IDENTIFYING ORGANIZATIONAL AND CONTRACTUAL DRIVERS BEHIND METRO ACCIDENTS IN SHANGHAI

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ABSTRACT

In recent years, China has witnessed rapid development in urban transportation, especially in metro projects. However, the safety records of metro projects are rather worrying and cannot help to make us think where actually is going wrong. Official reports have claimed that the causes for those metro accidents are mainly from technical and organizational aspects. But are the reports really telling the true story? Or are there deeper reasons that lead to accidents which are not so obvious?

In previous studies, Martin de Jong and Yongchi Ma have asked the same question. They conduct their research on three Chinese cities of Beijing, Hangzhou and Dalian through Jens Rasmussen’s safety theory: drift to safety boundaries. In this theory, various incentives drive stakeholders to trade off quality and safety for other core values, resulting in safety boundaries to be crossed. All three cities represent a certain extent of profit driven, excessive subcontracting and loose monitoring which rightly match what is described in Rasmussen’s theory.

In my study, I will take the city Shanghai as an example to do a replicative research following Martin de Jong and Ma Yongchi’s work. Based on the main research question of searching for the contractual and organizational arrangements in metro accidents, firstly Rasmussen’s theory will be discussed in Chapter 2 to lay a theoretical underpinning for latter research. Secondly, the development of Shanghai metro system will be introduced to provide background information for latter case studies. Then in Chapter 4 and 5, I am going to thoroughly study two cases: Line 1 and Line 10, which are representative in terms of social impact, data availability and data freshness. The history of development, organizational structure, contractual arrangements and value tradeoffs in the design and construction process will all be mentioned in the analysis of Line 1 and Line 10. Institutional context and underlying behavior pattern of stakeholders will be described as well. Rasmussen’s theory will be checked to see whether it is applicable in my case.

Comparison will be made among Shanghai cases and other three cases from value tradeoffs (time, scope, budget and quality) and subcontracting issues in Chapter 6. It is not surprising that many common characteristics exist in all cases, like profit driven, excessive and illegal subcontracting, immature safety regulations, low public participation and etc. These features exist for institutional and social reasons. I will discuss about it and find out the differences between the Shanghai cases and previous cases.

Finally in the conclusion and recommendation part, empirical and theoretical conclusions are drawn respectively to shape the mechanism of metro accidents in terms of contractual and organizational arrangements. Whether Rasmussen’s theory is suitable will be answered. On four levels recommendations will be given for policy practice in order to improve current metro management level. I will lastly carefully reflect on my research method in the research, and how I generally feel about the whole case study process. The lesson learnt in this experience will also be shared.
I would like to thank my main supervisor Martin de Jong, who generously gave me the chance to study this very interesting topic, which is so closely related to my home country, and professor Leon Hombergen, who gave me valuable advice on contractual arrangements, and professor Fred Hobma, who patiently explained everything I didn’t understand and gave me great confidence. All of them provide me with consistent support from beginning to end of my thesis. I also like to send my best gratitude to Professor Yongchi Ma from Dalian University of Technology for his precious guidance on my data collection. Last but not the least, I want to say thank you to my dear parents and friends in China who concern for my study and help me collecting data in all ways. I could never accomplish this work without their help.

It is the thesis writing process that gives me a great opportunity to understand and reflect on China’s metro development and Chinese society. Little by little I came to realize how influential institutional and social impacts could be on a country’s construction projects, how necessary a mature and sound legal system is in China and how important it is for public to strive for their voice to be heard no matter what it costs. I sincere hope the future for China’s metro development could be better and better.
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1. INTRODUCTION

December 22th, 2009 was just another ordinary winter solstice day in Shanghai. However the city will remember this day forever. At 5:50 in the early morning, an electric fault unexpectedly lead to power supply failure in Shanghai’s busiest metro line----Line 1, causing a few trains to stall between two stations of South Shaanxin Road and People’s Square. In the later recovery phase at 7:00, two trains, both moving slowly but in opposite directions, collided at Shanghai Railway Station and North Zhongshan Road. The collision immediately resulted in a 4 hour delay in public transport and tens of thousands of commuters were trapped and countless passengers were seriously affected. The service resumed around 12:15 in the afternoon.

This incident regarded as one of the most severe metro incidents in Shanghai has cast shadows on Shanghai’s metro safety, and cannot help to make us think what was really going wrong. In China, the last 10 years have witnessed a tremendous number of metro projects put into construction. However the safety records remain unsatisfactory and even disturbing to other countries. According to previous studies, Ma, de Jong and Koppenjan have done thorough research on metro accident topics in three cities in China (Dalian, Hangzhou & Beijing), under the theoretical context of Rasmussen’s concept of ‘Drift to safety boundaries’. Is there a similar pattern to observe in metro accidents in Shanghai or is there a new one?

1.1. Disheartening Safety Records

Long since the first underground system was built in London in 1863, the world has witnessed numerous metro projects taking place all around world. This trend is the result of satisfying the increasing needs for convenient public transport, starting from western countries and now becomes a fashion in China’s major cites under Chinese government’s strong ambition of boosting local economics. Though technology used in metro construction has been updating ever since, safety records remain disheartening. So how do major cities perform on their metro safety? Let’s first take a look at them before studying the Shanghai cases.

In Appendix 1 we can see major cities in the world: London, New York, Washington, Paris, Hong Kong, Singapore and New Delhi. All these cities own busy metro lines and are taking metro construction projects every year including extending new lines and reinforcing old ones. In Appendix 1 a table covering metro accidents in the last 15 years in these cities is drawn in which the number of accidents for each city is depicted. It can be seen that New York, London, New Delhi and Hong Kong have comparatively higher frequency rates of metro accidents (respectively 8, 7, 6 and 8 times). To make the comparison more complete, a list of metro accidents in major cities during the past 5 years in China is also drawn in Appendix 2. Cities chosen are Beijing, Dalian, Shenzhen, Xi’an, Chengdu, Nanjing, Hangzhou and Shanghai consulting from Ma et al 2012, 2013. Due to data availability, only the past 5 years’ data is collected but it still shows how Shanghai is doing among other Chinese cities. With a total number of 8 metro accidents, Shanghai ranks second together with Beijing right after Shenzhen as the most frequent metro
accident city in China. Unlike Shenzhen and Beijing where collapse is the main cause for accident, Shanghai attributes its metro accident to mechanical fault, supporting system falling and electrical failure evenly. Comparing Shanghai with other international cities, the rate of metro accidents is still high considering the fact that the development process for Shanghai metro is shorter than other international cities.

One of the reasons behind this phenomenon is that Shanghai has just started its first line in 1995, and in the late 20 years the city has been constructing other 13 lines while London, New York and Hong Kong have already completed this process decades earlier. Another reason could be the metro management capacity fails to match the metro construction speed: with insufficient preparation, tight time constraint, the immature emergency response system and lack of professional personnel both in management positions and onsite, the metro project’s quality is always severely affected. However the real reason behind the frustrating metro safety records in Shanghai will be studied and discussed in this paper. But firstly it is necessary to review the theoretical framework of Rasmussen and some former efforts made by Ma, de Jong and Koppenjan in the study of other cities in China.

1.2. Problem Identification

There are many causes that can lead to metro accidents: technical problems, unsound organizational regulations, lack of distinctive division of labor, errors during construction phase, public influence, etc. However, much has been written about the technical and circumstantial causes for these accidents, relatively little about organizational framework and contractual arrangements which constitute the context within which safety measures fail to be monitored and enforced effectively during such construction projects. Especially due to China’s high hierarchical political structure, the highest level of decision making (often viewed as government) owns highest priority in meddling in any decision making process. Also as China is now going through a stage of fast economic development, seeing profit-driven as the main value is inevitable. Both elements make China’s unique context in constructing metro projects.

