with the researcher. E-mail interviewing is additionally empowering to the participants because it essentially allows them to be in control of the flow of the interview (Bowker & Tuffin, 2004), enabling them to answer at their convenience and in any manner they feel suitable (Kennedy, 2000). Levinson (1990) considers that the asynchronous electronic communication's capacity to provide opportunity for reflection and editing of messages before sending them contributes to the production of a closer fit between ideas, intentions, and their expression in writing.

### **2.3.2 Conducting of e-mail interview**

The e-mail interview was performed with eight participants who had responded in the thirty-three invitations. According to the task of this study and the suggestion of my supervisor, the number of respondents was sufficient for future analysis. In the 27<sup>th</sup> mars, the interview guide was sent together in one e-mail, including the invitation for participation, background information about the interviewer, instructions of the research and the interview schedule, irrespective of their geographical location or time zone. This method eliminates the need for synchronous interview times and allows researchers to interview more than one participant at a time. However, the time period to collect e-mail interview data lasted in three weeks, because the number of respondents was insufficient after the first round of interview which has been lasted in two weeks that five people gave the responses. To ensure sufficient participation, reminders were sent to those who did not reply to initial invitations. Then the second round has taken one week and three people responded.

As in face-to-face and telephone interactions, most e-mail interview-based studies use an interview guide for data collection, which can be explained as semi-structured interviews. In this kind of interview, the interviewer develops and uses an 'interview guide.' This is a list of questions and topics (shown in Appendix A) that need to be covered during the conversation, usually in a particular order. The semi-structured interview guide provide a clear set of instructions for interviewers and can provide reliable, comparable qualitative data. Many researchers like to use semi-structured interviews because questions can be prepared ahead of time. This allows the

interviewer to be prepared and appear competent during the interview.

The interview guide was decomposed into several sections and a certain number of questions were asked at one time. The e-mailed questions must be much more self-explanatory than those posed face-to-face, with a clear indication given of the responses required (Meho, 2006). Because of lack of face-to-face or direct interaction in e-mail interviews, there is always room for miscommunication and misinterpretation. Therefore, managing this methodological dilemma requires meticulous attention to detail of making questions, with attempts to reduce ambiguity and improve specificity while avoiding the narrowing of participants' interpretations and constraint of their responses. According to Bowker and Tuffin (2004), restricting some of the ideas chosen for analysis will be inevitable, but it is very important and necessary to minimize participants' confusion and eventual frustration by specifying the meaning of interview questions. In this study, the questions of the e-mail interview have been modified in almost three times with the suggestions of the supervisor. In the overview of the responses, it has shown that all the participants understood the questions because all the explanations of the participants were clear.

## **2.4 Analysis of empirical data**

Data analysis is an important part of every assignment, and needs to be done accurately in order to get the correct information from the data collection phase. After the empirical data from the e-mail interviews were collected, in order to analyze the data, questions and answers were translated into English, which prevented the analysis from using direct quotation. When carrying out the analysis, the data material was organized by creating different paramount themes where this was possible. In most interviews, there were certain aspects which was not covered by other interviews. This means lack of generalization, however, it also provided with various input and viewpoints on several themes.

In this study, the data material was analyzed by establishing categories, applying these categories to raw data through coding and tabulating. The unwieldy data was condensed into a few manageable groups and tables for further analysis. The raw data was classified into some purposeful and usable categories. According to Goddard and Melville (2004), editing is the procedure that improves the quality of the data for coding. With coding the stage is ready for tabulation. Tabulation is a part of the technical procedure wherein the classified data are put in the form of tables. In the analysis of data, a theme-based approximation in thread with Thagaard (2009) was used, which means that a comparison of information was made based on each theme for all informants. The main point was to attain a deeper understanding for each

theme across the study objects, and at the same time look at similarities and differences.

## **2.5 Quality of empirical data**

When carrying out this research, an emphasis was made on securing good quality in the data collected. According to Denscombe (2003), the quality of responses gained through online research is much the same as responses produced by more traditional methods. The same conclusion was reached in several studies that compared, or conducted, both e-mail and face-to-face interviews (Curasi, 2001; Meho & Tibbo, 2003; Murray, 2004; Murray & Harrison, 2004). These studies found that participants interviewed via e-mail remained more focused on the interview questions and provided more reflectively dense accounts than their face-to-face counterparts. This means that the benefits of the e-mail interview are highlighted, which was possibly aided by the ability of both the researchers and the interviewees to take the time to be more thoughtful and careful in their responses to, or communication with, each other than they would during natural conversation (Karchmer, 2001; Murray, 2004; Young et al., 1998).

Data quality, according to Curasi (2001), is dependent on who is being interviewed, who the interviewers are, and how skillful they are in online interviewing. In this study, some e-mail interview participants provided very short and very precise responses to the questions posed. Others, however, discussed at length their experiences on conflict between objectives. In the study of Curasi (2001), responses are much more depth and detail than the responses in face-to-face interviews, especially when data from the initial questions are combined with those from follow-up questions. In other studies, data from face-to-face interviews did not reveal any information that was not already discovered via data from e-mail interviews (Meho & Tibbo, 2003). A distinctive feature in e-mail interviewing is that it allows participants to take their time in answering questions and to take part in the interviews in a familiar environment (e.g., home or office), which may make them feel more relaxed expressing themselves and in responding when and how they feel comfortable (Kennedy, 2000; Lehu, 2004). This may generate rich and high quality data.

## **2.6 Reliability and validity**

When collecting information, it is important to consider the information in terms of quality. When evaluating empirical studies, we should look at reliability and validity of the survey. The reliability focus on where the survey is conducted, i.e. how reliable it is. Validity focus on that the survey gave answers to what one would find out.



Reliability in connection with qualitative studies is referred to if the research results are consistent and credible (Kvale and Brinkmann, 2009). An important question is whether alternative researchers using the same methods have similar conclusions (Thagaard, 2009), or if the conclusions can be reproduced at another time by other researchers. A source of low credibility of a study is using poor questions. I have attempted to take into account such weakness by consulting my interview guide with my supervisor who has extensive experience on safety study. I also marked the individual's statements so that it shows that I have considered the analysis of the data material as a whole and not based on individuals' perceptions.

Validity is another criteria, which needs consideration to ensure good quality of data. Validity is a criterion used to check if our findings are true. Concerning this criterion, all used literature is mostly related to conflicting objectives. Other literature used is however vital, in order to provide a supplement to the comprehensive understand of conflicting objectives. Regarding the interviews, information is gathered only from persons with experience within the field, and has been collected from different areas within the construction company.

# 3 Theoretical Framework

In the researches on safety, it has been an extensive perception that there is a fundamental conflict between production and safety (Perrow, 1984; Reason, 1997; Rasmussen, 1997; Hollnagel, 2004). In this chapter I will briefly explain the development of the perspectives on safety and accidents in organizations. I will then present relevant theoretical perspectives on conflicting objectives.

## 3.1 Perspectives on safety and accidents

The nature of most accidents at the construction sites shows that the construction industry is unique. Factors involved include human behavior, different construction sites, the difficulties of works, unsafe safety culture, dangerous machinery and equipment being used, and non-compliance to the various set procedures. These factors are categorized as technical, human and organizational factors. Throughout history, the perspectives on the source of accidents and what creates safety in organizations have changed. The focus in the development has been shifted from on the technical factors, to on the human and organizational factors, and ultimately on the informal elements of the organization. The development is illustrated by figure 3.1. The changes of the focus reveal that the concept of safety culture has gradually become important (Hudson, 2007). This change has been proved to be beneficial to the construction industry in Hong Kong. In figure 3.2, the accident rate in the stage of improvement of safety culture has reduced significantly from previous two stages.

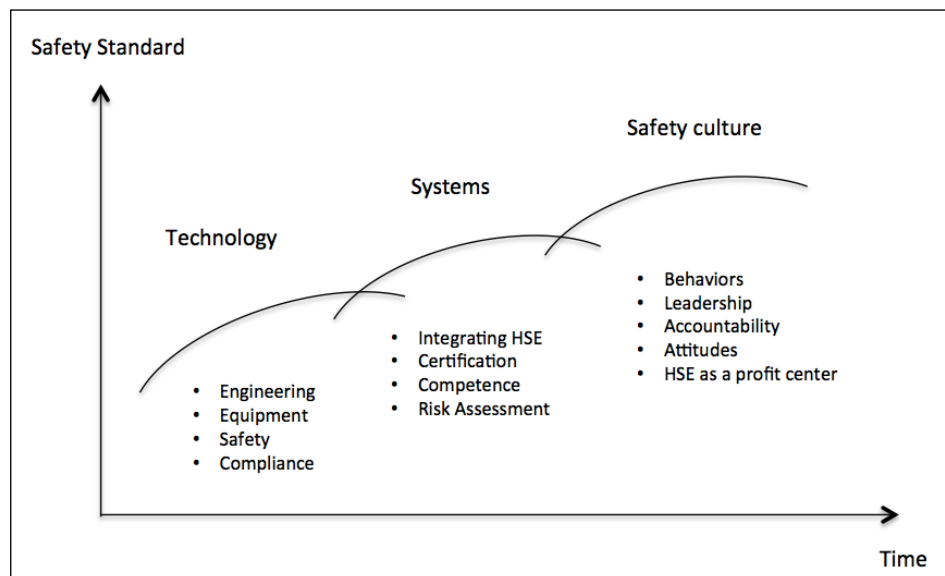


Figure 3.1: The development of safety standard (Hudson, 2007).

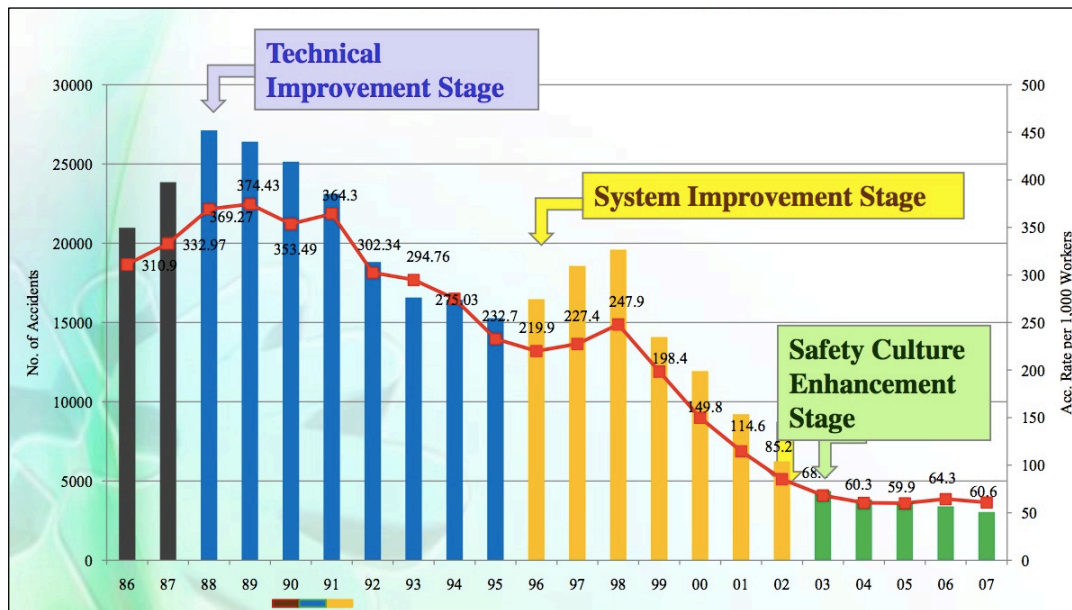


Figure 3.2: Accident statistics for construction industry in Hong Kong (Kuen, 2009).

As stated by Hale and Hovden (1998), the development of industrial safety was divided into “three ages”: age of technology, age of human factors and age of safety management. Now we live in the “third age of safety” wherein improvements mainly depend on safety culture and behavior. In the third age, the perspective of High Reliability Organizations (HRO) is important to enhance safety culture in organizations. HRO perspective was developed to account for the extraordinary capacity of some organizations to handle complex and potentially dangerous technologies under condition of high production pressure without generating major accidents (Laporte & Consolini, 1991). This perspective tells us to consider the presence or absence of organizational redundancy, i.e. patterns of cooperation that allow the organization as a whole to perform more reliably than each individual in isolation. HRO perspective emphasizes on the organizational conditions and management.

Using system approach, Leplat (1984) considered the accidents as a consequence of dysfunctioning in the actions of the organization. The organization may be divided into departments. The functioning of the organization depends not only on the functioning of these departments but also on the manner in which these functioning are coordinated to meet the aims of the organization. Several dysfunctions generating accidents can be ascribable to failures in this coordination. Another type of dysfunction is lack of link-up between the elements of system. The quality of the link-up between the elements of a system is not only the condition of efficiency but can also be the condition of safety. The link-up may concern firstly the members of a group: team or group cohesion. Lack of cohesion is often an obstacle to the circulation of information within the group, while the information is indispensable

when the actions of an individual depend on what another individual says or does. In the Barry Turner's theory of man-made disasters, the accident can be also considered as a breakdown in the flow of information (Turner, Man-made disasters , 1978; Turner & Pidgeon, 1997; Pidgeon & O' Leary, 2000).

In the book of Reason (1997), there are two kinds of accidents, i.e. individual and organizational accidents. While the studies mainly focus on the organizational accidents since they are a product of technological innovations, which have radically altered the relationship between systems and human elements. Organizational accidents happen rarely but occur in high-risk organizations. The range of such accidents affects beyond the organization and the causes are complex and may be attributed to an interacting process between different levels of the organization. So focus on the organizational factors is the way to avoid these accidents. Such a perspective has been the background to focus on safety management system and leadership to actively improve the organizational conditions and thus improve safety. After the Chernobyl accident resulting from a poor safety culture, people paid more attentions to the cultural aspects of the organization. Today the consensus among scientists is that cultural factors are important for safety in organizations (Reason, 1997; Vaughan, 1996; Pidgeon, 1998; Cox & Cheyne, 2000).

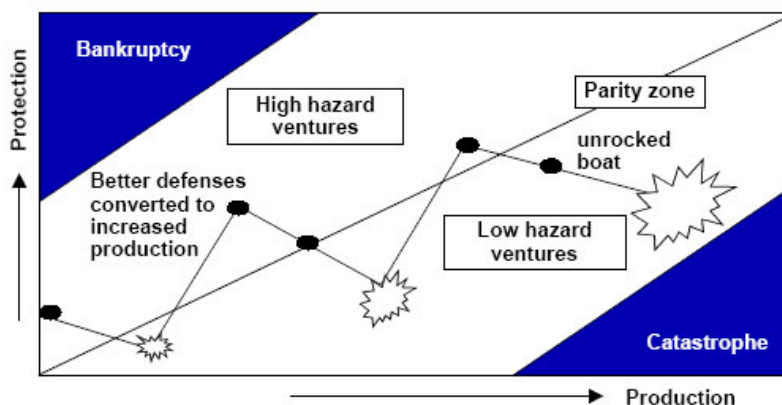
### **3.2 What is conflicting objective?**

There is no explicit definition of conflicting objective, but Norwegian Petroleum Authority has given their own understanding, which is:

“Conflicting objectives are a part of every day's life in all organizations and in all work place. We want to complete the job quickly and effectively, without error and without anyone being injured. Actually we are often forced to weigh various considerations. Hence a time-squeeze occurs, and the management must choose between to speed up the work or to reduce the cost, and to afford the prestige loss on delays. When a work team encounters unforeseen problems, they have to choose to hurry up to finish the work or take time to discuss the risks. As time goes on, conflicting objectives can lead to that the work team gradually begins to take small “shortcuts” that impair safety. If no one takes hold of these small changes, it will be dangerous that the long-term “shortcuts” become the accepted way of doing it. It is serious that “shortcuts” are accepted as long as it goes well, but punishment is that an accident will occur. So all organizations must deal with conflicting objectives” (The Norwegian Petroleum Authority, 2004: 18 – 19).