In Ma, de Jong and Koppenjan’s study, all authors tried to examine to what extent specific organizational and contractual practices in China can explain what is known in the literature on safety science and disaster management as Rasmussen’s safety theory “Drift to safety boundaries”(Martin de Jong, 2013). This theory employs a socio-technical approach declaring that decision making relevant to project safety is made at various hierarchical levels. (Martin de Jong, 2013) At each level, different forces and values compete with each other under a dynamic environment, leading to tradeoffs and setting a valuable context for the next level. Value tradeoffs at each level will cause individuals in the organization to behave unacceptable towards safety boundaries. Once crossed, the opportunity of accidents rises and the whole project’s safety is endangered. In the research of three Chinese cities, value tradeoffs are studied mainly from four core values: time, scope, budget and quality. Then how stakeholders are involved in the process of value tradeoffs and decision making are explained, making it clear how boundaries are crossed and what the consequences are.
In this paper, the main problem is to identify organizational and contractual drivers lying behind metro accidents in Shanghai under China’s unique political context with the theoretical framework of Rasmussen. What is the mechanism of metro accidents? Are they related to a certain person, a group or an organization? And how does each group influence each other and contribute to the whole pattern? The answers to such questions will be investigated through research into specific contractual relationships between various stakeholders in the metro system. Whether the strategic behaviors the stakeholders take are the results of trading values by provided contractual incentives or other reasons will be explored and explained. Finally the conclusion will be drawn on the mechanism of the metro accidents in Shanghai case s to see if it is within the theoretical framework Rasmussen has been worked out.

1.3. Research Question

When problem is identified, research questions naturally form. My research is a replicative case study based on Ma, de Jong and Koppenjan’s work, which the robustness of their conclusions for the rest of China will be checked for Shanghai. Combining their research questions and some of my own thoughts, research questions for my research are listed in the following table and will be discussed in the following chapters.

Firstly two metro cases should be introduced: Line 1 and Line 10. Built in 1995, Line 1 is the first metro line in China with a strong government support and a comparatively simple organizational structure. The collision accident occurred on Line 1 in December 2009 cast shadows on local government’s metro safety management. Line 10 is a relatively new line which was built in 2009 with a distinctive organizational pattern from Line 1. The collision accident occurred on Line 10 in September 2011 is even within the two years of operating time, causing negative social impact. Both cases reflect key problems in Shanghai’s metro industry. How they are chosen as examples to study will be elaborated in Case Selection chapter.

Table 1 List of research questions

<table>
<thead>
<tr>
<th>No.</th>
<th>Research Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>What are the organizational and contractual arrangements for subway construction in Shanghai case(s)?</td>
</tr>
<tr>
<td>2</td>
<td>What incentives are provided to players to deal with various values (time, scope, budget, various aspects of quality)?</td>
</tr>
<tr>
<td>3</td>
<td>Which kinds of risks are included in the contractual/organizational parties and how are they divided?</td>
</tr>
<tr>
<td>4</td>
<td>What measures should be taken in order to prevent metro accidents from happening?</td>
</tr>
<tr>
<td>5</td>
<td>Is the theoretical pattern established in earlier research confirmed or refuted?</td>
</tr>
</tbody>
</table>
1.4. Case Selection

In the former chapter of disheartening safety records, Shanghai has been compared to other cities home and abroad, showing a rather high possibility of metro accident rate. In Table 2 a more detailed list of major metro accidents happening in the last 10 years are represented with accident’s cause, contractual mode and social impact.

<table>
<thead>
<tr>
<th>Metro Line</th>
<th>Date</th>
<th>Accident Type</th>
<th>Accident Cause</th>
<th>Casualties</th>
<th>Contractual Mode</th>
<th>Social Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line 4</td>
<td>July 1, 2003</td>
<td>Piping collapses</td>
<td>lack of supervision</td>
<td>No one injured</td>
<td>Public funds</td>
<td>Direct economic loss 150 million RMB</td>
</tr>
<tr>
<td>Line 8</td>
<td>May 28, 2007</td>
<td>Wall collapses</td>
<td>Negligence of worker</td>
<td>1 severely injured</td>
<td>DBFO/SPV+TOT</td>
<td>Negligible</td>
</tr>
<tr>
<td>Line 9</td>
<td>Jan 8, 2009</td>
<td>Crane rollover</td>
<td>Mechanical fault</td>
<td>1 killed</td>
<td>DBFO/SPV+TOT</td>
<td>Negligible</td>
</tr>
<tr>
<td>Line 11</td>
<td>Jan 8, 2009</td>
<td>Fire</td>
<td>unknown</td>
<td>1 killed, 6 severely injured</td>
<td>DBFO/SPV+TOT</td>
<td>Seriously affects neighborhood and environment</td>
</tr>
<tr>
<td>Line 2</td>
<td>July 15, 2009</td>
<td>Delay</td>
<td>Electricity failure</td>
<td>No one injured</td>
<td>Public funds</td>
<td>‘the most severely delay in Line 2 history’, causing inconvenience to passengers</td>
</tr>
<tr>
<td>Line 1</td>
<td>Dec 22, 2009</td>
<td>Collision</td>
<td>Electricity failure</td>
<td>No one injured</td>
<td>Public funds</td>
<td>Hundreds of passengers were delayed in the metro for 4 hours. Traffic seriously disturbed</td>
</tr>
<tr>
<td>Line 16</td>
<td>Aug 18, 2011</td>
<td>Collision</td>
<td>Supporting system failure</td>
<td>2 killed, 4 injured</td>
<td>Bid-Build</td>
<td>unknown</td>
</tr>
<tr>
<td>Line 10</td>
<td>Sept 27, 2011</td>
<td>Rear-end collision</td>
<td>Supporting system failure</td>
<td>271 injured and 21 severely injured</td>
<td>Invest-build-operate-supervise</td>
<td>‘The darkest day in Shanghai metro’s operating history’</td>
</tr>
<tr>
<td>Line 12</td>
<td>Dec 31, 2012</td>
<td>Tower crane collapses</td>
<td>Insufficient supervision</td>
<td>18 killed, 5 injured</td>
<td>Direct funds</td>
<td>Direct economic loss 7 million RMB</td>
</tr>
</tbody>
</table>

Table 2 Metro accidents overview in Shanghai from 2003 to 2013

In Table 2, various contractual modes are adopted to each line. Line 1, Line 2 and Line 4 share the same mode of “public funds”, which the local government acts as the main sponsor to finance
the metro project. And in later phases like construction and operation, government will still be acting a significant and deciding part. For Line 8, Line 9 and Line 11, a contractual mode of DBFO (design, build, finance and operate) is used. In this mode, the most economically advantageous bid will be selected by the local government to execute four processes of design, build, finance and operate. However the bidding company only has management right, not property right. Property right belongs to the local government. Line 16 applies bid-build mode, or in other words, design-bid-build mode. In this mode the local government will firstly appoint architects and engineers to design the project, and then make tender for bidding. The winning bidding contractor will be responsible for the entire construction process of the project, and deliver the project back to the government after completion. For Line 10 and Line 12, a whole new mode is adopted: the Four Separation Mode, in which four functions of investment, build, operate and maintenance are allocated to four companies. The ownership of the lines involved in this mode belongs to Shentong Metro Company (and indirectly belongs to the local government). In Chapter 5.4 this mode will be discussed more in detail.

After comparison for these accidents, a more objective selection set of criteria is reached as follows:

- The date of the accident should be as late as possible.
- Combining casualties and social impact, the accident should have comparatively high influence.
- The availability of data is important.

Line 1 and Line 10 are selected based on the three criteria. Both cases happened in the last five years which is comparatively new, and they have significant impact to the society: The Line 1 case have caused thousands of passengers’ inconvenience and huge interruption to local traffic for a long time and the Line 10 case has caused a great number of injuries, regarded as ‘The darkest day in Shanghai metro’s operating history’. Also the available data for these two cases is much more than the other cases based on resources I could obtain. The Line 4 case has met the last two criteria but is relatively old (the Line 4 incident occurred almost 10 years ago which fails to represent the current management skills). Data for Line 11, Line 12, Line 16 and Line 2 cases is not sufficient enough to form a research. Line 8 and Line 9 cases are too small compared to other cases and their social impact is negligible.

1.5. Methodology and Research Procedures

The main methodology used is replicative case study in which cases of accidents in Shanghai metro will be studied based on the findings on formers cases in other cities in China. In the part of data collecting, the initial plan is to obtain resource through Internet, database from TUDelft and China (CNKI and etc.), newspaper, articles and journals, and conducting interviews and questionnaire with stakeholders and professors. However in the real data collecting process, the interview and questionnaire part is not carried out successfully due to various reasons (will be explained in the reflection part 7.4).
Research procedures are outlined as follows:

1) Identifying the problem (chapter 1)
2) Raising the research question and sub questions (chapter 1)
3) Literature review
   - conceptual framework of Rasmussen (chapter 2)
   - former accident reports in big cities in China
   - Chinese metro safety articles and journals
4) Collecting data
   - Detailed information about the accident case (casualties, direct and indirect causes, etc.)
   - official reports of the accident cases
   - Shanghai metro’s history, current situation and future scenario (chapter 3)
   - Metro company’s organization structure, regulation, contractual documents, etc.
   - Decision making process
5) Analyzing data
   - Study the cases from contractual and organizational aspects
   - Analysis the cases whether are suitable for Rasmussen’s theory and why
   - If the answer is yes, examine the value trading pattern in the whole construction process
   - Combining with China’s unique political structure and decision making pattern
6) Comparing cases
   - Compare the studied cases with each other
   - Compare the studied cases with former Chinese cases
7) Conclusion & Recommendation
   - Answer the research question
   - Justify how Rasmussen’s theory is interpreted in the studied cases
   - Provide recommendations for Shanghai metro’s safety management
   - Limitations of the research

1.6. Overview of Chapters

The paper is divided into 7 chapters. Chapter 1 is introduction, introducing the research problem, some background information of the topic, research questions and methodology that will be used. Chapter 2 is Rasmussen’s Theory, where Rasmussen’s conceptual idea of ‘Drift to safety boundaries’ will be discussed and explained in detail. Chapter 3 is Shanghai subway system, introducing the history, future scenario and accident list of Shanghai metro. Chapter 4 and 5 are detailed information of the selected case (Line 10 and Line 1), where in each case the chronology of the line, organizational structure, official report of the accident, contractual arrangements, and study into value trading will be given, providing an in-depth interpretation of the drivers behind the accidents. In Chapter 6 Analysis & Comparison, 2 cases in Shanghai will be compared with each other from several aspects, and they also be compared to other cases which have been studied by Ma, de Jong and Koppenjan before. The last Chapter is conclusion & recommendation where research questions will be answered and suggestions for possible improvements for the future will be raised.
2. RASMUSSEN'S THEORY

2.1. Development of Conceptual Framework

Risk exists everywhere. In definition, it is an uncertain event that if it occurs, has a negative effect on people and other things. No matter it is for an individual, a system or a society, we cannot deny its powerful influence on our daily life. Particularly in a construction project, various risks will cause bad consequences for project’s objectives: time, scope, budget and quality. These four objectives are also core values of a project and are closely connected to each other.

After decades of hard work, Jens Rasmussen has established a risk management model based on experiences gained during multi-disciplinary research on industrial risk management at Risø National Laboratory in Denmark and the interaction within a multi-disciplinary international network which evolved from the Bad Homburg workshop series “New Technology and Work” (Rasmussen, 1997). His research started to design control and safety systems for hazardous industrial process plants and later shifted to human error analysis, operator modeling and display design by an occasional comparing their results with accident records (Rasmussen, 1997). From there his focus turned to the performance of the people preparing the work conditions of operators, which naturally lead him to again examine his results in terms of management and organizational science and to consider decision errors at the management level. Also safety regulations are involved in his study. At some point he realized that by putting results from various disciplines together could be useful for individual actors and decision makers, but not very helpful in analyzing performance of a whole risk management system. So he was thinking about building a top-down, system oriented approach based on his original control concepts for the reason that the context of a system is always complex and changing and a system is much more than the sum of its elements.

Finally a socio-technical framework by means of a system-oriented approach is proposed by Rasmussen. Under this framework contexts and preconditions for accidents are modeled. This framework involves dynamic environmental conditions like market competition, economic and political pressures, legislation and increasing social awareness on safety and etc. The top-down framework represents a hierarchical structure which will be specified in the next section.

2.1.1. Hierarchical Structure

General speaking, the model Rasmussen described is a model of behavior shaping mechanism in terms of work system constraints, boundaries of acceptable performance and subjective criteria guiding adaption to change, instead of a simple task analysis focused of action sequences and occasional deviation in terms of human errors (Rasmussen, 1997). In the model there are 6 hierarchical levels from legislators on the top level to system operators on the bottom (Figure 1).
At each level of the socio-technical system, several research disciplines are involved and various environmental stressors are presented, passing through to the next level. On the top is Level 1, where government controls safety in society by means of legal system. In this level legislation set priorities for conflicting safety goals and acceptable human behavior boundaries. Research at this level will be focused on political science, law, economics and sociology, and public has opportunity to influence the decision making process in this level. In Level 2 the activities are mainly described of regulators, associations and interest organizations whose duty is interpreting and implementing regulations from Level 1 in their own sectors. Here sociologists and management professionals will be involved and contribute their research. Then legislations and rules will be interpreted and implemented into the next level: a particular company, where more details about specific local conditions will be added to the legislations to make them more practical and operational. Here new disciplines are involved like decision theory and organizational sociology. Level 4 is management, breaking down the company into several sectors based on different functions. In this level the activities will lead and control the work of the company’s staff, which forms the next level. In Level 5 each individual staff member’s activities will be studied and their psychological issues and interaction with each other and technology will be focused. On the bottom level engineering disciplines are encountered, both in the design of potentially hazardous equipment and operating procedures for process control.

In Figure 1 it is clear that between each level in the hierarchy information flows in and out and finally forms a close end feedback loop as a whole. In this way a two-way communication is established: decision makers at higher levels pass down their decisions and rules to lower levels, meanwhile information collected in the working process at lower levels is transferred up the hierarchy. Outside this loop, interfering forces have a strong influence for the circle at various hierarchical levels. These forces, including market conditions, financial pressure, education level, technology change and etc, are always unpredictable and changeable. For each level, both constraints imposed by other levels and from outside the loop should be well considered in risk management.
2.1.2. Dynamic immigration: Boundaries

Further, any individual from any level of the hierarchical model will encounter the problem of proper safety operation. To what extend the behavior is considered ‘safe’? In a complex and dynamic environment it is always difficult to define specific standards and procedures for safety operation because conditions keep changing and the situation is unpredictable. So Rasmussen defines safety operation based on functional abstraction instead of structural decomposition in his model (Rasmussen, 1997) by creating three boundaries to control system performance in risk management: economical failure boundary, acceptable performance boundary, and unacceptable workload boundary (Figure 2). Each boundary respectively reflects constraint as financial and economic constraint, safety regulations and procedures and individual unacceptable workload.

![Figure 2 Dynamic safety model: boundaries](Rasmussen 1997)

In the model the operating point location is influenced by gradients that drive operations away from the workload and economic failure boundaries and towards the unacceptable performance boundary (Rasmussen, 2005). Organizations will keep the operating point away from the acceptable performance boundary to prevent accidents from occurring. So over time a marginal boundary is formed marking the acceptable limit of operations. The gradients will induce variations in human behavior: over a period of time the adaptive behavior will lead people to cross safety work regulation boundary towards the boundary of functionally acceptable behavior. (H.Qureshi, 2007) The result of this migration is an accident if control cannot be maintained at the boundary. Rasmussen has given the example of Bhopal and Chernobyl accident, pointing out that the accident was not caused by coincidence of independent failures and human errors but a systematic migration of organizational behavior towards an accident under the influence of pressure toward cost-effectiveness in a aggressive, competitive environment (Rasmussen, 1997). So it is obvious in the example that accidents are caused slowly by attempting behaviors of adapting to environment stressors, rather than a single independent failure or error.