As shown in the quote, conflicting objectives can be described as a conflict between production and safety. Reason (1997) regards production and safety as two universal

characteristics of commercial organizations. In such of organizations, making money is the primary goal. The requirement in production is related to commercial objectives, which is to increase profit. The requirement of safety is to reduce the risks of unwanted events, which occur as a direct consequence of production. In an ideal world, production and safety should be in harmony. *“While the productive aspects of an organization are fairly well understood and their associated processes are relatively transparent, the protective functions are both more varied and more subtle”* (Reason, 1997: 3). But Reason (1997) highlights that in reality the partnership between production and safety is rarely equal. He writes: *“Since production creates the resources that makes protection possible, its needs will generally have priority throughout most of organization’s lifetime”* (Reason, 1997: 4). The source of this condition can be explained by the different characteristics of production and safety. The information relating to production is often direct, continuous and readily understood, while the associated information of safety is indirect and discontinuous and the measures involved are hard to interpret and often misleading. To give better understanding of production and safety, Reason (1997) developed a chart to describe the relationship between production and safety over the history of a hypothetical organization (Figure 3.3).



**Figure 3.3: Outline of the relationship between production and protection (Reason, 1997:4)**

Those in high-hazard ventures should operate above the parity zone, that is, protection (safety) should at least “match the hazards of productive operations” (Reason, 1997). The more extensive the productive operations, the greater is the hazard exposure and so also is the need for corresponding protection. Since safety consumes productive resources – such as people, money and materials – such grossly overprotected organizations would probably soon go out of business. At the other extreme in figure 3.3, organizations that only focus on production will face a very high risk of suffering a catastrophic accident. Thus, organizations should balance production and safety. This task requires to be undertaken cooperatively in the long term. If it is in the short term, conflicts will occur. Almost every day, line managers and supervisors have to

choose whether or not to cut safety corners in order to meet deadlines or other operational demands (Reason, 1997). For the most part, such short-cuts bring no bad effects and so can become an habitual part of routine work practices. Unfortunately, this gradual reduction in the system's safety margins renders it increasingly vulnerable to particular combinations of accident-causing factors. Our main concern is with how organizations handle with the conflict between production and safety. In a word, handling of conflicting objectives can be regarded as the ability of organization to balance safety and other operational demands.

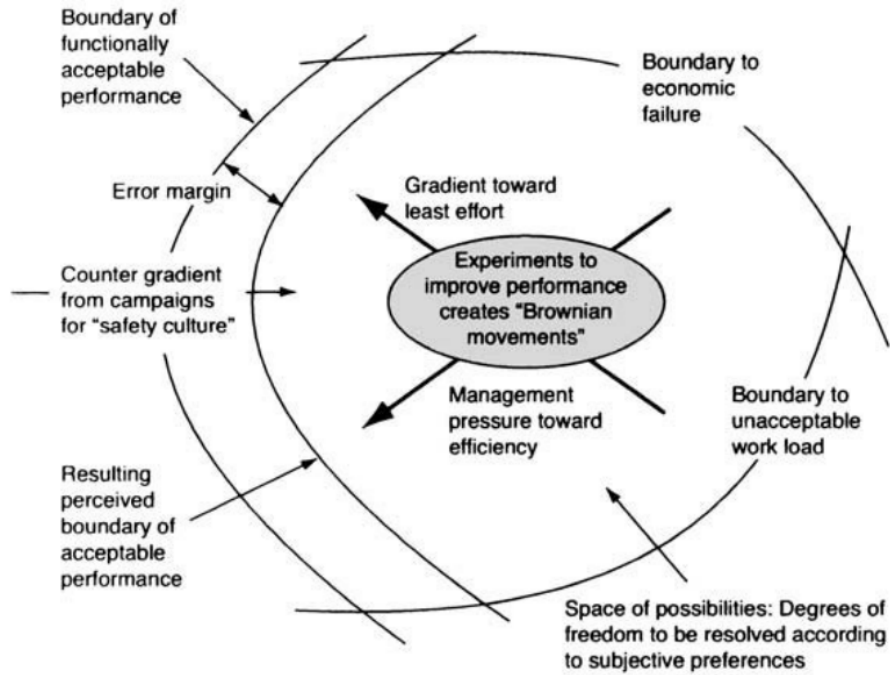
### **3.3 Analytical approach to handle conflicting objectives in organizations**

People at all organizational levels face critical decisions involving conflicts or tradeoffs between safety and competing objectives such as staying within budgets, completing projects on schedule, avoiding downtime or simply getting their job done. Inadequate handling of conflicting objectives has repeatedly been identified as a causal or contributing factor in accidents. In this section, I will present different perspectives of researchers on how conflicting objectives are understood and approaches to handle conflicting objectives in organizations.

#### **3.3.1 Migration toward the boundary**

As an objective, safety may conflict with other objectives. Initially, the conflicts are rarely conspicuous in a stable system, but today, in a dynamic and complex sociotechnical system, safety is gradually sacrificed in relation to other objectives due to the pressures or gradients stemming from different objectives. Rasmussen's migration model (1997) frames the core of this perspective.

Rasmussen (1997) suggested that we might think of the handling of conflicting objectives in terms of activities migrating toward the boundary of acceptable performance (Figure 3.4). The basic idea is that human behavior in any work system is shaped by needs and constraints which must be respected by the actors for work performance to be successful. To achieve such productive targets, individual actors are trying hard to keep the workload at a comfortable level, to find some intellectual joy in the activity, and to avoid failure. Facing the requirements and pressures, they try out different ways to handle these conflicting needs and constraints by continuous adaptive search. The space of safe performance within which actors can navigate freely during this search is bounded by unacceptable workload, economic failure, and functionally acceptable performance (e.g. safety regulations and procedures).



**Figure 3.4: Under the pressure of conflicting objectives activities tend to migrate toward the boundary of acceptable performance (Rasmussen, 1997)**

As shown in figure 3.4, the human behavior is likely to migrate towards the boundary of acceptable risk due to the combined effect of management pressure for increased efficiency and a trend toward least effort (Rasmussen, 1997). The exact boundary between acceptable and unacceptable risk is not always obvious to the actors, especially in complex systems where different actors attempt to optimize their own performance without complete knowledge as to how their decisions may interact with decisions made by other actors. At each level in the sociotechnical hierarchy (Figure 3.5), people are working hard to respond to pressures of cost-effectiveness, but they do not see how their decisions interact with those made by other actors at different levels in the system. Rasmussen claims that these uncoordinated attempts of adaptation are slowly but surely “preparing the stage for an accident”. He therefore argues that efforts to improve safety-critical decision-making should focus on making the boundaries towards unacceptable risk explicit and known, such that the actors are given the opportunity to control their behavior at the boundaries. Traditional strategies for ensuring safe handling of conflicting objectives rarely meet these goals (Størseth et al., 2010).

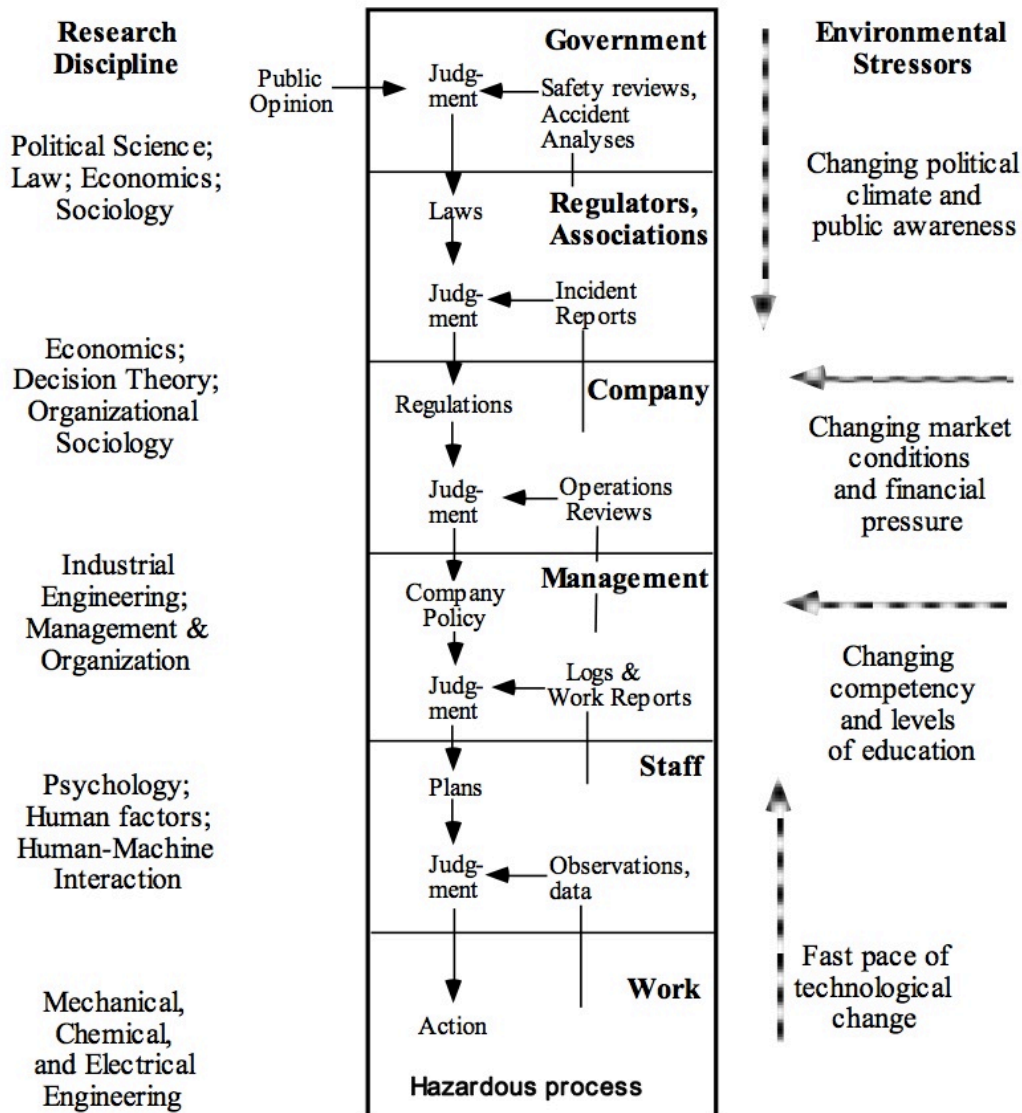


Figure 3.5: The sociotechnical system involved in risk management (Rasmussen, 1997)

### 3.3.2 Distributed decision-making

A system is characterized by distributed decision-making to the extent that it lacks a centralized decision-maker and each decision-maker has a model and information of a limited part of the problem (Brehmer, 1991). In this case, actors may strive for local optimization, based on their incomplete knowledge about the system. They will take into account the dangers and potential scenarios they know about, but not those that are “invisible” from their local point of view. Rasmussen and Svedung (2000) suggested that many accidents occur because couplings occur between activities which are usually not coupled in any functional way during daily work. Rasmussen (1994) suggests that it is feasible to provide the necessary decision support to help operators stay within the safe boundary in a well-structured process plant. Providing



visible margins to safety boundaries may even increase operations efficiency, since the operators will not need to maintain an excessive margin to an invisible boundary.

Many organizations have developed administrative systems in order to manage the risks associated with parallel activities and distributed decision-making. For instance, work permit systems are used in the process industry to make sure that critical tasks are properly coordinated, and that necessary precautions are taken. These administrative systems may be even more safety-critical than many technological barriers, because some tasks involve the temporary removal of several technical barriers. A failure related to the work permit system might thus hit the system in a very vulnerable state.

### **3.3.3 Trade-off decisions**

Trade-off decisions, particularly those that result from conflicting objectives (e.g. safety and productivity, efficiency and thoroughness) are an important feature of safe working practices (Hollnagel, 2009a; Rasmussen, 1997; Reason, 1997). In the context of risk management, it is fundamental to understand why and how trade-offs between production and safety goals operate because decisions taken may have serious consequences on the safety of the system. A number of studies have been conducted to understand managers' decision making when they are faced with conflicting situations between production performance and safety goals (Morel et al., 2008; 2009; Gomes et al., 2009; Cerdergren, 2011). Nevertheless, there is insufficient understanding of how workers manage conflicting demands between production and safety in complex systems.

As mentioned, Rasmussen (1997) proposed that a system is constrained by three boundaries: the boundary of economic failure; the boundary of unacceptable workload; and the boundary of acceptable performance. Between these boundaries individuals or organizations make on-going trade-off decisions. At the management level, so-called blunt end, trade-off decisions are made between production, safety, time, quality, budgets, and other considerations. Employees working close to production, so-called sharp end, also make many larger and smaller trade-off decisions each day (Woods et al., 2010). Blunt end trade-off decisions influence sharp end trade-off decisions and viceversa. In complex systems, trade-off decisions and adaptations are made without central coordination, to balance all kinds of pressures and safety. This is done on a local level and based on experiences, without always being able to know if safety is sacrificed (Dekker, 2011).

Hollnagel (2009b) investigated trade-off decisions in more depth, especially with regards to decision-making. Hollnagel defined the ETTO (Efficiency – Thoroughness

Trade-off) principle as, *“In their daily activities, at work or at leisure, people routinely make a choice between being effective and thorough, since it rarely is possible to be both at the same time. If demands for productivity or performance are high, thoroughness is reduced until the productivity goals are met. If demands for safety are high, efficiency is reduced until the safety goals are met”*.

The ETTO-principle suggests a binary approach of efficiency (productivity) and thoroughness (safety). It proposes that efficiency and thoroughness rarely can be reached at the same time. In a complex world all kinds of opposing objectives exist, driven by all kinds of pressures and reducing this to efficiency and thoroughness has its limitations. Besides that, relaxing productivity which means being less efficient in order to be thorough, can introduce new probably unknown risks. The ETTO principle in many ways resembles some key points of the perspective of conflicting objectives. ETTO is not limited to deliberate decision-making. On the contrary, ETTO is carried out more or less automatically much of the time, and the subject may not be aware fully aware of compromises he or she makes in order to reconcile efficiency and thoroughness requirements.

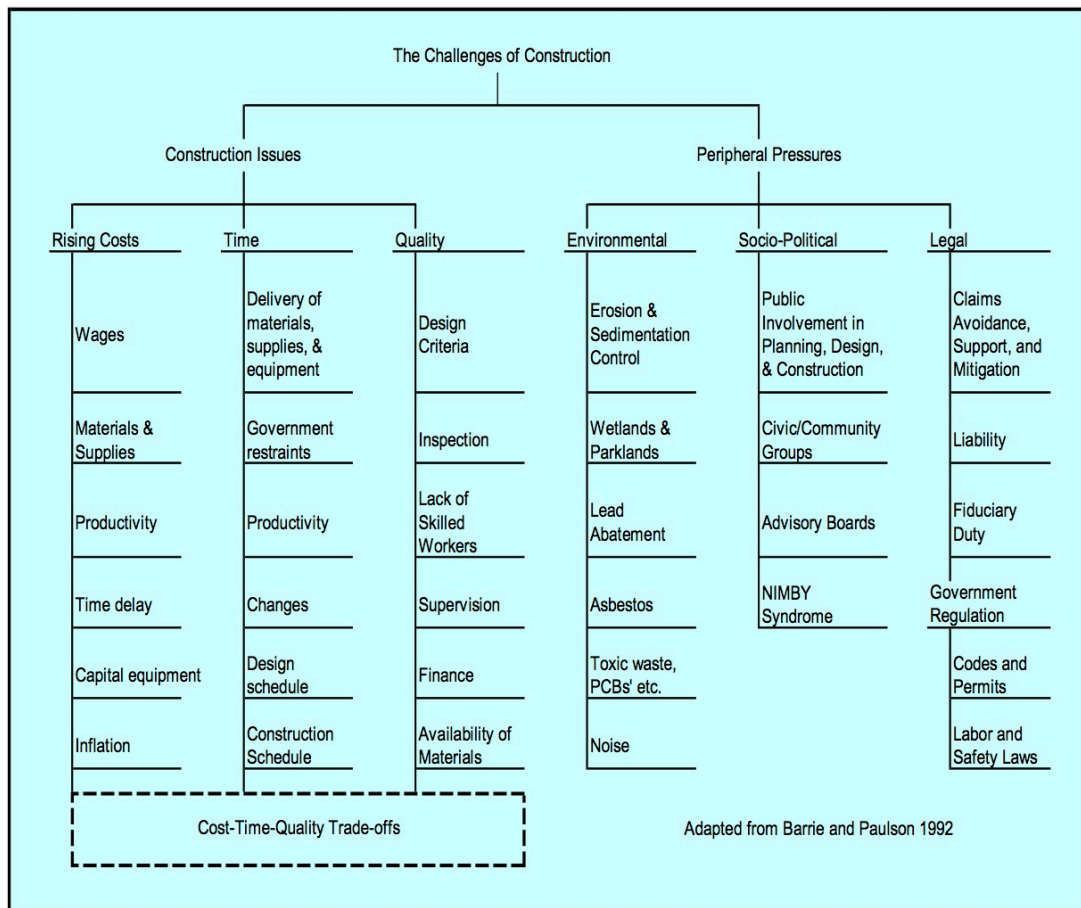
## **4 Literature Review**

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In this chapter, the relevant literature on conflicting objectives in construction will be presented, including identifying conflicting objectives by reviewing the current situation of construction management, analyzing the relationship between safety and other objectives, reviewing the previous study on interface management, and introducing the relevant solutions that contributes to handle conflicting objectives.