2.2. Application in Previous Study

In previous papers of Ma, de Jong and Koppenjan, Rasmussen’s idea has already been applied to
metro cases of Hangzhou, Dalian and Beijing. The authors first make a brief introduction of the Rasmussen theory, then follow the line of socio-technical approach system that decision making relevant to safety is made at various hierarchical levels (de Jong et al, 2013). To support their point, they carefully described the organizational structure and contractual arrangement of the metro company which is directly related to where accident happened. In the hierarchical organizational structure, stakeholders’ relationships are clearly revealed and a notable fact should be mention that the extent to which government participating in the decision making process is quite significant. In each level of decision making, certain environment influences are talked about like public expectations, society’s economic level, inflation and etc. These influences are what Rasmussen has illustrated in his model as “Environmental stressors”. Through contractual arrangement, how work is distributed and allocated from a higher level to a lower level is shown to better tell how decision making is going between levels. It is under dynamic environmental influences and unique decision making pattern that potential disasters are likely to take place.

To deeper apply Rasmussen’s “Drift to boundaries” concept, value tradeoffs are introduced in the former papers as well. Basically four core values are referred to: time, scope, budget and quality. In a metro project, the four values are traded off for each other at various circumstances. In general the “profit-driven” value is seemed as the leading value in metro projects studied in all cases. This inevitably causes boundaries to shift to grey areas where conditions emerge in which the occurrence of incidents and system breakdown grow substantially (Ma and de Jong, 2012).

2.3. Conclusion

Rasmussen’s theory for improving risk management is to apply the socio-technical approach to model the dynamic mechanism of organizations and environments. In his theory a hierarchical structure involving several levels. Interaction exists between levels and in the hazardous environment as well. Each level has to identify safety operations for itself within the safety boundaries to ensure the opportunity of accidents is null, making it vital that the behaviors at the boundaries should be in good control.

As my study is a replicative study of former research, I am going to follow their footsteps in applying Rasmussen’s idea of socio-technical system. I will start my research by an introduction of Shanghai metro system in which organizational structure is included. Then I will specify on the two accident cases selected before: Line 1 and Line 10, with detailed contractual arrangement and value tradeoffs. In this way how decisions are made during construction process can be known. Further in Chapter 6 I will make deeper analysis on how stakeholders act in the game and what strategic behaviors they take, finally drawing to the conclusion that how boundaries are crossed. Then some of my research questions could be well answered.
3. SHANGHAI SUBWAY SYSTEM

Shanghai, the third city in China that has its own subway system right after Beijing and Tianjin, is the symbol of modern and fast economic development in the whole country. With its first line opened in 1995, Shanghai metro has been operated for almost 20 years. Generally speaking, Shanghai metro is a rapid transit system incorporating both subway and light metro lines in Shanghai. In general, there are 12 lines and 288 stations in Shanghai Metro system. It covers an operating route length of 435 kilometers and delivers 2.276 billion rides in 2012, making it the world’s third longest and fifth busiest metro system. On March 9th 2013, it reaches its daily ridership record of 8.486 billion (Transit, 2013). In this chapter I am going to introduce Shanghai subway system from aspects of Shanghai metro’s history, its future scenario and its organizational structure.

3.1. History of Shanghai Metro

As early as 1958, Shanghai government has started preparation for metro construction. At beginning, Russian experts said that the ground condition of Shanghai is not suitable for building tunnel construction. To test the feasibility of tunnel construction in Shanghai, in 1963 a tunnel was built in Pudong with a diameter of 4.3 meters. Another experimental project “Project 60” was carried out near Hengshan Park in 1964, but failed due to wrong estimation for tunnel size. By the end of 1970s a second experimental tunnel was built under Caoxi Park with an investment of 40 million RMB and a total length of 1290 meters. This time the tunnel survived and this line has been served as official line for Line 1 of Shanghai Metro. In May 1989, Chinese government signed a contract with Germany on the 0.46 billion Mark loan on subway and in the next year the construction of Line 1 of Shanghai Metro started officially (from Shanghai South Railway Station to Shanghai Railway Station). On 9th of January 1993 Line 1 went into trial but some electricity problem occurred in the middle due to lack of experience. On the second day Line 1 successfully went into trial with no emergency happening. Then finally on 10th of April 1995, Line 1 was open to traffic. By the year 2000 Line 1 to Line 3 were built with a total length of 65 kilometers, and by the end of 2007 8 lines were built. By February 2012, Shanghai Metro has 11 lines (Line 1 to Line 11) with a total of 280 stations, covering an operation length of rail transit of 425 kilometers (Transit, 2013).

With the help of Shanghai government, Shanghai Metro has contributed a lot to local economy and transport. During the 2010 World Expo Exhibition, Shanghai Metro has received a passenger capacity of 7.54 million people per day, the highest record before 2013 ever since. (Actually the record is updated in March 2013 by 8.48 million) By February 2012, Shanghai Metro has undertaken 34 % of the city’s public transport.

3.2. Future Scenario

Currently four lines under construction will be completed in 2013: Line 12, Line 13, Line 14 and
Line 21. Line 17 has just been put into construction in March 2013 and is supposed to be completed in 2016. In the following years Line 18 and 19 will start construction very soon. In the latest report it is said that by 2020 Shanghai metro network will consist of 22 lines covering an operating route of 877 kilometers. According to local government, in the long term the length of the operating route will reach 1000 kilometers (Mingyang, 2010).

The future expansion of Shanghai metro network has closely connected Shanghai to its neighboring areas. Line 11 is planned to connect Kunshan (Soufun, 2012) and Line 19 is planned to expand to Changxing Island and Chongming Island in the Northeast of the city. Line 22 and Line 5 will be extending to Hangzhou Bay in the south. Other lines will be strengthened and connect more urban areas.

![Figure 3 Shanghai metro plan in 2030](image)

**3.3. Organizational Structure of Shentong Metro**

Currently the main body of Shanghai Metro system in terms of financing, investment, construction and operation is Shentong Metro Co.Ltd (Shentong Metro), which plays a significant role in Shanghai urban public transportation. (company, 2012)The predecessor of Shentong Metro is Shanghai Metro Company, founded in 1985 by Shanghai government. At that time Shanghai Metro Company is a state-owned enterprise, financed by two government-owned companies: Shanghai Jiushi Corporation and Shanghai Chengtou. It is under this organizational structure that Line 1 was built. Then after 15 years of practicing, in 2000 Shanghai government
abolished Shanghai Metro Company and established Shentong Metro, integrating capitals from Shanghai Jiushi Corporation and Shanghai Chengtou. The organizational reform changed the fact of government leading to market oriented, where responsibilities of metro development are divided and assigned to subsidiary companies under Shentong Metro, which gives birth to the development of Line 10. In Chapter 4 and 5, two organizational structures of metro development will be elaborated more in detail respectively for Line 1 and Line 10.

Generally speaking, Shentong Metro consists of three managerial levels from top to bottom: headquarters, network management and control level and onsite execution level (Fig 4). The hierarchical structure shows a clear division of functions within the company.

Figure 4 Organizational Structure of Shanghai Shentong Metro
(a: headquarters, b: network management and control, c: onsite execution)
3.3.1. Headquarters

The headquarters is the key part of the whole company. It consists of stakeholders’ meeting, board, supervisory committee, (vice) general manager, chief engineer and six departments. As Shentong Metro is a listed company, its management must strictly follow the requirements of ‘Company Law of People’s Republic of China’ and China’s Securities Regulatory Commission (CSRC). The stakeholder’s meeting is the highest authority in the company, responsible for making company’s policies including operating principles, investment strategies, election of the board, financial issues and etc (Metro, 2012). The board is the executive body of the company, responsible for the stakeholders’ meeting. Nine directors make up the board including one chairman. The board’s duty is holding stakeholders’ meeting, reporting working progress to the board, executing its decisions and setting the managerial structure of the company. The general manager is employed by the board to manage daily operation activities in the company and be responsible for the six departments. A vice general manager is set to assist the general manager with the work. The chief engineer acts to check technical and designing faults in the construction and communicate with the vice general manager. The general manager always has to consult with the chief engineer and the vice general manager in his work. The supervision committee is an independent institute which is accountable for the stakeholders’ meeting, mainly in charge of supervision company’s activities and decision making process of managers at high managerial positions. Currently there are three supervisors in the committee.

The 6 departments look independent from each other, but they are closely connected. Department of construction management needs technical support from department of planning, while department of maintenance is making daily routine more smooth and with good supply. All the departments require fund from department of asset management and department of operation management can pass its information source to other departments for necessary use.

3.3.2. Network Management and Control Level

This level has 8 centers: information management center, rail transit operation center, construction management center, technology research center, maintenance center, training center, asset management center and fund management center. The first two centers belong to the department of operation management, in charge of daily operation of metro lines. Construction management center is in the department of construction management, dealing with contractors and project management in the construction phase of the project. Technology research center provides technical support for the company including designing blueprints and feasible study of a certain technique or plan. Maintenance center and training center respectively supply daily maintenance, restore and recruitment for the company. Assessment management center and fund management center offer financial support and business solutions. In a word, linking headquarters to the onsite execution level, the network management and control level plays a significant part in coordinating roles in the company organizational structure.

3.3.3. Onsite Execution Level

In this level, specific units of are shown. In rail transit operation management center are four
operating companies, a ticket office and department of demand and control. Several project companies are attached to construction management center, responsible for their separate metro project’s construction. Design institute, research institute and consulting company work together to draft blueprints of a certain project and make it feasible. Five companies subordinated to maintenance center supplies vehicle, electricity, logistics and beaconage for the project.

To conclude, the three levels illustrate how labor is divided inside Shentong Metro. The hierarchical structure gives a similar image of the socio-technical structure of Rasmussen’s theory.

3.4. Conclusion

This chapter gives a vivid image of how Shanghai subway is developed and evolved to what is now. After decades of preparation and with the help of local government, Shanghai metro booms from Line 1 to 12 lines, and in the future 10 years there will be 22 lines, covering approximately 1000 kilometers distance in total. The significant body in Shanghai metro development is Shentong Metro, a company which was originated Shanghai Metro Company and comes to a huge organization with distinctive functions and clear levels. The hierarchical structure of Shentong Metro has forms a top-down decision making pattern in the company, rightly matching Rasmussen’s theory of socio-technical map.

In Chapter 4 and 5, organizational structure of the development of Line 1 and Line 10 will be elaborated respectively. Especially in Chapter 5 where Shentong Metro is established, the company will be viewed as a whole function unit in the entire development of Line 10.
4. CASE STUDY 1 – Line 1

4.1. Case Description

At 5:50 on December 22, 2009, an electric fault caused a few trains to stall in the tunnel between South Shaanxi Road and People’s Square stations. A collision occurred between two opposite trains on Line 1 when the track was under repair, trapping scores of passengers underground for up to 4 hours and affecting millions of early commuters. No one was injured, as the train collided at low speed, although the front of the train was badly damaged (Chinanews, 2009). The service resumed around 12:15 pm (Gao Changxin, 2009).

![Figure 5 the Line 1 incident](image)

The Line 1 incident is one of the most severe incidents in Shanghai metro history, also in China. Actually on the day the incident happened, two more small incidents took place on Line 1 (Baike, 2012). One incident is at about 13:00 in the tunnel near South Shaanxi Station, power was suddenly disrupted, resulting in a temporary suspension. Another incident is the breakout of fire on 20:40 in the substation of South Shaanxi Station, causing the result. Is it a coincidence or there is something else lying behind it? The case starts to beg the question that why the frequency of metro accidents so high in Shanghai and what should be blamed for this unsatisfactory safety records, bringing into mind that the horrible Line 4 incident in 2003 which loses millions of RMB.
To dig out the true reason for the accident, I am going to apply Rasmussen’s theory to the case from aspects of Line 1’s decision making process in planning, organizational set up and contractual arrangements. How and to what level these factors contributing to the disaster and what we can learn from it will be discussed in the following chapters.

4.2. Official Report

Right after the “12.22” accident, 6 experts from Ministry of Railways and Tongji University were invited by the accident investigation group to make analysis of the true cause for the accident. Through onsite research and a deep study, they draw their conclusions:

“Under the circumstances of power failure, the signal system in section N11-1438 mistakenly sent speed signal of 65 km/h to train 150#, leading to insufficient braking distance for the train. The liability lies in CASCO Signal Ltd.”

Though experts claimed that the accidental case cannot prove the whole Line 1 signal system is not in good function, doubts on metro’s emergency management system still exist. What’s more, there are hidden organizational problems in the construction process that may have indirect connection with the accident. These problems are not that apparent and take time to be revealed, and they must have been rooted in the metro system and are very possibly influenced by China’s administrative culture. In the next chapter I will elaborate on how organizational structure and contractual arrangements affect the metro project and what are the uncomfortable truths that experts failed to disclose.

4.3. Network Plan and Decision Making Process

Basically the development of Line 1 can be seen as the beginning of the metro project development in Shanghai. As early as 1956 Shanghai government has initial intention to build underground transportation. From 1960s to 1980s, experiments were undertaken by local government which provides the technical foundation for Line 1. In 1983 the basic shape of Line 1 was put forward officially by Shanghai Planning Commission, with the route running from Jinshanwei to Baoshan, covering south to north. The year 1985 is remarkable because the predecessor of Shentong Metro was established: Shanghai Metro Company. With the help of local government and foreign loans, Line 1 successfully started construction at the beginning of 1990s. In the following 10 years Line 1 has gone through its construction phase and started to operate. It was not until the year 2000 that Shentong Metro was established, marking a new era for Shanghai metro development.

<table>
<thead>
<tr>
<th>A Brief Chronology of Shanghai Metro Line 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>August 1956</strong>: The Municipal Construction and Transport Office of Shanghai People’s Committee submitted an initial draft plan for Shanghai’s underground to the local government, in which Line</td>
</tr>
</tbody>
</table>
1 is first time put on the schedule.

**November 1964**: An underground trial experiment is conducted on Hengshan Road by the local government. Until 1967, two 600 meter tunnels are completed but later the metro project is suspended due to “Cultural Revolution”.

**1978-1983**: A second experimental tunnel is built under Caoxi Park with an investment of 40 million RMB and a total length of 1290 meters. This tunnel is later served as Line 1.

**April 1983**: A proposal of building rapid transit projects in Shanghai is put forward by Shanghai Planning Commission, proposing to build a rapid transit line passing through the city, running from Jinshanwei in the south to Baoshan in the North. The basic shape of Line 1 comes to the light.

**March 1985**: Shanghai Metro Company is established, the initial form of Shanghai Shentong Co. Ltd.

**July 1986**: Relative departments in Shanghai submit the report of metro construction to the State Council.

**August 1986**: The State Council approves the metro project.

**February 1988**: The State Council approves the project’s feasible study report.

**May 1989**: China and Germany sign a 460 million mark loan contract for metro construction.

**January 19, 1990**: The State Council approves that the construction of Line 1 starts.

**June 8, 1991**: Excavation starts.

**January 10, 1993**: The first metro train goes into trial in the section between Xinlonghua and Xujiahui.

**May 31, 1994**: Line 1’s tunnel is totally completed.

**April 10, 1995**: Line 1 is open to public for test run.

**December 28, 1996**: The south extension part of Line 1 starts for test run.

**July 1, 1997**: The south extension part of Line 1 connects to the main part; The completed length of Line 1 is 21.35 kilometers.

**March 30, 1999**: The south extension part is officially opens to public.
April 28, 2000: Shanghai Shentong Co. Ltd is established, together with its wholly-owned subsidiary company Shanghai Metro Operating Co. Ltd. The latter company is responsible for the management of Line 1’s daily operation.

May 1, 2001: The south part of Line 1 (from Shanghai Train station to Xingzhuang) reaches whole on-listed with the establishment of Shanghai Shentong Metro Co. Ltd, with a stock symbol of 600834.

December 28, 2004: The northern extension part of Line 1 opens to traffic. Up to now, Line 1 has a total length of 33 kilometers.