### **4.1 Challenges facing today's construction management**

Nowadays, construction project management becomes more and more complex and difficult because of facing numerous challenges shown in figure 4.1. Some are new to the industry, and some are centuries old. Many of these challenges are a direct result of construction operations, while others a result of indirect, peripheral activities. A surprising number of challenges are not construction issues but must be addressed and managed by the project management to ensure project success. Non-construction challenges are part of the business landscape include legal issues, government regulations, environmental concerns, and socio-political pressures. The project management must control, deflect, or mitigate the effects of any occurrence or situation that could affect project success. Some of the construction issues include workforce considerations, safety, time constraints, and the changing nature of the work. If the effective management cannot be done, the conflict will occur between different objectives. It is thus critical that the project management understands the demanding realities that they face in the planning and control of construction operations (Muir, 2005).



**Figure 4.1: The challenges facing today's construction project management (Muir, 2005).**

The research of Bennet and Grice (1990) reveals that the clients of the construction industry are primarily concerned with quality, time and cost and yet the majority of construction projects are procured on the basis of only two of these parameters, namely time and cost. This is understandable since the majority of project management control systems highlight time and cost, and overlook the relative importance of quality (Hughes & Williams, 1991). It is argued by Herbsman and Ellis (1991) that the major failings in traditional approaches to project delivery have been in extensive delays in the planned schedules, cost overruns, serious problems in quality, and an increase in the number of claims and litigation associated with construction projects.

In order to plan and manage a successful project, the three parameters of time, cost and quality should be considered. Hughes and Williams (1991), in arguing for the consideration of these three factors in attaining the client's objectives, propose that these factors are the three points of a triangle and that neglecting one factor will have a corresponding detrimental effect upon the other two. In support of this, Lansley (1993) argued strongly for the importance of studying the behavioral aspects of management in attempting to address the problems facing the construction industry,

i.e., that it is the issue of the ‘human factor’ involved in construction projects that needs to be addressed. Rwelamila and Hall (1995) further argue that little evidence exists of successful projects where these three factors have been balanced and there is a need to embrace time, cost and quality management as a human activity system.

According to Khozein et al. (2012), initiating to implementing an investing plan or a project is the first step to entry the business world competition and survival in this complex and uncertainty environment needs to step steady and intelligently by optimized decision-making. A project is an organization of people dedicated to the deployment of a set of resources for a specific purpose or objective (KarimiAzari, 2011). Project management is defined as planning, directing, and controlling resources to achieve specific goals and objectives of the project (Fan, Liu, & Burns, 2008). Construction and project planners often face the challenge of optimum resource utilization to compromise between different and usually conflicting aspects of projects and one important aspect of project management is to know about the information related to the optimum balance between the project’s objectives (Afshar, Kaveh, & Shoghli, 2007). Time, cost, quality and risk as four critical objectives of construction project management, are not independent but intricately related (Khozein, Badi, & Khamaki, 2012). Trade-offs between project duration, total cost, quality and risk are extensively discussed in the project scheduling literature because of its practical relevance and it is one of the highly important issues in project accomplishment and has been ever taken into consideration by project managers. Heretofore, extensive researches to develop time-cost-quality trade-off problems have been conducted. Nowadays, in engineering contracts, the risk of projects is also added to them. The aim of time-cost-quality-risk trade-off problem is to accomplish the project or to select a set of activities by considering the minimal cost, time and risk and the maximal quality simultaneously (Khozein, Badi, & Khamaki, 2012).

According to Rahnamayroodposhti (2008), in today’s developing business environment resulted from globalization and competitive conflicts, organization survival depends on paying attention to value creation management and establishing optimum relationship between optimal value and customer satisfaction and optimal value for organization. Quality and delivery time along with cost are among elements of survival triangle considered as one of the major approaches of management accounting in value creation cost management (Rahnamayroodposhti, 2008) to which the factor of risk is added and the result would be “Survival Pyramid” shown in figure 4.2. These factors consume organizational resources and affect the organization’s value creation. The components of the survival pyramid are among essential factors determining strategies for achieving success.

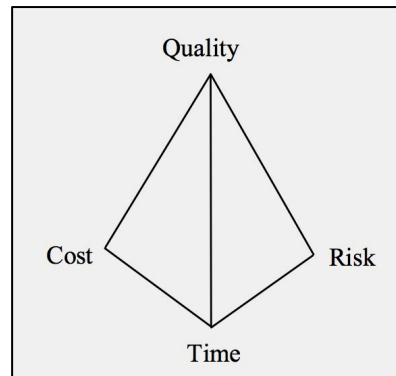


Figure 4.2: Survival Pyramid (Rahnamayroodposhti, 2008)

## 4.2 The impact of production pressure on safety

The previous section has indicated that the four critical objectives of construction project management are time, cost, quality and risk. In the study of this thesis, the risk in the survival pyramid can be seen as safety risk. Thus the four critical objectives are time, cost, quality and safety. This section will review the literatures on the relationship between safety and the other objectives or how the three objectives impact on safety.

The development of new technologies has been led to rapid changes in our society and working environments, also resulting in increasing complexities and changes in the causes of accidents (Leveson, 2012). To reflect the complexity and coupling of system components into safety management, the concept of systems thinking – understanding the behavior of an entire system as a result of interactions among individual system components – has been applied to accident analysis and investigation (Goh, Brown, & Spickett, 2010; 2012; Leveson, 2011; 2012). In construction, safety is also an integral component of a construction project that cannot be isolated from other project elements (e.g., schedule, cost, and quality) (Hinze, 1997). As progress deviation increases, workers are encouraged by management to complete their work within the contract time. The resulting production pressure (e.g., being pressed to work faster to earn more money) adversely affects safety performance (Hinze & Parker, 1978; Hinze, 1997; Goldenhar, Williams, & Swanson, 2003; Mitropoulos & Cupido, 2009). Rework that results from quality deviations is also a major contributor to production pressure (i.e., schedule pressure), which consequently degrades safety management (Rodrigues & Williams, 1998; Love, Manual, & Li, 1999; Park & Peña-Mora, 2003). A systems thinking approach explains that this variation can lead to accidents by mentally influencing operators (i.e., construction workers) (Leveson, 2012). Under production pressure, the managerial priority may not be given to safety, and hence the objective conflicts with

other project elements, such as schedule (time), cost and quality, need to be understood to prevent accidents and to improve productivity.

To understand such relationships between production pressure and safety performance, research efforts have been made in construction during the last decade. For example, Nepal et al. (2006) investigated the impact of production pressure on productivity and rework through cause-and-effect analysis. Lee et al. (2005) proposed a framework for project planning and control in design and construction processes that allows assessing the effects of changes and rework on schedule and quality performances. The complex relationship between rework and schedule and cost performances was also studied to identify effective strategies for the prevention of rework (Love, Mandal, & Li, 1995; 2002). As to safety, Mitropoulos et al. (2005) presented an accident causation model illustrating how at-risk situations are generated in a production system. Specifically, the impact of production pressure on safety has been studied. A review of the relevant literature reveals that perceived production pressure affects worker productivity and can result in a degradation of safety, which eventually has an impact upon both safety management and accident rates (Hinze, 1997; Rundmo, Hestad, & Ulleberg, 1998; Brown, Willis, & Prussia, 2000; Mohamed, 2002; Seo, 2005; Mitropoulos, Abdelhamid, & Howell, 2005). However, such findings and knowledge still have not been applied to actual practices during a construction project. Underwood and Waterson (2013) pointed out that this gap between research and practice is due to investigator bias, resource constraints, and the qualitative nature of a systems approach affecting its reliability.

#### **4.2.1 The impact of schedule and quality performances on safety**

A successful construction project must meet performance and delivery requirements for time, cost, quality, and safety. Achieving these diverse goals usually creates the complexity and coupling of management elements in a project's execution. To gain an understanding of the interactions among the four objectives, thus this section will focus on production pressure resulting from scheduling and quality management, which can negatively affect safety.

From the research of Hinze (1997), project duration impacts on Construction Health and Safety (H&S). A shortened contract period may result in a project duration that is incompatible with the nature and scope of the work to be executed. A shortened contract period invariably results in a relative increase in the number of workers and/or the number of hours worked per worker, amount of plant and equipment introduced and used in the workplace, and the simultaneous contributions of an increased number of subcontractors. Research conducted in South Africa (Smallwood & Venter, 2002) determined project schedule to be the primary cause of stress among

construction management and workers, and overtime was ranked 13 out of a total of 27 causes of stress. Hinze (1997) cites pressure to meet unrealistic deadlines as a common source of mental diversion, which diversion increases the susceptibility of injury.

Production/Time pressure is closely related to scheduling. Hinze (1997) demonstrated that the schedule status of projects is correlated to the frequency of injuries; for instance, subcontractors who were ahead of schedule had a smaller number of injuries, while subcontractors who were behind schedule obviously had more injuries in their projects. This result implies that managerial actions for the recovery of schedule delays adversely influence workers as being under pressure to increase their production rates. When perceiving production pressure (e.g., excessive workload, required work pace, and time pressure), workers perceive increasing risk and barriers, leading to a higher chance that they will work with unsafe behavior (Seo, 2005). Statistically, the behavior measurement and recordable injury rates are significantly correlated (Krause, 1990). Also, about 80 – 90% of accidents are strongly related to the unsafe behavior of workers, which is affected by safety-related factors (e.g., management, safety programs, and environments) (Heinrich, Petersen, & Roos, 1980; Salminen & Tallberg, 1996; Helen & Rowlinson, 2005). Consequently, previous studies show that production pressure is a key linkage between scheduling and safety in construction operations.

On the other hand, quality management is also associated with safety. In construction, rework results from quality deviations caused by changes, errors, and omissions during design and construction (Sommerville, 2007; Farrington, 1987). Rework, which means to work again, is a major contributor to schedule delays and cost overruns, which are negative factors in safety management (Rodrigues & Williams, 1998; Love, Manual, & Li, 1999; Park & Peñ a-Mora, 2003; Lee, Peñ a-Mora, & Park, 2005). Love and Edwards (2004) stated that rework – that often requires diverting resources (e.g., overtime work, new hires, pushing workers to work fast) for the recovery – undermines the effective supervision of other work and results in demoralization, fatigue, and absenteeism, all of which have a negative effect on project safety. Nguyen and Ogunlana (2005) also studied how rework causes schedule delays that require overtime to rectify; this results in a high rate of worker turnover. Safety is then affected by the turnover when the cumulative experience of on-site workers deteriorates. Mitropoulos and Cupido (2009) additionally showed that accident rates could be reduced through the prevention of errors during dangerous activities. These studies imply that rework is relevant to production pressure eventually affecting safety (e.g., safety supervision, schedule delays, frequent errors).



#### **4.2.2 The impact of economic factors on safety**

In the research of Sawacha et al. (1999), they found that there was a high correlation between safety performance and hazard payment. This indicates that tasks where operatives are paid hazard money are subject to higher risk of accidents. This is tantamount to an inducement to task risks, and that such an inducement ran counter to aims of safety promotion on site, and in the construction industry generally. The result of the research also showed that there was a strong relationship between productivity bonus pay and safety performance. Bonus payments can lead operatives to achieve higher production through performing unsafely at the site level. It is therefore an incentive to work faster than is usually the case, and in the process, unsafe methods of work by chance-taking become the norm, and hence accidents result. People tend to commit unsafe acts because they have been rewarded in the past for doing so; that is, operatives received bonus payments for extra productivity that may have been achieved by performing insafely. A similar finding was evident in the work of Leather (1984) who concluded that management was indeed concerned with the problem of bonus. A staggering 67% of foremen, and 43% of housing managers in the Public Sector Group did consider bonus targets to be a major contributing cause of risk-taking and corner-cutting by the direct labor operatives. Rather than paying productivity bonuses as an incentive for higher productivity without due regard to safety, safety bonus should be paid instead as it combines productivity and safety performance as a goal for reward. Hinze and Parker (1978) concluded that good safety performance and high productivity are compatible and they should not be sacrificed with one another. Good safety performance is also related to the management style and that applying excessive pressure by any means to the workmen resulted in increased injuries.

In a British study of health and safety in small firms, a number of the owners and managers interviewed reported that their ability to invest in health and safety was limited by the narrow profit margins that they were operating under as a result of the contract prices demanded by larger clients (Vickers, Baldock, Smallbone, James, Ekanem, & Bertotti, 2003). In the precarious forms of employment, such as result from the supply of labor through employment agencies, through labor leasing or through subcontracting, Quinlan (2001) and his colleagues have argued that the economic pressures and reward systems encountered in these forms of employment result in poorer health and safety outcomes than might be anticipated in more traditional employment arrangements. In an earlier article, Mayhew and Quinlan (1997) argued that while self-employed construction workers face greater risks of harm, this is not because the hazards they experience are intrinsically different from those faced by employed workers; rather, it is because the self-employed work longer hours, more intensively, in more hazardous sub-sections of the industry under greater economic duress. Indeed, they state that the most fundamental cause of diminished

occupational health and safety performance is the fierce level of competition for building contracts (Mayhew & Quinlan, 1997).

### **4.3 Interfaces among various construction parties**

A construction project involves many participants. The multitude of project participants causes a large number of interfaces between them. Both industry and academia has begun to search for technical innovations as well as advanced construction management strategies and tools (Chen, 2007). Efforts have been made to:

- Increase the use and quality of pre-fabricated building components,
- Explore energy-efficient equipment or appliances,
- Launch supply chain management,
- Employ Information Technology (IT) applications, and
- Improve performance widely in design, planning, scheduling, construction, cost control, and safety management.

Although remarkable progress has been seen in practice, surprisingly, the individual objectives of those efforts have never been completely fulfilled due to frequent incompatibilities and interruptions arising from the dynamic construction environment. Consequently, the building process still faces numerous conflicts and is executed with low efficiency. The final product is also inferior in many aspects and cannot reach original expectations. Interface issues have been considered major causes leading to such conflicts and project failures (Al-Hammad, 2000; Pavitt & Gibb, 2003; Nooteboom, 2004). Chen et al. (2008) also stated that these interface events might impact the project negatively regarding to schedule, cost, safety and quality. Interface issues have significantly lowered overall project performance and implicitly hindered industrialization of construction, thus effectively managing and tracking interfaces of the construction is necessary.