Source: [link](http://webcache.googleusercontent.com/search?q=cache:http://club.metrofans.sh.cn/thread-50096-1-1.html)

### Table 3 A Brief Chronology of Shanghai Metro Line 1

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Description</th>
</tr>
</thead>
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<tr>
<td>April 28, 2000</td>
<td>Shanghai Shentong Co. Ltd is established, together with its wholly-owned subsidiary company Shanghai Metro Operating Co. Ltd.</td>
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<td>The northern extension part of Line 1 opens to traffic. Up to now, Line 1 has a total length of 33 kilometers.</td>
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</tbody>
</table>

### 4.4. Organizational Structure

In 1985 Shanghai Metro Company was funded by Shanghai government. It is a state-owned enterprise, fully responsible for Shanghai metro’s design, construction and operation with 47 subsidiary companies before it evolves into Shentong Metro in 2000. The development mode of Line 1 is ‘government invests, company manages’ (H. Sun, 1997). To be more specific, Shanghai government first drafts the metro route plan. Then two companies: Shanghai Chengtou and Shanghai Jiushi Corporation which are owned by Shanghai government will take the job of financing for the project. After financing, the two companies administratively transfer the funds to Shanghai Metro Company for further use, instead of using contracting ways. Meanwhile Shanghai Metro Company acts as an agency on behalf of the local government in aspects of making project plans and implementing them, construction, daily operation and management, maintenance, etc.

![Figure 6: Organizational structure of the development of Line 1](image-url)
Figure 6 illustrates the organizational structure of how Line 1 is developed. It is very clear almost half of the total investment comes from foreign loans, in which Germany has the biggest proportion (Wenku, 2012). Up to now, Line 1 is the only metro project that uses foreign loans in Shanghai. The other half comes from commercial loans, for instance local metro construction enterprises, local banks, etc. Though the financing responsibility is distributed over Shanghai Chengtou and Shanghai Jiushi Corporation, the real power of decision making still lies in Shanghai government, which means that all the decision making at the level of Shanghai Metro Company are actually under the eye of Shanghai government and the latter can intervene with the former’s decision making process in any phase (planning, tendering, building, operating and maintaining).

Though Shanghai Metro Consultant Supervision Co. Ltd seems to be the monitoring party, it was actually just established in August 1993, 2 years after the project started. Also the company is subsidiary to Shanghai Metro Company, not independent at all. In this way efficient monitoring is hard to guarantee. Also due to the immaturity of Shanghai Metro Company (it starts its business in construction industry and lacks experiences in management and operation), a period of time for accumulating experience is necessary for the company. So as a result, the future development of this organizational mode is not optimistic as long as the singular government-oriented decision making pattern remains the same.

### 4.5. Contractual Arrangements

<table>
<thead>
<tr>
<th>Line 1 main players</th>
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<tbody>
<tr>
<td><strong>Client:</strong> Shanghai Metro Company</td>
</tr>
<tr>
<td><strong>Design Party:</strong> Shanghai Tunnel Engineering &amp; Rail Transit Design and Research Institute</td>
</tr>
<tr>
<td><strong>Supervision Party:</strong> Shanghai Metro Consultant Supervision Co. Ltd</td>
</tr>
<tr>
<td><strong>Builder:</strong> Shanghai Construction No.1 Group Ltd (civil part), CASCO Signal Ltd (signal part)</td>
</tr>
</tbody>
</table>

Table 4 Main players in Line 1

Generally speaking, there is no excessive subcontracting in the construction of Line 1 as shown in Table 4. Shanghai Metro Company transferred the work to Shanghai Construction No.1 Group Ltd, which is subsidiary to Shanghai Metro Company. However through all stages, Shanghai government still holds the highest priority to interfere. This is because the Line 1 project is a government-owned project, with most of its funds sourcing with the help of Shanghai government. Though in Figure 8 it shows that Shanghai Chengtou and Shanghai Jiushi companies are in charge of financing for the project, about half of the total funds are borrowed from western countries by the local government, and it is Shanghai Jiushi that operated the funds for specific financial usage later. Shanghai government has penetrated into all phases of decision making processes in the Line 1, making a transparent supervising mechanism quite difficult.

### 4.6. Value Tradeoffs

The organizational structure and contractual arrangements have demonstrated the hierarchical context where Line 1 was built, which fits what Rasmussen’s concept of a social-technical system.
In this concept, stakeholders are stimulated by certain incentives to trade off project’s safety for other values, resulting in crossing the safety boundary. Usually there are four key basic values in a project: time, scope, budget and quality (Maylor, 2010). Each value matters a lot to the project and has strong connection with each other. In next paragraphs I am going to indentify how project safety is traded off for these values and how these values are traded off for other values.

4.6.1. Dangerous Schedule

Time compression is never new in China’s construction projects, Line 1 is no exception. Especially under China’s high hierarchical political context, government can meddle in the project’s schedule, forcing lower levels to finish the work rashly without other considerations. In the beginning of 1993, Shanghai government demanded that 5 stations be completed before Spring Festival and the whole line be completed by the end of 1994. At that time all Shanghai citizens were eagerly looking forward to the opening of their first metro line, adding pressure to the tight time schedule. Yet what government wanted is really demanding. How to accomplish the mission impossible? The construction team had no choice but to open only one tunnel and use only one train as sightseeing train for tourists and local residents. However the other tunnel was still under construction and the whole line was not finished until half a year later(Metro, 2013). This time, time is traded off for unrealistic political wishes.

Another true story took place in May of 1992 when the station Xujiahui is being built. A senior engineer discovered a potential danger of a lack of 12 supporting items in the tunnel. As there were many residential buildings on the ground of Xujiahui, the potential danger could be fatal if not being removed timely. Meanwhile the whole construction team was busy running the project’s progress ahead of schedule and could hardly stop the excavation. The engineer then risked his life, jumped into the foundation pit and prevented the disaster from happening (Metro, 2013). Here if not of the brave engineer, project’s quality and safety would be easily and unconsciously traded off to time causing unimaginable loss to the city.

**Conclusion:** time compression is very common in the construction of Line 1. Project schedule is always strongly influenced by political power, while workers’ awareness of project safety is rather low. In the second story, if all the workers have high awareness of project safety, the engineer wouldn’t need to risk his life to save the entire project. Both stories imply that the work schedule of Line 1’s construction is always compressed and workers are just complying with it with little regarding to more important values (project safety).

4.6.2. An Extended Scope for Urban Development

The original route plan of Line 1 is firstly put forward by Shanghai Planning Commission in 1983 and is approved by the State Council in 1986. In the plan the scope of Line 1 covers north to south of the city, from Jinjiang Park to Shanghai Railway Station. In Figure 9 this section is between two yellow dots, starting from Zhabei District and ending at the boarder of Xuhui and Minhang District. Then the 1990s saw population booming and migration in Shanghai: the nine inner urban districts have a comparatively lower percentage of population increase while the
outskirt districts closed to the center gain higher population growth, with Minhang and Baoding districts just the good example. Between 1990 and 2000, these two districts have achieved a more than 50% boom in population, forming an urgent need for efficient public transport. So in 1997 the southern extension from Jingjiang Park to Xinzhuang is completed, stretching further into Minhang District. In the following ten years two more extensions in the northern part are finished respectively extending to Gongfu Xincun (the green dot in Figure 7) and Fujin Road (the northern end of red line in Figure 7), deeper into Baoding District.

The population growth is the result of fast urban development. As economic development is always put onto the first priority by local government, more companies from every industry are opening in the suburban areas of the city, making an urgent need for local infrastructure like public transport and residential buildings. Also as more and more people are living in the urban area, the cost of living raises rapidly which drives more people to live far away from the center, where natural environment is more pleasant as well. Therefore the extension of Line 1 becomes necessary.

An important scope change to mention took place at the construction of Xujiahui Station. In the original plan, Shanghai government decided to remove the old library built in 1847 by the Society of Jesus. However this plan was soon encountered with strong protest by famous intellectuals including Ba Jin, one of the greatest writers in China. Ba Jin wrote a letter with joint appeal to the government, requesting for keep the historic heritage. Finally their efforts paid off. The library was kept and renewed and open to public until today.