Al-Hammad and other researchers have conducted extensive research about interface problems among various construction parties in Saudi Arabia. In a conclusive paper, Al-Hammad (2000) identifies 19 main interface problems among various construction parties. These problems have been classified into four categories: financial problems, inadequate contract and specification, environmental problems, and other common problems. Strictly speaking, these problems (shown in Table 1) are not interface issues, but more likely reasons or factors causing various interface issues. As listed below, “*insufficient work drawing details*” may lead to assembly difficulties, errors,

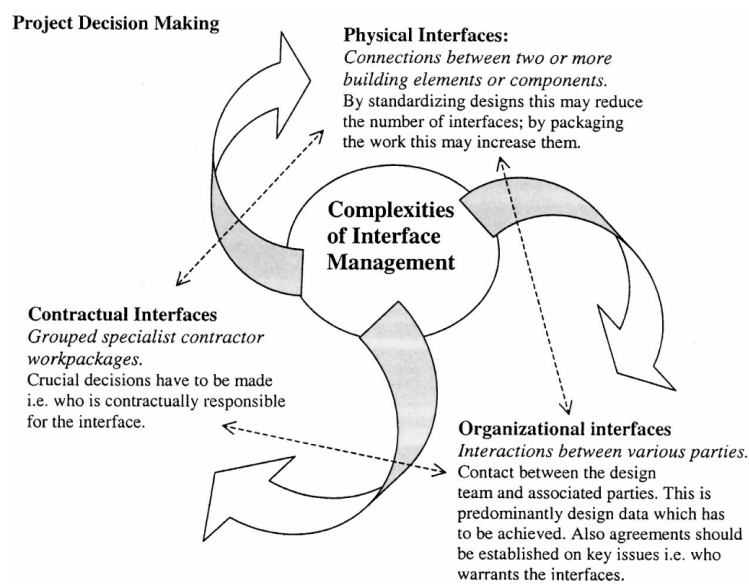
or physical conflicts between two building components. “*Delay in progress payment by owner*” may incur a poor working relationship as well as suspension of work in a project.

**Table 1: Common interface problems from construction parties’ viewpoint (Al-Hammad, 2000)**

**TABLE 1. Common Interface Problems According to Construction Parties' Viewpoint**

Interface problems (1)	Responses					Mean (7)	Importance index (%) (8)	Rank (9)
	Very strongly affects (2)	Strongly affects (3)	Moderately affects (4)	Strongly doesn't affect (5)	Very strongly doesn't affect (6)			
<b>Financial problems</b>	<b>68</b>	<b>176</b>	<b>113</b>	<b>34</b>	<b>6</b>	<b>2.67</b>	<b>66.8</b>	<b>1</b>
Delay in progress payment by owner	26	39	31	5	1	2.82	70.6	3
Accuracy of project cost estimate	14	55	27	5	0	2.77	69.3	5
Owners low budget for construction relative to requirement	21	53	22	5	1	2.77	71.6	2
Prices change of materials and laborers during construction	7	29	33	19	4	2.07	51.6	17
<b>Inadequate contract and specification</b>	<b>71</b>	<b>206</b>	<b>193</b>	<b>39</b>	<b>0</b>	<b>2.61</b>	<b>65.3</b>	<b>2</b>
Insufficient working drawing details	13	39	43	7	0	2.57	64.2	3
Insufficient specification	11	44	41	6	0	2.59	64.7	9
Violating conditions of the contract	5	13	4	0	0	3.05	76.14	1
Poorly written contract	10	42	35	14	0	2.48	61.9	5
Change order	11	30	50	11	0	2.40	60.0	7
<b>Environmental problems</b>	<b>14</b>	<b>30</b>	<b>92</b>	<b>63</b>	<b>5.5</b>	<b>1.93</b>	<b>48.2</b>	<b>4</b>
Weather	4	11	49	36	2	1.79	44.9	19
Geological problems at site	10	19	43	27	3	2.06	51.5	16
<b>Other common problems</b>	<b>106</b>	<b>325</b>	<b>309</b>	<b>67</b>	<b>7</b>	<b>2.56</b>	<b>64.4</b>	<b>3</b>
Lack of communication between construction parties	10	38	47	7	0	2.54	63.5	10
Slowness of owner in decision making	13	47	32	8	1	2.62	65.6	2
Delay in finish of project	9	38	42	13	0	2.42	60.5	18
Unavailability of professional construction management	7	28	48	17	2	2.2	55.2	15
Skills and productivity of laborers	15	40	43	40	0	2.65	66.2	13
Poor quality of work	18	52	28	3	1	2.81	70.3	4
Poorly done planning and scheduling	16	38	24	5	1	2.62	65.4	11
Unfamiliarity with local laws of related governmental agencies	18	44	27	10	2	2.65	66.3	14

Pavitt and Gibb (2003) divided project interfaces into three main categories: physical, contractual, and organizational. They also clarified the important interactive relationship among the defined interface types during a project decision-making phase, as shown in Figure 4.3.



**Figure 4.3: Interactive relationship among three interfaces during project decision-making phase (Pavitt & Gibb, 2003)**

## **4.4 Relevant solutions – safety in design**

According to Jeffrey and Douglas (1994) it has to be accepted that in terms of causation there is a link between design decisions and safe construction. This is based on research carried out by the European Foundation for the Improvement of Living and Working conditions, which concluded, that of site fatalities, 35% were caused by falls, which could have been reduced through design decisions. Schneider and Susi (1994) in turn say that constructing a new building is, by its very nature, a problem in ergonomics, as construction requires work at floor and ceiling level, resulting in, kneeling, bending, reaching out, twisting and in general, the adoption of uncomfortable work postures.

Designers influence H&S directly through design specific, supervisory and administrative interventions, and also indirectly through type of procurement system used, prequalification, project time, partnering and the facilitating of pre-planning (Smallwood J. , 2000). A further role identified for designers is that of optimal interaction with clients, particularly at the design brief stage. This is the most crucial phase for the successful, and healthy and safe completion of any project. Deviations from it at a later stage resulting in variation orders can be the catalyst that triggers a series of events from designer through to workers that culminates in an accident on site. Consequently, clients must know exactly what they require and develop a comprehensive brief for the design team (Jeffrey & Douglas, 1994).

Behm (2005) concluded that the construction industry should implement the concept of designing for construction safety as a standard practice to reduce overall project risks. The prevailing view of managing safety places the burdens of construction safety solely on the constructor. While the constructor will always bear the responsibility for construction site safety, utilization of this concept allows design professionals to participate in enhancing site safety. Design professionals are in a position to make decisions about construction safety and reduce or eliminate certain identifiable risks before those risks reach the construction site (Behm, 2005). This makes theoretical and practical sense from a traditional safety perspective – the recommended hierarchy of controls suggests that hazards be designed out such that they are eliminated or reduced before workers are exposed and then forced to react to minimize these hazards.

# 5 Interview Results and Analysis

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In this chapter, the interview results will be presented and the chapter is divided into four parts. The first subchapter gives the work task of the interviewees and a general overview of the results. The rest three parts are organized accordingly to the three main questions presented in chapter 1:

- *What kinds of conflicting objectives can occur in construction projects?*
- *Why do the conflicting objectives occur?*
- *How to deal with the conflicting objectives between safety and economy/efficiency in interfaces between different stakeholders?*

Under each of these three parts, the answers of the interviewees will be summarized and analyzed in details. These answers will give contribution to the further discussions in chapter 6.

## 5.1 General overview

Email interviews were conducted with thirty-three people working in a large construction company of Norway, including eight Project Managers, seven Engineering Managers, seven Construction Managers, five Operations Managers, five Purchasing Managers and one Trainee. But the survey was completed by eight respondents. The first round of interview started in 27th Mars and has been lasted in two weeks then five people gave the responses. The second round has taken one week and three people responded. The overview of the interview results is given in Table 1. The eight respondents are three Project Managers, four Engineering Managers and one Trainee. In many companies, Engineering Manager and Project Manager are two common positions. Although both positions require management skills, the positions have many differences. The following part will introduce the two important positions. Based on the understanding of their tasks and responsibilities in the project, the results of the interview will be comprehensive and reliable.

**Table 2: The results of interview**

Question Respondent	Role in the company	Conflicting objectives that can occur	Causes of conflicting objectives	Significance of participants for conflicting objectives	Handling conflicting objectives in practice	Suggestions for a better handling of conflicting objectives	Other information related to conflicting objectives
1	Project manager	Conflicting objectives in the schedule between two subcontractors, and between the project manager and the subcontractors.	Time arranged inappropriate in project management or the subcontractor does not put on the correct staffing.	Everyone must be aware of this.	Handling in different, is person depending including experience etc.	Management/ Subcontractor must prepare good thoroughly work schedules (detail plans), and add "slack" in the plan.	
2	Project manager	Unforeseen problems vs. time.	Poor planning and safety work have not been done properly earlier.	Safety work is prioritized differently among the various stakeholders.	Handling in different. Company culture is important.	Good planning and communication.	To create a good environment in the workplace will reduce the number of conflicting objectives.

Question Respondent	Role in the company	Conflicting objectives that can occur	Causes of conflicting objectives	Significance of participants for conflicting objectives	Handling conflicting objectives in practice	Suggestions for a better handling of conflicting objectives	Other information related to conflicting objectives
3	Project manager	Different views on tasks in the project and on what in the contract against both the client and subcontractors.	Time pressure and short building time. Insufficient explanation and understanding of the contract before signing.	The client and the main contractor are responsible for this.	Conducting morning meetings on current production and HSE schedule. Handing out a block to everyone to write down incidents, hazards etc.	Improved planning and involved planning before start-up. Implementing safety courses.	Communication and planning together across disciplines.
4	Engineering manager	To earn the most, safety will be challenged. Overtime work results in unwanted events.	Claims for liquidated damages if the project is not to be delivered on time.	The client puts too tight deadlines in contract.	High focus on solutions, try to attempt challenges in good time before start-up, also focus on involved planning.	Larger focus on safety, good planning (involved planning) in design and execution.	Pressure on the engineering group could lead to problem on safety.
5	Engineering manager	Safety against finances and time.	Not enough focus on safety in early stages.	All stakeholders have a HSE responsibility on their work.	Focus on safety in an early stage in building process.	Must have HSE focusing especially in its early stages.	

Question Respondent	Role in the company	Conflicting objectives that can occur	Causes of conflicting objectives	Significance of participants for conflicting objectives	Handling conflicting objectives in practice	Suggestions for a better handling of conflicting objectives	Other information related to conflicting objectives
6	Engineering manager	Conflicts between economics and quality, and described solution.	"It's money we live by," but the current system with many procedures, management systems and processes are time consuming.	It is crucial to cooperate good between the clients, contractors and consultants.	Communication and dialogue are important. Sitting down together at a table is much better than using e-mail and telephone.		
7	Engineering manager	Quality of solutions vs. costs, and progress vs. decisions.	Conflicts of interest and lack of understanding between the parties.	Client, architect and contractor have great significance.	Client draws up notifications of changes and decision plans. Clarifying expectations in advance.	Focus on clarifying expectations in advance. Greater awareness of the product and contract. Mutual respect for plans and changes.	The better the different stakeholders know each other before, the better is cooperation.
8	Trainee	Conflicts of interest between the different subjects.	Different assumptions and the pursuit of an end product/result.	Each stakeholder can lead to conflicting objectives.	People must "give and take" during a project.	Good dialogue, respect other's goals and don't focus on challenges.	



### **5.1.1 Role of project managers**

As shown in Table 1, three of the interviewees are Project Managers, who have the responsibilities on the planning/scheduling, execution and closing of any project. A project manager is the person responsible for accomplishing the stated project objectives. The key responsibilities of project management include creating clear and attainable project objectives, building the project requirements, and managing the constraints of the project management triangle, which are cost, time and quality. A project manager is also a client representative and has to determine and implement the exact needs of the client, based on knowledge of the company which they are representing.

A project manager is the bridging gap between the production team and client. So he/she must have a fair professional knowledge in his/her industrial field so that he/she is to understand, discuss, and even solve the problems with either party. The ability of adapting to the various internal procedures of the contracting party, and to form close links with the nominated representatives, are essential in ensuring that the key issues of cost, time, quality and client satisfaction can be realized. The term “project manager” is more properly used to describe a person with full responsibility and the same level of authority required to complete a project.

### **5.1.2 Role of engineering manager**

As shown in the previous introduction, a project manager typically manages a project and not people directly. Different with the project managers who are responsible for gathering several teams of people to accomplish a project, engineering managers typically hold the responsibility for managing a group of employees who work solely for him. Engineering manager bridges the boundaries between engineering and project management, leading the technical workers who contribute to the building of structures or products. In some cases, an engineering manager is the same as a project manager but in most cases these two professionals have joint responsibility for leading a project.

An engineering manager has technical knowledge and skills in an engineering field. The role of the engineering manager can often be described as that of a liaison between the project manager and the technical disciplines involved in a project. An engineering manager has four areas of responsibility: supervising engineers or engineering technologists, project management, working with clients, and providing advice and acting as a resource. An engineering manager must be a fully licensed, professional engineer.

Since an engineering manager is directly responsible for his employees, he is usually responsible for the relevant human resource and development aspects (Matta, 2014). In addition to annuals reviews, he is also responsible for training and career development of his employees. If an employee requires termination or a promotion, he will work directly with a human resources specialist on the task. Project managers typically do not have this employee responsibility.

## 5.2 Conflicting objectives that can occur

There are many conflicting objectives that can occur which could be considered for construction projects. Based on the expert opinions from the interview, the conflict issues that mostly face during construction are related to time, cost, quality, safety, scope and personnel involved. A large majority (50%) of the interviewed participants experienced the conflict issues that time and cost could impact on safety. The underlying reasons for conflicts in the project are due to “Time is Money!” Every party involved generally agreed to perform in such a way so as to meet the requirements of project time, reduce costs and at the same time improve quality without safety issues. This is particularly challenging with rising costs in labor and materials, and in building increasingly complex structures. *“The desire of working teams to earn the most...” “Project management wants to speed up to catch up the lost time in the project, which leads to increase the workload and working time. People get tired and inattentive, then accidents can occur.”*

There are two respondents thought that the conflicting objectives can occur on work scheduling between different subcontractors and between contractors and subcontractors. In fact, it is also related to time when there are issues such as poorly develop project planning and scheduling, late handover and change the location of construction sites/areas etc. When issues happen in the project, it needs often to resolve quickly to save the time. *“If, for example, we need extra scaffolding during the operation, they will be given in place by good planning. However, if you have no planning, it will often take long time to get them. It will then be easier to take a shortcut...”*

In a project, there may be many different conflicting objectives. This is because that there will always be a big conflict of the personnel interests. The conflicts are due to involvement of different people with different personality and disciplines in the project. The issue could be mainly due to personality clashes, ego and attitude of the person. It could also be due to work culture but mainly because of the commitment made by the personal involved while undertaking project task. Besides qualification and background of the person involved, the behavior and personal character would

also influence to the project. Shortage or absence of competent technical, managerial or supervisory personnel at construction site is also the issues for conflicts related to personal in projects. The conflict issues are also related to the different perspectives on work task and various understandings of contract. One of the interviewees experienced the conflict of interests between different professions. *“The goal of an Architect is to deliver a product that is aesthetically pleasing, in terms of materials, light technical solutions, etc. For us as a contractor, it is also important to provide an aesthetically pleasing product, but not with the same assumptions as an architect. We have more elements that we have to take into account during production, cost, NS quality, convenient, environmentally friendly, etc.”*

### **5.3 Causes of conflicting objectives**

Carmicheal (2002) identified causes of construction conflicts caused by contractors which include inadequate contractor’s management, supervision and coordination, delay or suspension of works, failure to plan and execute the changes of works, lack of understanding and agreement in contract procurement, reluctance to seek clarification and inadequate scheduling and update requirements. These also can be considered as the causes of conflict between the different objectives.

Time pressure within work scheduling was mentioned frequently in the interview. Time pressure was related to undertaking tasks for example, poor work set-up prior to task commencement, interruptions whilst working, and the pressure to meet deadlines. With the opinion of the interviewees, one of the reasons for the time pressure is that *“the project with a high degree of difficulty which is not reflected in the construction phase leads to time pressure”*. This reveals that the client should setup sufficient building time in the contract to reduce the pressure. Another reason can be seen that *“the project must be delivery on time. Delayed works will be claimed for liquidated damages”*. To earn the most, it has to increase workload in a constant time, and then the safety will be challenged. In the interview, it was indicated that unskilled labor and poor subcontractors leads to time pressure, *“subcontractor have not put on the correct staffing”*.

For the conflict between time and cost, there is a respond that *“it's money we live by, but the current system with many procedures, management systems and processes are time consuming”*. It is said, *“Time is Money”*. To ensure that time consuming is worthy, the project management thus will have to consider alternative solutions for the success of the project. *“Many of our competitors don't have many administrative systems to take into consideration.”* It should be encouraged *“to have everything on care”*.