**Conclusion:** Basically the scope extension of Line 1 is the result of urban development. However as Line 1 is the first line in Shanghai which has been prepared and planned by the government, altering routes is never easy. Here we can see public is making effort in this process and put pressure to the government using influence of famous intellectuals, and they win. In Line 1 case, historical heritage is nearly traded off for scope.
4.6.3. Budget: A Big Problem

Several factors influence the project’s budget in the construction phase of Line 1. The first factor is inflation. The political turmoil in 1989 and the Price Reform starting the same year have pushed the inflation rate to an extreme high point: 14.7% in 1993 and 24% in 1994 (Huasheng, 2008). This gives rise to the increasing prices in construction materials like steel. Another consequence of inflation is fluctuation of foreign exchange rate. As a large proportion of investment is from foreign loans, the changes in foreign exchange rate can have negative impact on the time for local government to repay the loans. As a result, local government has to bear the risk of extra budget brought about by inflation. However, what the profit-driven government chose to do is sacrificing other values for the sake of saving budget to deal with inflation, instead of adding more budget.

The second factor is the extra cost of inexperienced contractors and workers. As such huge project in Shanghai’s unique environment is quite new for local government, contractors and workers, lacking of experience in construction and management will often bring about problems in the construction phase. So, extra budget will be spent on training workers and contractors which could be saved for better use. Also immature management will cause additional cost in possibility of construction risks included. To save additional cost, decision makers will always prefer to cut down these “unnecessary procedures”, producing hidden problems for project’s quality.

Conclusion: Profit-driven makes budget the first priority in decision maker’s eyes. No matter it is inflation or inexperienced contractors and workers, to finish to work within schedule at the lowest cost is what most of players pursuit. Usually quality is traded off for such value.

4.6.4. Quality: An Empty Promise?

In the former discussions, quality is mentioned many times. But what is project quality? Specific for the metro case, I define quality into three parts: project safety, environment safety and public participation.

*Project safety:* As said before due to time compression and a limited budget, project safety is always endangered. What’s more, unqualified workers make the problem more severe, not to mention the dependent supervising party. Though Line 1 is the first metro line in Shanghai indicating an intensive concern from the society, lack of experience in time control and staff training is still noticeable.

*Environment safety:* As the construction period of Line 1 is too early, I fail to obtain sufficient information on how the environment impact assessment is carried out in Line 1 (there is the possibility that there is no such assessment). However from the brave behavior of intellectuals saving historic buildings it could be deduced that government does not have the awareness of protecting cultural relics, or maybe the natural environment as well, considering the fact that China’s first *Environmental Impact Assessment Law* is just published in 2002 (PeopleNet, 2002a), 8 years after Line 1’s construction.
Public participation: In the decision making process of Line 1, there is no public participation at all. In the construction process when important cultural relics are threatened, social intellectuals come out and make their voice heard, and change the reality. If without the help of intellectuals, it is hard to believe just by efforts of ordinary citizens can change the government’s plan.

Conclusion: In Line 1, quality is easily traded off for time and budget under a government-oriented society. Unqualified workers, missing supervision party and environment laws are endanger the project’s quality. The only silver lining is perhaps the public participation, though isn’t in big scale but is powerful.
5. CASE STUDY 2- Line 10

5.1. Case Description

On September 27, 2011, at about 14:00, due to technical fault, two trains on Line 10 collided near Station Laoximen. More than 270 passengers were injured, just months after the deadly high-speed rail crash in Wenzhou that shocked China. The metro company said that 500 passengers had been evacuated from the trains but no one was dead (Herald, 2011).

The Line 10 incident is regarded as ‘the darkest day in Shanghai metro’s operating history’. Unlike the Line 1 incident which is blamed for signal failure, the reason for Line 10 incident is more controversial and involves more factors. News reports and investigation team have indicated the cause for the incident as ‘an accidental power outage’ which leads to the failure of signal system, and the substituting manual dispatching system also fails to function due to immature emergency management (Wei, 2011). However the real reason lying behind the tragedy is far more complex. Public were not totally convinced with the official report, as the so-called expert group has only 4 experts and the left 11 members of the investigation team are from local government, lacking a neutral standpoint in the case. Due to China’s hierarchical political structure, the transparency in decision making between various political levels is low which makes the case more complicated (Dailymotion, 2011).
5.2. Official Report

Right after the incident, a special investigation team organized by Shanghai Administration of Work Safety and other bureaus immediately started the investigation, with the help of an expert group from the third party. The team published their investigating results 9 days later, determining that the incident is “causing significant social impacts and liabilities” and 12 persons that had liability involved were seriously dealt with (Donfangwang, 2011). According to the investigation report, the direct cause is:

“When equipment failed at Xintiandi Station, metro managers opted to run the line via phone by subway staff rather than by electric signals. This approach appeared to work reasonably well for the next 41 minutes. But at 2:51 p.m., two trains collided under the direction of unidentified telephone operators.”

The three indirect causes included are: “Ineffective emergency management, lack of a sound safety management system and good maintenance of facilities, low awareness and quality of staff workers”.

5.3. Network Plan and Decision Making Process

In the early 2005 Shentong Metro launched an open tender for the design of Line 10, and Shanghai Tunnel Engineering & Rail Transit Design and Research Institute won the bid. In the same year Shentong Metro launched an open tender for its construction, which was divided into 11 contractual sections (Century, 2011). The winning bids are in Appendix 2 (due to availability of data the winning bids of the last two sections cannot be obtained). It is notable that two companies are in a dominant position in the construction bid: Shanghai Construction Group General Co. (SCGG) and Shanghai Tunnel Engineering Co. Ltd (STEC). Shanghai Tunnel Engineering & Rail Transit Design and Research Institute together with SCGG and STEC are big state-owned enterprises and are in leading positions in China’s construction industry.
A Brief Chronology of Shanghai Metro Line 10

Phase 1: Planning and preparation


*31th December, 2004*: Headquarters of Shanghai Rail Transit Construction had a meeting with vice CEO of Shanghai Shentong Metro Group to discuss about the requirements on the preparation for the construction of Line 10. In the meeting, Shanghai Shentong Metro Group is required to submit a station plan and the scope of demolition of surrounding residents to the local government, ensuring that in 2005 a number of metro stations can be put into construction.

Phase 2: Bidding and design

*2005*: Shanghai Tunnel Engineering & Rail Transit Design and Research Institute wins the bid for the project phase 1’s masterplan. In the masterplan, the construction process is divided into 11 sections (Appendix 2).

Phase 3: Construction

*20th December, 2005*: Construction officially starts.

*13th September, 2009*: The first train runs for trial.

*April 10, 2010*: Main line runs from New Jiangwan Town to Longxi Road.

*November 30, 2010*: Branch line runs from Longxi Road on the main line to Hangzhong Road.

Future plan:

In the future 20 years, Line 10 will increase 5 more stations in the northern direction and reinforce its ‘golden line’ position in Shanghai.

Source: [http://hi.baidu.com/ctokthcnmbpruq/item/a517374a84ac00fcdfc9f5c07](http://hi.baidu.com/ctokthcnmbpruq/item/a517374a84ac00fcdfc9f5c07)


Table 5 A Brief Chronology of Shanghai Metro Line 10

5.4. Organizational Structure

In 2000 due to organizational reform, Shanghai government decided to abolish Shanghai Metro Company and establish Shentong Metro. The new company is still a state-owned enterprise, including 26 billion RMB from Shanghai Jiushi Corporation and Shanghai Chengtou as registered capital. The previous organizational structure has changed into a new ‘four separation administrative’ mode. Unlike the previous one where planning, construction, operating, maintenance and supervision all belong to Shanghai Metro Company’s responsibilities, the “four separation administrative” mode separates four functions of investment and financing, construction, operation, resource development and other relating businesses in different
companies. Shentong Metro is responsible for investment, financing and resource development part. Shanghai Metro Construction Co. Ltd is in charge of metro construction, acting as the general contractor to invite tenders and to supervise the whole project (safety management and project quality). Shanghai Metro Operating Co. Ltd answers for metro’s daily operation and management. Shanghai Metro Consultant Supervision Co. Ltd (a subsidiary company of Shentong Metro) together with Rail Transit Management Office (under Shanghai Urban Transport Management Bureau) is responsible for management on other relating businesses (He, 2006). Theoretically speaking, the Four Separation Mode is intended to separate four duties so that they can operate individually and independently without interest relationship with each other (Figure 10).