*“According to the agreed schedule, the first subcontractor must finish the task to a certain time before the second subcontractor starts.”* Because the inappropriate arrangement of time, *“we in the project management give the first subcontractor so little time to finish their own task...”*, conflict occurs. This example shows that conflicting objectives can occur by poor planning. It is a common problem that projects designed without taking into account that work can be performed in a normal, safe way. In addition, there is not enough focus on safety when work is planned in an early stage. *“Conflicting objectives can occur because the safety has not been done properly earlier. Old habits take time to change.”*

The participation of different parties in a project is governed by a contract which defines the exchange of construction materials and services for money. As the opinion of the interviewees, contractual issues including definition, interpretation and clarification of the contract can also cause the conflict of the objectives. *“There are different understandings of the content in a contract and the contract is not reviewed enough with regard of the scope of work and time off to the different operations before signing on the contract.”* This should be aware by the contractor and subcontractor.

## **5.4 Significance of participants for conflicting objectives**

*“Each participant has their things they are measured against, leading to conflicting objectives. This is completely natural.”* But participants in the project must be highly aware of the importance of the conflicting objectives and do their best to find solutions to reduce the conflicts and complete the task successfully. Most of the interviewees were agreed that, *“all participants in the construction project have a responsibility, i.e. client, architects, consultants, contractors and individual workers. All these have a responsibility of HSE in their fields of work”*. But some people believed that the client and the contractor play an important role in the occurrence of the conflicting objectives. The clients setup a tight deadline in the contract as a result of time pressure. *“The client has a large part of the responsibility for giving sufficient time to the project.”* The client has also a major responsibility *“when it comes to choosing the cheapest contractor at a price competitive”*, so that it is possible to staff up the construction work for a contractor in a proper manner, and then the safety can be taken care in a proper manner by the contractor.

Client and contractor often have different goals of project, in particular, cost and quality. Architect and contractor often disagree on design and cost. It is crucial to have a good cooperation between the different participants. Flexibility and understanding from the client are important to address on both safety and quality. It is

also important that contractor and consultants have a same goal to achieve that the customer will get a product as good as possible within the frameworks we have at disposal.

## 5.5 Handling of conflicting objectives

Considering the differences of personality and discipline, communication and dialogue during the whole project is important and is also the easiest way to know each other and find solutions when the objectives have conflict. One stated that *“sitting down together at a table and find the best solutions. Avoiding using so much e-mail and telephone because they often result in unnecessary time using and conflicts occur easier”*. *“Anything that you are unclear must be said out.”* *“The better the different participants know each other, the better is cooperation.”*

As mentioned in chapter 3, handling of conflicts can be regarded as the ability of an organization to balance safety and other demand. It can also be the ability to project management of a company. Deficiencies in project management and planning can lead to difficulties with the project schedule. These in turn result in time pressure on all involved within a project, with subsequent problems such as crowded workspaces, reduced attention to detail and happening of unwanted incidents and accidents. Therefore, one of the interviewees has suggested that, *“management/subcontractor must prepare good thoroughly work schedules and detail plans including planning the delayed time caused by unforeseen circumstances”*. At the meantime, all the participants should be encouraged to involve into the planning, especially for the subcontractor. *“Involved planning (IP) is a very useful tool...”* *“Improved planning and involved planning before starting the project.”* It should be also larger focus on the phases of design and execution by using involved planning.

Essentially, having HSE focusing specially in the early stage of the construction process will reduce the conflict between safety and the other objectives, *“for example assembling the right equipment before starting the work”*. To avoid the conflicting objectives in practice, one proposed to conduct morning meetings on the production and the schedule of HSE, and *“hand out a block with ‘green tags’ to everyone to write down the unwanted incidents, dangerous etc.”*. *“In addition, conduct a safety course for all executing in all projects before the physical work can happen out of the project. The safety course will end with a diploma and a sticker on the helmet showing that the safety course has been completed.”*

The client should have focus on the changing of messages and carrying out the policy plans. Clarification of expectations in advance is to make the targets of the different parties clearly to reduce the interest conflict. Greater awareness of the product and the contract, mutual respect for plans and changes can also reduce the conflicts. The contractor needs to build a sufficiently work team who needs to plan the operations in

a responsible way on the basis of the agreed time, undertake risk assessment etc. In addition, before to sign the contract, clarified conversations both in terms of scope and safety requirements of the project should be carried out by the client, the main contractor and the subcontractor. The good communications and dialogues between the different participants will decide the conflicts that can be resolved or not. All these ways of handling of conflicting objectives are feasible if they have a good enterprise culture which can create a comfortable and safe working environment for all workers. One of the interviewees said that, *“I think that to establish a good environment in the work place will reduce the number of conflicting objectives. It is also important to engage the best participants to work on our construction site.”*

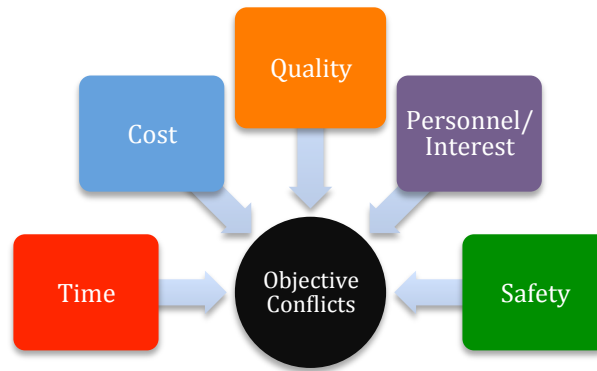
## 6 Discussion

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There are many conflict issues which could consider for construction projects and most of them are related to priorities, administration procedures, and human resources at various phases of the project life cycle. This chapter will use the results from the interviews presented in chapter 5, together with theories deduced in chapter 3 and literature reviewed in chapter 4. Based on the literature review and expert opinions, we could categorize the conflict issues that mostly face during construction, are related to project objectives such as time, cost, quality, safety and personnel/interest. Further descriptions of each specific issue and the causes of conflicting objectives are presented in the following sections. Sequentially, recommendations on handling of conflicting objectives will be given, as we have known the sources of problems. The discussion has its foundation in the three questions presented in chapter 1, structured in resemblance as the preceding chapter.

### 6.1 Conflicting objectives in construction project

Construction projects represent a unique set of activities that must take place to produce a unique product. The success of a project is judged by meeting the criteria of cost, time, safety, resource allocation, and quality as determined by the client. Many researches and the interview result in this thesis have indicated that all superior construction firms focus on four critical objectives, which are safe projects, quality work, on time production and competitive cost to the client. In Chapter 4, Khozein et al. (2012) stated that, time, cost, quality and safety as four critical objectives of construction project management, were not independent but intricately related. From the interview, some respondents also considered different interests as a conflicting objective. These objectives have to be central to any organization and to their professional thinking. In order to improve the probability of project success, it is hence more and more crucial to identify and fix at the earliest stages potential quality and safety issues and minimize the risks of schedule delays, cost overruns or claims, from design to contracting to final inspections and commissioning. However, they historically have conflict and it is very difficult to give a balance between these objectives. Any conflict is controllable, but left unaddressed because it threatens the revenue dollar with slower turns and higher costs. Identifying and understanding the conflicting objectives will give a contribution to handle the conflict. Figure 6.1 shows the common objectives that can lead to conflicts with each other according to the study of literatures and interview results.



**Figure 6.1: Five conflicting objectives can occur in construction projects.**

### **6.1.1 Time**

According to the respondents, the occurrence of the conflict between different objectives is not in a regular way. It can happen between two of them or all of them. It is worth noting that more than half of the respondents stated that conflict occurred between time and other objectives. It is clear that timely completion of a construction project is frequently seen as a major criterion of project success by clients, contractors and consultants alike. From literature review, the underlying reasons for conflicts during construction stage are also due to the importance of time for project. Newcombe et al. (1990) noted that there had been universal criticism of the failure of the construction industry to deliver projects in a timely way.

Every party involved generally agreed to perform in such a way so as to meet the requirements of project time, but this is not easy to fulfill in construction project. It is required a disciplined management effort to complete a construction project on time, and that this concerted management effort will help to control safety, costs and quality. This is tantamount to saying that the client's objectives can be achieved through a management effort that recognizes the interdependence of time, cost, safety and quality. It means that effective management is crucial to complete a project successfully.

### **6.1.2 Cost and quality**

The participants are like enter into business venture and conserve project cost as one of the main objective. In order to increase the profit under the confined condition, the interview result indicated that the conflict must be happened. It is common that conflict occurs between cost and quality in terms of the empirical data. Quality is mean to build exactly to drawings and specifications but such things are difficult to meet. Sometimes, quality means different to different perceptions such as supervisors



and managers. The conflicts are often arising during construction project execution. The quality of building materials and solutions can cause cost overruns and project delays. This is frequently identified as one of the principal factors leading to the high cost of construction.

### **6.1.3 Personnel**

According to the empirical data, conflict issues of construction project include interest conflict. The conflicts are due to involvement of different people with differences of personality, discipline and project goal. The conflict issues in the interview result are related to the different perspectives on work task and various understandings of contract. Conflict of interest will arise in the construction management process when one party has been entrusted with the responsibility for making judgments, and then stands a chance to receive a tangible benefit, directly or indirectly, as a result of such decisions (Cushman, Stover, Sneed, & Palmer, 1983). The key to solve this conflict is solidarity and cooperation in the project.

### **6.1.4 Safety**

In fact, safety remains an on going concern for the construction management. Safety issues refer to managing safety and health which is good for safety reasons. It is also good in terms of business sense on the contractor side. But often these issues are overlooked by contractors and owners to implement the safety practices at construction site. Construction by nature is inherently dangerous, with a high degree of hazard and risk. Neglecting the safety can results into accidents and mainly becomes the room for conflicts. Usually, the safety issues would drag time and cost of the project, in such situations the conflicts between the participants become more and complex.

The interview result indicated that the conflict between safety and other objectives can occur frequently. From the previous study, in my opinion, safety can have conflict with any other objectives and at the mean time the conflicts between all objectives may lead to safety issues. As mentioned the theory of Reason (1997) in Chapter 3, safety consumes productive resources – such as people, money and materials. People may think that the productivity declines resulting from high focusing on safety management. Therefore, safety management will conflict with the construction management, since they must share the limited resources during the construction. Obviously, this is not true! It would be a rare worker who has not felt pressure to be more productive. It would be an even rarer worker who hasn't felt tempted to cut corners in order to increase their productivity. However, for workers in safety-critical

jobs, cutting corners can have very real consequences.

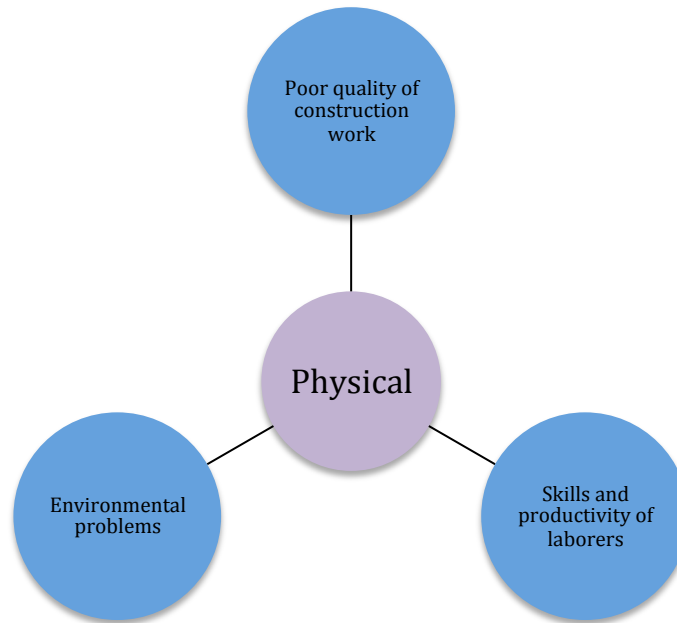
In fact, good balancing safety and production can create benefits. Employees are more productive in a safe environment, and it is better to have employees working with you to manage their own safety, in that way they feel more responsible for the safety of not only themselves, but their co-workers as well. Involved employees are more conscientious, more productive, and have less absenteeism. Safe workplaces are more efficient, more productive, and the substantial costs of injuries and occupational illnesses should be significantly reduced by implementing effective safety management.

## **6.2 Causes of conflicting objectives**

In order to prevent conflicts between different objectives and handle conflicts when they occur, the first important action is to trace the origins of problems. Many researchers have studied on conflict that addresses huge numbers of variables regarding the sources or causes of it in the construction industry. According to Chen et al. (2008), the interface issues may impact the project negatively regarding to schedule, cost, safety and quality, thus the occurrence of conflicting objectives among different participants can be regarded as the result of interface problems among various construction parties. Combining with previous knowledge of interface management, conflicting objectives causes in terms of literature and empirical data are discussed in this section from the three main categories of interface, which are physical, contractual and organizational interface (Pavitt & Gibb, 2003).

### **6.2.1 Causes from physical interface problems**

Physical interfaces are “the actual, physical connections between two or more building elements or components” (Pavitt & Gibb, 2003). Normally, physical interfaces are tightly connected with construction methods and construction resources (Al-Hammad, 2000; Chen, 2007). The number and the complexity of such interfaces are mainly determined by the detailing design as well as the contemporary techniques of manufacturing or construction. The failure at physical interfaces directly leads to the project failure with respect to the final product of building as well as the occurrence of accidents during construction. The common causes of conflict between different objectives (Figure 6.3) are presented in the following part.



**Figure 6.2: Physical interface problems cause conflicting objectives.**

***Poor quality of construction work***

According to Al-Hammad (1990; 1993), once the general contractor has been awarded the construction contract, he may award part or most of the contract to subcontractors. If any one of the subcontractors performs substandard work in his part of the project, he may affect the work standard of the entire project and thus create a conflict problem.

***Skills and productivity of laborers***

Skilled labor is required to complete high quality work. Labor may not clearly be mentioned in the bid documents; however, a shortage of this important resource will affect the quality of the completed work and thus create a conflict among the construction parties (Al-Hammad, 1993; Al-Hammad, 1995).

***Environmental problems***

In the conditions of bad weather, work productivity will be low because it is very difficult to perform certain construction activities. Consequently, the quality of construction work may be affected. Delays and lower quality work will lead to complaints from the client and will create conflict issues among construction parties (Al-Hammad & Assaf, 1992; Al-Hammad, 1993; 1995). Similarly, the contractor or his subcontractor may find out that the geological characteristics of the project site were not as expected; for example, the site may be more rocky than first thought or at

different elevations than reported. In such case, changes in designs, equipment used, foundation design, and excavation plans are required; those changes will create conflict problems on time and cost (Al-Hammad, 1990; 1993).

### 6.2.2 Causes from contractual interface problems

Contractual interfaces occur where there is the grouping together of work elements into distinct work packages to suit the design information availability or the general contractor's program (Pavitt & Gibb, 2003). In another word, contractual interface represents interactions among the general contractor, subcontractors, suppliers, and any external providers with regard to their scopes of work, schedules, and responsibilities for construction. The conflict causes are mainly related to documentation and project management (Al-Hammad, 2000; Chen, 2007).

Any document errors or misunderstanding and indistinct of contract will cost unforeseeable amount of money and lead to time pressure caused by wasting time, as a result of safety issues. There are changes in space usage to accommodate revised clients needs, something unforeseen occurs, the documents and work scopes must be adjusted. The more complex the project, the more ramifications a change has. The shorter the period allowed for design, the more addenda's that are required, and the more the opportunity for errors. Contract documents are one major origin of conflicts. Document errors become the fault of the owner when they cost the contractor un-bid or unforeseeable amount of money. Contractual issues (Figure 6.4) cause a significant conflict in many projects.

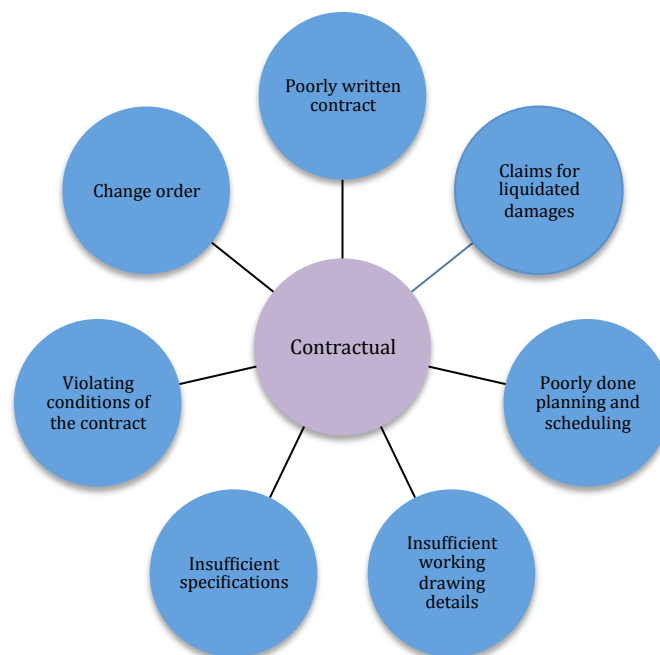


Figure 6.3: Contractual interface problems cause conflicting objectives.

### ***Poorly written contract***

The interview result indicated that poorly written contract caused misunderstanding, which might lead to conflict during the construction. A contract is written to prevent unlawful acts; it refers to all records in connection with the work at any specific time. The contract should cover all the client, designer, contractor, and subcontractor responsibilities. Any construction contract should contain the cost to be paid, the time allowed to complete the work specified and the requirements of Health, Safety and Environment (HSE) must be followed. If the contract is poorly written, interpretation problems among the construction parties will occur (Al-Hammad, 1990; Al-Hammad & Al-Hammad, 1996).

### ***Claims for liquidated damages***

In Chapter 5, the respondents stated that to avoid being claimed for liquidated damages, the project must be delivery on time. "Time is money" - this expression is perhaps nowhere more true than on the construction site. Every construction contract states or implies that work will be performed over a certain period of time. Contractors and owners rely on this expectation. Delay will usually frustrate these plans, causing inconvenience and loss to the innocent party. In addition, a contractor may be asked to accelerate production in order to make up for lost time. This will usually result in overtime, decreased productivity, scheduling problems, and a corresponding increase in costs.

### ***Poorly done planning and scheduling***

Planning involves listing all construction activities in a logical order; scheduling involves calculating the duration of those activities for the entire project and establishing starting and finishing dates. The contractor will schedule his construction activities and that of his subcontractors to meet the identified project duration. HSE plan should also add into the scheduling at the early phase of project. If any party delays the execution of his scheduled construction activities, it will consequently delay the progress of the activities of the other party (Al-Hammad 1990).

The empirical data showed that poor planning and scheduling would make time pressure to all the participants. Time is money to owners, builders, and users of the constructed facility. From the owner's perspective there is lost revenue by not receiving return on investment, cash flow crunch, potential alienation and loss of clients/tenants, extended interest payments, and negative marketing impacts. From the users' perspective, there are financial implications similar to owners. Delays in upgrading facilities translate into operating at below optimum efficiency resulting in higher user cost. Delays in constructing or rehabilitating infrastructure negatively

affects businesses and the public at-large. Time implications from the constructor's perspective include liquidated damages (negative) and incentive/disincentive payments. Delays result in extended overhead costs and puts a crunch on critical cash flow. Extending project durations limits the constructor's bonding capacity and ability to bid more work (opportunity cost). Inefficient time management results in higher labor and equipment costs. Consequently, it will also lead to conflict between time and other objectives.

### ***Insufficient working drawing details***

Al-Hammad (1990; 1993) declared that clear working drawings were important for effective execution of the construction work. If the working drawings are incomplete or unclear, these will be problems with interpretation, which will affect the quality of the work and create conflict problems among the construction parties.

### ***Insufficient specifications***

The bid documents, which include technical specifications, and other documents are the basis of the agreement between the client and contractor. One of the interviewees mentioned that the conflict could occur because of insufficient explanation and misunderstanding of the documents before signing. If the bid documents are incomplete or unclear, the following may occur: (1) the contractor will attempt to minimize cost and maximize profit at the expense of the project; (2) the owner will attempt to maximize the amount of work; and (3) the conflicting objectives will lead to disagreement and the possibility of delays in the completion of the project (Al-Hammad 1995).

### ***Violating conditions of the contract***

The contractor or the subcontractor may neglect implementing some conditions of the agreed contract between him and the client, such as using substandard construction materials. If the owner becomes aware of this, a dispute will arise between construction parties. Another form of violating the contract's condition is when the subcontractor makes adjustments to his bid after submission to the general contractor. These adjustments are generally stated as being made as a result of a revised bid from a supplier or to correct a mistake (Al-Hammad 1993).

### ***Change order***

The owner may require a change order when there is a need to add, modify, or delete

the original working drawing and the specifications. Changes could be complicated if the client, contractor, and designer have finalized the drawings and specifications and have started the project. Such changes will create a conflict problem among the construction parties (Al-Hammad 1990; Al-Hammad and Assaf 1992; Al-Hammad and Al-Hammad 1996).

### **6.2.3 Causes from organizational interface problems**

Organizational interfaces are the interactions between various parties involved in a construction project (Pavitt & Gibb, 2003). Organizational interfaces include the relationship between individuals and parties involved in the construction process from its initial conception to its final handover. The common problems that lead to the occurrence of conflicting objectives are caused by people/participants. They are actors of a construction project. Either individuals or organized parties perform certain activities that are necessary for completing a project. Such activities are more or less interrelated due to the activities themselves (dependent or concurrent activities) or the building products (components or subsystems) they yield (Chen, 2007). Interactions among different people/participants are unavoidable and need to be properly coordinated to prevent various conflicts and inferior project performance. Many suggestions for handling conflicting objectives were given in the interview result emphasized on communication and cooperation, which reveals that the organizational interfaces problem are the underlying causes leading to conflicting objectives, and they must be pay high attention to resolve. Figure 6.2 illustrates the four main causes for organizational interface problems, which can be easily understood.

#### ***Poor communication***

Communication is the means of acquiring and transmitting information. A construction project involves many participants forming a temporary multi-organization, which cannot function effectively without good communication among people in it. Effective information exchange, especially in some information-intensive project phases, is essential for project success. Poor communication easily creates design errors, assembly conflicts, delays, and other project failures. In practice, communication within the same party is usually much better performed than that across the boundary of parties. The lack of communication often results from unknown information needs. The dominant “pushing” method for communicating project information does not work well when information dependencies among parties are obscure. It leads to information redundancy as well as shortage. The reason for delayed and ineffective communication is threefold. First, inferior human/organization relationships prevent timely and effective information

exchange. Second, inferior means of communication slow down information sharing. Third, the lack of information standards lowers the quality of information generated and reduces the communication efficiency and subsequent application. Therefore, the improvement of communication should target these three aspects (Chen et al., 2008).

### ***Poor coordination***

Coordination is very critical in both design and construction to enhance constructability, ensure compatibility of components/ subsystems, and minimize conflicts in schedules, site activities, and resource utilization among contractors. Nevertheless, there are some underlying causes worth discussion. The currently prevailing project delivery methods (except design-build) could not enable coordination between designers and contractors. The same issue exists among specialty subcontractors without a direct contracting relationship to each other (Chen et al., 2008).

### ***Poor decision-making***

Accurate and sufficient information as well as a decision-maker's experience are equally important to the decision making process. Poor decision-making increases errors, changes, conflicts, delays, disputes, and wastes in construction, and usually leads to project time and cost overruns. It also lowers the quality and systems performance of a built facility. For example, project complexities and uncertainties prevent decision makers from reaching a good understanding of a project. This oftentimes leads them to bad decisions in selecting design approaches, project delivery methods, subcontracting strategies, materials/components/subsystems, construction methods, work sequences, or equipment/tools. Sometimes, decisions are not adaptable in a changing environment (Chen et al., 2008).

### ***Financial problems***

Possible financial problems in a construction project include delayed payments, underbids, cash flow problems, cost disputes, etc. These problems cause low productivity, poor quality, suspensions of work, delays, and disputes. Actually, financial problems easily ruin intercompany relationships due to interrupted monetary interests. Among various financial problems, low budget for design and construction leads to diverse conflict issues by limiting designers' capability to find a better design approach and contractors' willingness for coordination and improvement. In the end, such a cost cut usually comes at a high price to the project (Chen et al., 2008).



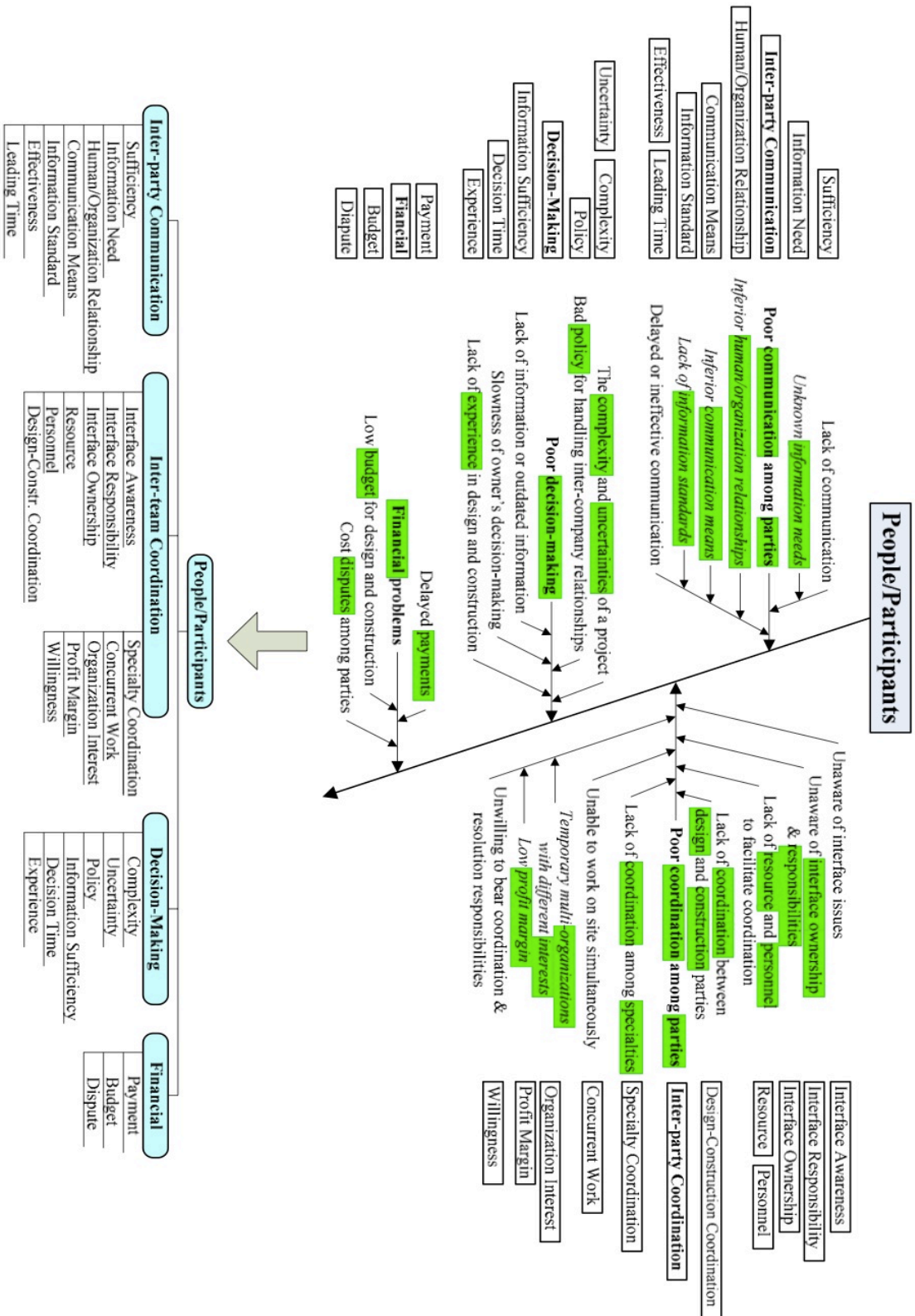


Figure 6.4: Elements of organizational interface problems for the People/Participants Category (Chen, 2007)

## **6.3 Recommendations**

Many organizations treat safety management as a negative production process, which means highly focusing on safety will impact on production. It is concerned that safety tasks are 'extra' work that require time but that are not necessary to the production of final output. Thus, completing more safety tasks increases the total time per task and lowers productivity. On the contrary, safety solutions that are properly executed and adapted from the beginning will increase productivity. We can increase productivity by using safe work practices and providing a safe work environment. On the other hand, an excessive focus on productivity, without regard for other considerations can often reduce safety and through increased waste and injuries, can actually reduce productivity. The organizations may think that they could control the accidents by setting reduced negative outcome targets for the coming accounting period (Reason, 1997). But accidents, by nature are not directly controllable. So much of their causal variance lies outside the organizations. The organization can only defend against hazards, but it cannot remove or avoid them. Similarly, an organization can only strive to minimize unsafe acts, but it cannot eliminate them altogether.

Rather than struggling vainly to exercise direct control over accidents and incidents, effective safety management focus on regularly measure and improve those processes – design, hardware, training, procedures, maintenance, planning, budgets, communication, objective conflicts and the like – that are known to be implicated in the occurrence of organizational accidents. It is more like a long-term fitness programme than negative production, and those manageable processes can determine a system's safety health. In this way, safety is not an add-on, but an essential part of the system's core business (Reason, 1997). Thus Reason (1997) stated that conflicting objectives might occur due to insufficient project management including safety management.

In this section, the recommendations on handling of conflicting objectives will be firstly presented based on the theories. Then the section will focus on making good scheduling involved safety concern and establishing a safety culture to handle the conflicts between objectives in terms of the interview results and the literature review.

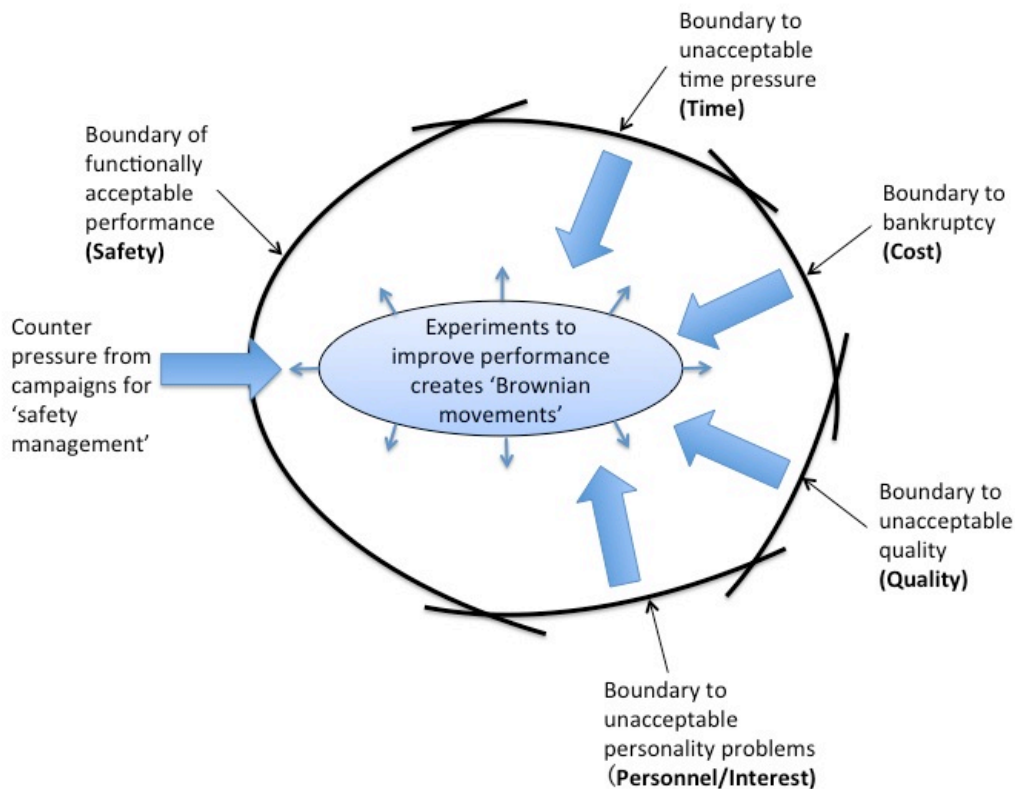
### **6.3.1 Theoretical handling of conflicting objectives**

According to the perspective of the Rasmussen model of system dynamics (Rasmussen, 1997), Rosness (2013) recommended to handle conflicting objectives following these points:

- Establish “counter-pressures” supporting safety objectives
- Make boundaries visible
- Learn operators to cope with the boundaries
- Establish unambiguous criteria for critical decisions
- Build human redundancy (High-Reliability Organizations)
- Encourage discussions on conflicting objectives
- Encourage whistle-blowers
- Establish communication patterns for safe distributed decision making
- Keep the organization open to critical outsiders

The Rasmussen model of system dynamics (Rasmussen, 1997) provides an explanation of why efforts to improve safety have generated only equivocal indications of success. The key feature of Rasmussen’s model is its dynamic character. Combining with the empirical study, the Rasmussen model can be illustrated as Figure 6.6. According to the model, systems under the stress of the four conflicting objectives will be migrate towards high production and towards the boundary of unacceptable performance, i.e. the place in operational space where accidents occur. Migration towards the boundary can be offset by counter pressures, e.g. encouragements to “be safe”, but pressures of conflicting objectives are usually unremitting in real world systems so that preventing migration requires constant counter pressure and a willingness to tolerate the inefficiency that remaining distant from the boundary entails. In a word, in order to deal with conflicting objectives, it is crucial to establish an effective safety management as a constant counter pressure and focus on making the boundaries towards unacceptable risk explicit and known.

In the research of exploring safety critical decision-making involving conflicting objectives, Størseth et al. (2010) concluded that it is necessary to formulate and justify precise criteria for handling the critical decision. They also encouraged discussing conflicting objectives, which should be emphasized on the value of disagreement and requested participants to record divergent opinions rather than strive for consensus (Størseth et al., 2010). It is necessary for participants to spend more effort at listening and less effort at convincing each other during the discussion. In this way, participants might be able to discuss a safety critical issue without clashing together, and they could focus on the need to provide decision-makers in the sharp end with the best possible aids and criteria to handle critical situations.



**Figure 6.5: Under the pressure of different objectives activities tend to migrate toward the boundary of unacceptable performance.**

Direct experience with accidents provides unambiguous information about the location of the boundary and offer opportunities to devise programs to keep operations away from the boundary. Because the boundary location is changing with time, however, long accident-free periods are the exception rather than the rule. Long accident free periods will result in migration towards the unacceptable performance boundary as the system seeks higher efficiency in operation. Workers will be encouraged to “cut corners” to achieve production goals and the workplace will be regarded as too “rich” when accidents are rare. As the system operating point migrates towards the accident boundary under these pressures, accident occurs. These provide indications that the system operating point has now become too “lean” and these pressures will be overcome by the strong need to “be safe”, moving the operating point away from the accident boundary. Significantly, the actual shape and location of the accident boundary can only be inferred. It is for this reason that high-reliability organizations (HRO) are inherently conservative about applications of new technology or changes in operational procedure; their close proximity to the boundary of unacceptable performance requires that they constrain the movement of

the operating point in order to avoid accidents. It seems that building HRO will be favorable on conflicting objectives.

As known from the theory, it is fundamental to understand why and how trade-offs between production and safety goals operate because decisions taken may have serious consequences on the safety of the system. Complex organizations are characterized by distributed decision-making, and require a sharing of perspectives among distributed decision makers if they are to coordinate activity and adapt to changing circumstances (Brehmer, 1991). Rasmussen and Svedung (2000) suggested that many accidents occur because couplings occur between activities which are usually not coupled in any functional way during daily work. Sharing of perspectives demonstrates the value of sharing information, experiences and expert knowledge within the organization. Through sharing of perspective, a communication pattern will be created, which contributes to a tight coupling.

In order to handle the conflicting objectives, the management, so-called blunt end of the organization, should learn operators who work at the sharp end to resolve conflicting objectives in advance, e.g. through procedures, so that actors at the sharp end are relieved from making trade-off decisions between safety and conflicting objectives. It is also necessary to everyone working within the organization to report the findings and experiences involving safety issues during the work and keep the organization open to receive supervisions and suggestions from external organizations or individuals. Situations will continue to occur and change with time. Therefore we maintain that the issue of handling conflicting objectives should not be taken off the agenda.

### **6.3.2 Making good schedule and plan**

Good schedules and plans are critical to project success as most of the interviewees have mentioned. The plan and schedule phase is right before the construction starts. This phase provides a very good opportunity for the design-build team, contractor and subcontractors to establish their relationships and coordinate their construction plans and schedules. However, in practice, this opportunity is not fully utilized by project participants. In fact, a successfully conducted plan and schedule phase should be able to establish the best working relationships among participants prior to the real construction. These relationships include effective and efficient communication channels, clarified and accepted coordination responsibilities, and the willingness to share various resources and cooperate closely. Also, the success of this phase includes extensive coordination among participants' detailed construction plans and schedules. In order to make good planning and scheduling, the following presents some methods that can be used in practice.

### ***Critical Path Method and linear schedules***

In today's intensely time driven business environment, superior planning, scheduling, and control are vital. The project manager is faced with the challenges of completing high volumes of work within tight time frames, and generally finite resources. They must comprehensively plan construction operations and closely monitor progress. According to Callahan et al. (1992), the effective planning, scheduling and control of construction projects is necessary. The benefits of implementing and maintaining this set of three management systems are reduced construction time, reduced cost overruns and the minimization of disputes. These benefits accrue to the contractor, client, suppliers and workers in the form of improvements in productivity, quality and resource utilization (Mattila & Abraham, 1998). Critical Path Method (CPM) schedules and linear schedules are valuable tools that provide several advantages in managing construction operations. Schedule preparation requires managers to think the project through prior starting the work and provides a structured approach to planning. Comprehensive schedules provide a means of communicating the work plan to others. Schedules must be an accurate portrayal of the work plan to realize the full value. A good, regularly updated schedule in the hands of a competent project manager is a powerful tool.

### ***Involvement planning and partnering***

Resulting of the interview shows that the respondents suggested handling conflicting objectives by carrying out involvement planning in the early phase of project. Early Contractor Involvement (ECI) contracts are a recent model that has become one possible solution to involving Contractors in the preliminary design process (Frazer, 2012).

The "traditional" construction contract model involves the client engaging a designer to design the works and an engineer to oversee the project (Grierson et al., 2012). The client subsequently engages the contractor to build the works and the Contractor enters into subcontracts with sub trades. The problem with this "traditional" contracting is that it leads to adversarial behaviors given the conflicting objectives of the parties. Under a "traditional" model the client can seek to minimize its risk exposure by adopting variants such as Design Build or Turnkey contracts, however the trade-off is that it can lose control over the project. Also, such contract models can result in a reliance on risk allocation rather than risk identification and mitigation (i.e risk management). In such circumstances, the lack of pre-contract risk management can be exacerbated by inappropriate apportionment of risk or inappropriate pricing of

risk.

Early Contractor Involvement (ECI) attempts to optimize risk management, risk allocation, price and control for the client (Grierson et al., 2012). ECI is effectively a first cousin to the Design Build contract model. It seeks to exploit a Contractor's specialist knowledge of construction processes to the benefit of the design process. The key difference between Design Build and ECI is that ECI, as its name suggests, seeks to obtain this benefit at a much earlier stage. The rationale being that it is during this early stage of project planning that the greatest influence on capital costs and project outcomes is possible. It is essentially a form of collaborative contracting. Like alliancing, ECI envisages the early involvement of the Contractor and the adoption of “best for project” attitudes by all parties.

ECI can be regarded as a form of project delivery (Swainston, 2006). Swainston (2006) stated that, “*ECI is a new, two-staged approach similar to a project alliance during the first stage. It essentially involves putting additional resources into the crucial early planning phase in order to maximize the benefits and cost savings that can be achieved during construction. Its innovation comes from the selection process, the interaction between the client, contractor and designer during stage one, and the strong relationship-based interaction between the parties.*”

### ***HSE planning and checklist***

As stated by Reason (1997), conflicts between production and safety can often occur in the short term. Thus avoiding the conflict between safety and another objectives demands HSE and construction to go hand-in-hand in the long term. To keep the harmonic relationship, before started projects, a HSE management plan (Appendix B) must be developed by clients and contractors which defines the HSE principles and practices to be applied during the project (English, et al., 2013). The scope of the work and role and responsibility of HSE must be explicit in construction projects. In the plan, the role and responsibilities of key HSE personnel will be clearly defined. In general responsibilities, all employees are responsible for stopping work if they identify anything that could cause harm to any person for which controls are not in place; reporting incidents and illnesses or injuries; assisting in incident investigations; identifying, reporting and eliminating (if within their authority and ability) hazards in their workplace; participating in relevant injury management programs if required; complying with relevant requirements of HSE policy, procedures and standards.

If the HSE documents are incomplete or unclear, the conflicting objectives will lead to disagreement and the possibility of delays in the completion of the project. In case these problems happen, before the project execution, all employees will be given a

copy of their position description which will define their HSE responsibilities. Employees sign a copy of their position description as an acceptance of those responsibilities.

In the construction process, the contractor or the subcontractor sometimes may neglect implementing some conditions of the agreed contract between him and the client, such as using substandard construction materials. If the client becomes aware of this, a dispute will arise between construction parties. Under this situation, HSE coordinators are responsible for facilitating good communication between the client, designers, contractors and subcontractors before violating the conditions of the agreed contract. There must be an open and continuous line of communication between the client, the contractor and subcontractor to discuss any unsafe acts or conditions that may arise during the whole project.

To ensure the HSE performance of the contractor in construction projects, a contractor checklist can be implemented (Appendix C). The basic requirements of the HSE performance will be described in the checklist (Central Committee of Experts SCC, 2008).

### **6.3.3 Building a culture of safety**

All the previous study points out that highly focusing on safety and establishing a safety culture is important in organizations. Investigations following many major accidents have ascertained that the incidents were triggered by a weak safety culture (Gard News 200, 2010). This expression is used to describe how, over time, organizations have placed a decreasing amount of emphasis on safety measures and thus developed dangerous practices. In other words, the problem is not errors made by individuals, but rather a number of errors made over time, that become part of general work practices. The culture of the organization ignored the risk of such practices.

It is often said that procedures are not followed because of negative attitudes among operators. However, usually these attitudes are a direct result of the culture of the organization (Misnan & Mohammed, 2007). Safety culture could be described as how an organization prioritizes safety and the behavioral norms which have evolved relating to safety (Gard News 200, 2010). How the operators understand and relate to conflicting objectives is a good example of how culture influences working practices. Conflicting objectives are often seen as a perceived pressure or expectation which exists more or less implicitly within the organization. The fact that conflicting objectives will always be present must be acknowledged. In other words, it is impossible to totally eliminate conflicting objectives so one should concentrate on methods to manage them. Addressing safety culture and considering how an



organization prioritizes safety may be a good starting point for improvement. Organizations with a well-developed safety culture are fully aware of these issues. Safety is acknowledged as one of the core elements of the overall business goals.

The issues of conflicting objectives can be addressed by creating a culture of safety means that the employees are constantly aware of hazards in the workplace, including the ones that they create themselves. It becomes second nature to the employees to take steps to improve safety. The responsibility is on everyone, not just the management. However, this is a long process to get to that point (Dilley & Kleiner, 1996). The role of management and the involvement of all employees as important key players in safety culture are important in order to cultivate the positive beliefs, practices, norms and attitudes among all in the company. Glendon and McKenna (1995) identified four critical indicators that will be a useful guide to build a safety culture:

- Effective face-to-face communication, it leads to commonly understood goals and means to achieve them at all levels.
- Good organizational learning, whereby organizations are able to identify and respond appropriately to changes.
- Organizational focus upon health and safety, how much time and attention is essentially paid to health and safety.
- External factors, including the financial health of the organization, the prevailing economic climate and impact of regulation and how well these are managed.

These measures will create a more positive safety culture, which encourages everybody within the organization to take responsibility for overall safety and warn of any possible risks to it. Work with safety culture is a never-ending story and it can take some time before results are evident. It is also important to be aware that, even in the best organizations, human error will occur. The difference between the good and the not-so-good organizations is that those with a good safety culture acknowledge that human error can occur and therefore try to improve working conditions. To quote from Reason (1997), “*we cannot change the human condition, but we can change the conditions under which people work.*”

## 7 Conclusion

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The purpose of this thesis is to investigate the conflicting objectives between safety and economy/efficiency (i.e. production) in interfaces between different stakeholders in the construction industry. In order to give recommendations on handling conflicting objectives, the common conflicting objectives in construction project are identified, and the causes of conflicting objectives are also explicitly understood by reviewing literature and conducting e-mail interview with some experts of a construction company.

By studying the literature and interview result, it is concluded that the current situation in construction industry demands that effectively managing a construction project must consider the five critical objectives, which are time, cost, quality, personnel/interest and safety. It is essential to balance the relationship between safety and the other objectives, otherwise the unwanted harmful consequences will occur. When the conflict arising, it is important to recognize and understand the problems as early as possible. The causes of conflicting objective were discussed combining with the previous study on interface management and the empirical data. As the occurrence of conflicting objectives among different participants can be regarded as the result of interface problems among various construction parties, the causes were categorized into *physical interface problems* including poor quality of construction work, skills and productivity of laborers and environmental problems; *contractual interface problems* including poorly written contract, claims for liquidated damages, poorly done planning and scheduling, insufficient working drawing details, insufficient specifications, violating conditions of the contract and change order; and *organizational interface problems* including poor communication, poor coordination, poor decision-making and financial problems. Many suggestions for handling conflicting objectives were given in the interview result emphasized on communication and cooperation. Thus these organizational interface problems are the underlying causes leading to conflicting objective. It should be pay high attention to resolve the problems.

According to the theory of migration model (Rasmussen, 1997), it is essential to handle conflicting objectives by establishing an effective safety management as a constant counter pressure to support safety objectives, and focusing on making the boundaries towards unacceptable risk explicit and known. It is also necessary to formulate and justify precise criteria for handling the critical decision. When conflict between objectives occurs, it is encouraged to discuss how to address it within the organization and establish a communication pattern by sharing information, experiences and expert knowledge. Building HRO is also favorable that they

constrain the movement of the operating point in order to avoid accidents. Conflict can also be handled by learning operators to manage the boundaries and encouraging everyone who works within the organization to report the findings and experiences involving safety issues during the work and keep the organization open to receive supervisions and suggestions from external organizations or individuals.

In practice, in order to resolve the conflict issues related to time which was stated frequently by interviewees, it is essential to make good scheduling and the involvement planning was also suggested by interviewees. Highly focusing on HSE in preliminary phase in construction project and making good HSE planning are also the solutions on handling of conflicting objectives. The overview of all the suggestions from interview result and literature has indicated that it is crucial to establish a safety culture that encourages everybody within the organization to take responsibility for overall safety and warn of any possible risks to it.

In the future work, two tasks should be done. The most of the recommendations based on migration model is more focus on theoretical measure. The first future work of this study thus should work out how to apply these theoretical measures into practical work. Another task is to carry out an in-depth interview such as face-to-face interview with all the stakeholders in construction project (client, contractor, subcontractor, supplier etc.). This will make contributions to do a more comprehensive research on conflicting objectives in different interfaces of construction project.

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# Appendix

## Appendix A – E-mail interview guide

Jeg heter Tianshu Liu og skriver dette semesteret masteroppgaven ”Målkonflikter i grensesnittet mellom produksjon og sikkerhet i bygg- og anleggsprosjekter” ved institutt for industriell økonomi og teknologiledelse, NTNU. For å svare på problemstillingene i oppgaven, vil jeg invitere deg til å delta i et e-post intervju.

Ved at du svarer på spørsmål nedenfor, er det mulig for meg å få kunnskap om samspillet mellom aktører i et prosjekt og hvordan sikkerhet ivaretas.

Bedriften vil få tilgang til den endelige masteroppgaven. I masteroppgaven blir all innsamlet informasjon anonymisert.

I oppgaven forstår jeg målkonflikter på følgende måte:

*”Målkonflikter er en del av hverdagen i alle organisasjoner og på alle arbeidsplasser. Vi ønsker å gjøre jobben raskt og effektivt, uten feil, og uten at noen blir skadet. I praksis tvinges vi ofte til å veie ulike hensyn mot hverandre. Det kan oppstå en tidsklemme, og ledelsen må velge mellom det å forsere arbeidet eller å ta kostnadene og prestisjetapet ved forsinkelser. Et arbeidslag kan støte på uforutsette problemer og må velge mellom å "koste på" for å bli ferdige eller ta seg tid til å diskutere risikoen ved å fortsette. Over tid kan målkonflikter bidra til at arbeidslagene gradvis begynner å ta små "snarveier" som svekker sikkerheten. Dersom ingen tar tak i slike små endringer, kan det være fare for at "snarveier" over tid blir den aksepterte måten å gjøre det på. Det er alvorlig at "snarveier" blir akseptert så lenge det går bra, men straffet den dagen det skjer en ulykke. Alle organisasjoner må forholde seg til målkonflikter” (fra Petroleumstilssynet).*

Det vil si at målkonflikter kan beskrives som en uoverensstemmelse mellom hensynet til produksjon og hensynet til sikkerhet.

Spørsmålene er:

- 1. Hva er din rolle i bedriften?**
- 2. Hvilke målkonflikter kan oppstå prosjekter? Beskriv gjerne konkrete eksempler**
- 3. Hvorfor oppstår disse målkonfliktene?**
- 4. I hvilken grad vil du si ulike aktører har betydning for målkonfliktene?**

- 5. Hvordan håndteres målkonfliktene i praksis?**
- 6. Har du forslag til hvordan målkonflikter kan håndteres bedre? Hvordan?**
- 7. Har du annen erfaring eller informasjon relatert til målkonflikter, som du mener er relevant for oppgaven min?**

All informasjon blir behandlet konfidensielt. I masteroppgaven vil all informasjon og informanter være anonymisert.

Svarfrist: innen to uker

Jeg ønsker så utfyllende svar som mulig, men korte svar er bedre enn ingen svar.

På forhånd takk,

Med vennlig hilsen

Tianshu



## Appendix B – The elements in HSE management plan

1. Objectives
2. Scope
3. Project HSE management plan resources
4. Roles and responsibilities
5. Safety meetings
6. HSE in design
7. Environmental and permitting requirements
8. Selection of work-site subcontractors
9. Project-level safety training
10. Site-specific HSE manual
11. Project-level incident-management requirements
12. Project-level measurement and reporting of performance
13. Requirements for construction sites
14. Communication of work-site safety expectations
15. Subcontractor participation
16. Demonstration of work-site management commitment and leadership
17. Work-site safety resources
18. Fitness for duty
19. Identification of key safety program element and selection of safety initiatives
20. Minimum HSE initiatives requires
21. Work-site hazard recognition and control
22. Work-site safety policies, procedures, and safe work practices
23. Personal protective equipment
24. Safe Job Analysis (SJA) / Job Hazard Analysis
25. Recognition program
26. Inspections
27. Audits

**Appendix C – Questions of HSE checklist contractors (Central Committee of Experts SCC , 2008)**

<b>Section 1. HSE policy and organization, involvement of the Management Board</b>	
1.1	Has the company drawn up a HSE policy statement?
1.2	Has the company appointed a Safety and Health Officer?
1.3	Is the organization in the possession of a HSE structure?
1.4	Are managers appraised in terms of safety, health and the environment?
1.5	Is the Management Board actively involved in HSE?
1.6	Does the Management Board carry out assessments of compliance with the HSE Checklist Contractors (SCC) requirements?
1.7	Is an objective formulated and followed up with respect to the Injury Frequency Rate (IF) for lost time accidents?
1.8	Are HSE targets formulated and implemented?
<b>Section 2. HSE risk management</b>	
2.1	Is the company in the possession of an up-to-date HSE risk inventory and evaluation?
2.2	Do task-risk analyses take place?
2.3	Is Last-Minute Risk Analysis (LMRA) carried out before commencing work?
2.4	Is the appropriate personal protective equipment issued, maintained and replaced free of charge?
<b>Section 3. Training, information and instructions</b>	
3.1	Are all employees in the possession of vocational training and experience relating to the work they are to carry out?
3.2	Are all operational employees in the possession of a ‘Basic Elements of Safety SCC’ diploma, testimonial, or certificate?
3.3	Are all operational supervisors in the possession of a ‘Safety for Operational Supervisors SCC’ diploma, testimonial, or certificate?
3.4	Are all employees in the possession of specific knowledge and expertise pertaining to specific high-risk tasks or work in a high-risk environment to be performed by them within the company?
3.5	Does the company provide specific in-house HSE information and instructions?

3.6	Is there an adequate procedure for the correct management and completion of the Personal Safety Logbook (where relevant)?
3.7	Can communications pertaining to HSE issues be effected without language impediments?
3.8	Are the employees cognizant with the internal regulations/procedures at the principals where they will work, such when this requirement is explicitly specified and the necessary information is made available by the principals?
<b>Section 4. HSE awareness</b>	
4.1	Does the company conduct HSE consultations?
4.2	Has the company introduced a program for the improvement of HSE awareness and SHE conduct?
<b>Section 5. HSE project plan</b>	
5.1	Does the company make use of HSE project plans?
5.2	Do the employees receive instructions about the contents of the HSE project plan?
5.3	Do the employees of subcontractors receive instructions about the contents of the HSE project plan?
5.4	Is the HSE plan submitted to the principal for discussion?
5.5	Is a Safety and Health Coordinator appointed for each project?
<b>Section 6. Environmental protection</b>	
6.1	Are sufficient preventive environmental-protection measures implemented which are focused on the prevention of soil pollution and waste management?
6.2	Has the company appointed an Environmental Officer?
<b>Section 7. Preparations for emergency situations</b>	
7.1	Is the company prepared for an effective response to emergency situations?
7.2	Have the employees assigned responsibilities in emergency situations received the commensurate training?
<b>Section 8. HSE inspections</b>	
8.1	Are periodic workplace inspections carried out by the operational supervisors?
8.2	Are trend-analyses performed on the shortcomings encountered during inspections?
<b>Section 9. Company health service</b>	

9.1	Are employees in given positions and/or employees to be deployed at specific workplaces subjected to an examination of their medical suitability?
9.2	Have specifications been drawn up of the employees in given positions who are required to undergo periodic medical examinations in view of the exposure risks associated with those positions?
9.3	Are employees offered an opportunity to consult with a qualified medical expert or occupational medicine prevention consultant?
9.4	Does the company conduct a policy which stipulates that employees can be offered modified duties subsequent to an accident?
<b>Section 10. Purchase and inspection of materials, work equipment and personal protective equipment (PPE)</b>	
10.1	Does the company purchase materials, work equipment and personal protective equipment that are justifiable from a HSE perspective?
10.2	Are the work equipment and personal protective equipment inspected at periodic intervals?
<b>Section 11. Procurement of services</b>	
11.1	In the event of the use of subcontractors, are procedures in place which ensure for compliance with all the relevant SCC requirements at the workplace?
11.2	Are subcontractors who are frequently contracted to carry out work subjected to structural assessments and selection on the basis of their HSE performance?
11.3	Are temporary employees hired from temporary employment agencies with SHE Checklist Temporary Employment Agencies (SCT) certification to carry out high-risk work?
<b>Section 12. Notification, registration and investigation of accidents and HSE incidents</b>	
12.1	Is the company in the possession of a procedure for the notification and registration of employee accidents resulting/not resulting in lost time?
12.2	Does the company investigate accidents resulting/not resulting in lost time?
12.3	Is the investigative method used to investigate accidents resulting/not resulting in lost time, based on the determination of the underlying causes?
12.4	Is the company in the possession of a procedure for the notification and registration of near-accidents and/or HSE incidents?
12.5	Does the company investigate near-accidents and other SHE incidents?

## **1. HSE Policy and Organization, Management Board Involvement**

In order to reduce accidents, incidents and material and environmental damage, and continually improve the HSE performance, the first step is to formulate an integrated and structured HSE policy and it must be announced to all employees. All those involved in the specification and implementation of the HSE policy are fully cognizant of what is expected from them with respect to HSE issues, including the supervisors who must be cognizant of their HSE duties, powers and responsibilities. When the issues take place, the HSE Officer has responsibility to coordinate and report directly to the Management Board. To exert a positive influence on the HSE conduct of the management, the company should institute an appraisal system for employment incorporating HSE issues and all supervisors are also subjected to an annual appraisal. The appraisal must be reported and followed up in the event of non-compliance.

The Management Board involved in HSE contributes to promote the HSE performance by means of chairing or attending HSE meetings, carrying out evaluation of accidents and analyses of the trends and evaluation of HSE activities. To organize inspections at workplace is also in the charge of the Management Board. After a year's work the Management Board is required to evaluate the achievement of the HSE targets and the implementation of the measures.

## **2. HSE Risk Management**

Prevention of HSE incidents depends on risk control with respect to the work to be carried out by the company. Risk analysis is carried out before starting work. The objective is that the employees carry out a check at the workplace to verify that all risks have been recognized and that adequate control measures have been implemented. The approach is based on the principle that the employees start high-risk work only once adequate measures have been implemented. During the work the employees are provided the appropriate personal protective equipment and the issue, inclusive of maintenance/exchange, is free of charge. To determine and control HSE risks, the company has to have an up-to-date HSE risk inventory and evaluation. Up-to-date HSE risk inventories and evaluations are available for all positions within the company which have been specified as jobs with associated risks. Risks determined during the evaluation are controlled by implementing effective measures, whereby preference is given to tackling the risks at source. HSE risk inventories and evaluations are evaluated at least once a year on the basis of notifications and incidents, and amended as necessary, with the active participation of the HSE Officer.

### **3. Training, Information and Instructions**

A summary of the vocational training and experience requirements are applicable to each position and procedures providing assurance for workplace are compliance with the stipulated training and experience requirements. This is to achieve the objective that all employees are in the possession of the vocational knowledge and expertise required to carry out their duties in the company. Similarly, all employees are in the possession of the specific knowledge and expertise required to perform high-risk tasks and/or work in a high-risk environment in the company. All operational employees and operational supervisors must have a valid diploma, testimonial or certificate to prove that they are in the possession of HSE knowledge. The company should provide specific internal HSE information and instructions to make sure that all employees are cognizant of the SHE regulations and instructions, as well as the SHE instructions governing the work they are assigned to carry out in their customary work environments. Employees who speak other languages are deployed in a manner providing for the effective communication of relevant SHE issues. An adequate procedure for the correct management and completion of the Personal Safety Logbook is also needed.

### **4. HSE Awareness**

The promotion of the motivation with respect to and attention to HSE issues in the company is very important. The company should conduct HSE consultations with the Management Board, employees' representatives and all operational staff to discuss relevant HSE subjects and issues requiring attention as a result of notifications of SHE incidents and inspections. The company also need to introduce a program for the improvement of SHE awareness and SHE conduct by means of observation program, improvement program based on the findings from the observation program and feedback mechanism to inform the relevant employees of the findings.

### **5. HSE Project Plan**

HSE project plan is the coordinated control of SHE risks associated with projects. The contents of the plan are the SHE risks of relevance to the project and the measures to be implemented, the SHE organization, the organization of safety inspections, the reporting of incidents, and a signature by the person responsible for the project. The employees and employees of subcontractors must receive instructions about the contents of the SHE project plan to make sure that all the employees are cognizant of the risks specific to the project and of the control measures. The HSE project plan will be submitted to the principal for discussion and registration on HSE risks of relevance

to the specific project, as well as the requisite control measures. The HSE Officer is demonstrably present at the project to a sufficient extent and can be contacted. The HSE Coordinator is appointed for each project.

## **6. Environmental Protection**

One of the objectives is the prevention of soil pollution and the effective management of waste. Minimum requirements include inventory of the risks relating to soil pollution and waste (related to the company's activities), and the implementation of the necessary preventive measures. The other objective is the coordination of environmental issues within the company during its everyday operations. The Environmental Officer reports directly to the Management Board, and is incorporated by name in the organization chart. The job description of the Environmental Officer incorporates an explicit specification of the concomitant duties, responsibilities, and powers. The Environmental Officer is in the demonstrable possession of the necessary expertise, or has demonstrable recourse to internal/expertise.

## **7. Preparations for Emergency Situations**

The company must be prepared for an organized and effective response to emergency situations. The employees should cognize the procedure for the issue of notification, warning, giving the alarm, and evacuation in connection with emergency situations. The First-Aid equipment, fire-extinguishing equipment and any specific equipment at workplace are available in sufficient quantities and maintained in the correct condition. The employees will have assigned responsibilities in emergency situations received the commensurate training. It means that the employees are in the possession of an adequate training/instructions for first aid, fighting beginning fires, evacuation, accompanying the first-aid services and so on.

## **8. HSE Inspections**

HSE inspection is the timely identification of non-compliances in the conditions at the workplace and the conduct/actions of the employees, and the implementation of corrective measures intended to prevent accidents/SHE incidents. Inspections of each workplace are necessary to be carried out at least once a month by the operational supervisor. Inspection reports should incorporate a list of the non-compliances that were observed, the improvements to be implemented, the person responsible for the implementation and the scheduling for the implementation. Trend-analyses will be performed on the shortcomings encountered during inspections. According to the category, nature and causes Classification of the shortcomings can be classified.

## **9. Company Health Service**

In the part, the objectives are the deployment of employees who are medically suitable for the performance of the duties associated with their position and/or for assignment to specific workplaces; the prevention of detrimental effects on the health of employees due to exposure to the relevant compounds during the performance of duties associated with their position; employees who feel a need to do so can consult a medical expert; and the promotion of recovery and the restriction of lost time after accidents incurred by employees that could result in lost time, by offering them modified duties that take account of their residual capacity for work.

## **10. Purchase and Inspection of Materials, Work Equipment and Personal Protective Equipment**

The use of materials, work equipment and personal protective equipment is justifiable from a SHE perspective. Minimum requirements include inventory of materials, work equipment and personal protective equipment accompanied by potential risks; SHE requirements be met by the above to preclude the potential risks; procedures providing for the assurance of the purchase solely of materials, work equipment and personal protective equipment which comply with the SHE requirements; and periodic updates of SHE requirements on the basis of risk inventories and evaluations, inspections and tests. The work equipment and personal protective equipment also should comply with the specified SHE requirements at all times. Minimum requirements are inventory of the work equipment and personal protective equipment to be subjected to periodic examination; inspection requirements; frequency of the inspections: at least once a year, with reasons for any departures from the frequency if lower; expertise of the persons carrying out the inspections; procedures providing for the assurance that non-approved work equipment and personal protective equipment tools will not be used; and identification of the expiry date of the period of approval on work equipment and personal protective equipment.

## **11. Procurement of Services**

Providers of services with an adequate knowledge of SHE issues can be involved. In the event of the use of subcontractors, procedures will be in place, which ensure for compliance with all the relevant HSE requirements at the workplace. This is to assure for the deployment of subcontractors with sufficient SHE knowledge and expertise. To deploy qualified subcontractors, subcontractors who are frequently contracted to carry out work are subjected to structural assessments and selection on the basis of their HSE performance. Temporary employees must be hired from temporary



employment agencies with certification to carry out high-risk work, which is to insure for the deployment of temporary employees with sufficient SHE knowledge and expertise.

## **12. Notification, Registration and Investigation of Accidents and HSE Incidents**

This part is insight into the current SHE performance and learning from accidents and SHE incidents. The company is required to be in the possession of a procedure for the notification and registration of employee accidents resulting/not resulting in lost time and of near-accidents and other SHE incidents. When the accidents occur, an investigation will be organized by the company with using investigative method to investigate accidents which results in an explicit specification of the underlying causes. The company should also investigate near-accidents and other HSE incidents to learn from them.