![Figure 9 Four separation administrative mode of Line 10](image)

As shown in Figure 9, the ‘four separation administrative’ mode has better refinement in division of work than the mode in Line 1. Though Shentong Metro is still owned by Shanghai government, the decision making process in the development of Line 10 is more market-oriented: Shanghai government holds power only in providing general guidance and suggestions to network planning, construction and ways of operation; the actual investment, financing, construction and operation are in the hands of Shentong Metro and other stakeholders, adopting a commercial way of development (R. Chen, 2005).

5.5. Contractual Arrangements

According to Shentong Metro, the qualifications that contractors were required to make a bid for the construction phase of Line 10 were demanding and strict, including (Bidchance, 2012):

- A superfine grade for general construction contracting of municipal public projects, including following practical conditions: owning a registered capital no less than 300 million RMB; with net assets of at least 360 million RMB; an average annual income for the last three years reaches no less than 50 million RMB; a minimum of 10 years’ experience in project management; etc.
- A superfine grade for general construction contracting of urban rail transit projects,
including following practical conditions: owning a registered capital no less than 100 million RMB; owning capable construction equipment; a minimum of 10 years’ experience in project management; etc.

- A superfine grade for general construction contracting of railway projects.

Though in the tendering it is declared that meeting only one of the requirements is enough, it is still extremely high for many construction companies. As a result, only the state-owned large construction companies with strong relationship with the government and Shentong Metro can have good chance of winning the bid. According to Appendix 2, only large companies like Shanghai Construction Group General Co. and Shanghai Urban Construction Group have won more than 80% of the bids based on project price (taking into the fact that Shanghai Tunnel Engineering Co. Ltd is a subsidiary of Shanghai Urban Construction Group Co.).

Line 10 Section 6 main players

| Client: Shanghai Metro Construction Co. Ltd (subsidiary company of Shentong Metro) | Bid winner: Shanghai Urban Construction Group Co. |
| Design Party: Shanghai Tunnel Engineering & Rail Transit Design and Research Institute (subsidiary company of Shanghai Urban Construction Group Co.) |
| Supervision Party: Shanghai Metro Consultant Supervision Co. Ltd (subsidiary company of Shentong Metro) & Rail Transit Management Office |
| Builder: Shanghai No.2 Municipal Engineering Co. Ltd (subsidiary company of Shanghai Tunnel Engineering Co. Ltd, civil part), CASCO Signal Ltd (signal part) |
| Attaching contractors: Shanghai Urban Construction Group Co. → Shanghai Tunnel Engineering Co. Ltd → Shanghai No.2 Municipal Engineering Co. Ltd |

Table 6 Main players of section 6 in Line 10

Table 6 illustrates how main players are doing in the contractual arrangements in section 6 of Line 10 where East Nanjing Road Station part is built. The bid winner for this section is Shanghai Urban Construction Group Co. The design party is Shanghai Tunnel Engineering & Rail Transit Design and Research Institute, which is subsidiary to the bid winner. The builder (sub-sub-subcontractor) for the civil part is Shanghai Tunnel Engineering Co. Ltd, also a subsidiary company of Shanghai Tunnel Engineering Co. Ltd; the latter is again a subsidiary company of the bid winner. Here the fact is that the contractor always subcontracts the work to its subsidiary company, and the latter will continue this mode to the end. In this mode, fair and objectivity of monitoring is difficult to reach because all the attaching contractors are actually within Shanghai Urban Construction Group Co. Apart from civil engineering part for the project which four subcontractors are shown in Appendix 2, another company CASCO Signal Ltd should be mentioned. CASCO Signal Ltd is responsible for building signaling system for Line 10. So here I regard it as the fifth subcontractor. CASCO Signal Ltd is owned by Shanghai Railway Administration.

Now it’s time to briefly introduce these subcontractors in Appendix 2. Shanghai Construction Group General Co. is a large state-owned company with total assets of 23.8 billion RMB and a highest level of double qualification in contracting buildings and municipal public projects in
China. It has 9 branch companies and 20 wholly-owned subsidiary companies (SCG, 2008) and it uses Shanghai Construction No.2 Group Co. Ltd, one of these subsidiaries, as a sub-subcontractor. Shanghai Urban Construction Group Co. is also a state-owned enterprise, with 15 subsidiary companies. It is noticeable that Shanghai Tunnel Engineering Co. Ltd is one of its subsidiary companies (SUCG, 2006). Shanghai Tunnel Engineering Co. Ltd owns 17 subsidiary companies and in section 6 one of them Shanghai No.2 Municipal Engineering Co. Ltd becomes its subcontractor (Baike, 2011). Tengda Construction Group Co. Ltd acts as the main subcontractor of its section, with no sub-subcontractors under its level (TENDA, 2007). Hongrun Construction Group Co. Ltd has 33 branch companies, 13 subsidiary companies and 29 project management departments, and it uses some of its project management departments and subsidiary companies as sub-subcontractor (Hongrun, 2011).

In the subcontracting process, signal system is an individual branch from civil construction. It requires specific high tech which few companies in China can provide. CASCO Signal Ltd is one of these companies. Founded by China Railway Signal & Communication Corp (China’s biggest signal system company) and Alstom Group, CASCO is China’s first joint venture company in railway industry. It has two overwhelming advantages in winning the bid for signal system: its strong support from China Railway Signal & Communication Corp which is China’s most authoritative institution in railway industry, and its high cost performance compared to other companies in China. No wonder CASCO has monopolized approximately 60% of China’s railway projects (Fang, 2011).

But is CASCO really what it calls itself “Your trustable signaling solution specialist”? According to data, metro tragedies also took place in cities like Shenzhen and Wenzhou where CASCO was responsible for the signaling design. The Wenzhou incident, which happened just two months before the Line 10 incident, was regarded as China’s first high-speed rail fatal crash, and the third deadliest high-speed rail accident in history. The Shenzhen Line 2 incident coincidentally happened two months after the Line 10 incident. Ironically, when Line 2 was completed, CASCO had proudly announced that the time duration for Line 2’s signaling system construction was the shortest in CASCO history (Huang, 2012) However even though CASCO has brought such great panic to the public, the company still undertakes projects of main Chinese cities’ metro signaling system: 28 projects in China in which 20 are in Beijing and Shanghai. CASCO can achieve such popularity which is attributed to its close relationship with China Railway Signal & Communication Corp, strongly sponsored by Chinese government and owns many specialists who have right to speak in assessing signaling technology in rail transit system. As a result, potential worry exists in the future not only for Line 10, but for all the metro lines involving CASCO in China.

To better see the picture of contractual arrangements of Line 10, a theory of Porter five forces will be introduced. The theory is a framework for industrial analysis and business strategy development which derives five forces to determine the competitive intensity of stakeholders (Porter, 2009), in my case, contractors and (sub) subcontractors and workers. The five forces include three forces from ‘horizontal’ competition: threat of substitute products or services, threat of established rivals and threat of new entrants, and two forces from ‘vertical’ competition:
bargaining power of suppliers and bargaining power of customers (Porter, 2009). In the case of Line 10, as the main contractor Shanghai Urban Construction Group Co. has a very strong position in the market due to its close connection with local government and its excellent performance in the metro industry, it will not be easily replaced by other companies. However, the subcontractor and the sub-subcontractor are more easily replaced especially the sub-subcontractor because what they offer is just a part of the construction process like excavation or laboring, instead of a unique product as what the main contractor will be delivering. Consequently, competition for subcontractors and sub-subcontractors is really tough. Each of them is fear of potential entrants with advantages to out win them, and is under threat of current rivals. Those competitors may have cost advantages, or better quality workers and more resource, etc. On the other hand, suppliers of raw materials can have impact on sub or sub-subcontractors through many ways and so do customers (for sub-subcontractor customer is subcontractor, and for subcontractor customer is the main contractor). As a result, subcontractors and sub-subcontractors are always put at a difficult position, making efforts to reach their customer’s expectations. But when monitoring is not effective or sufficient, the competition between those players becomes fiercer and even illegal, and the main contractor would turn a blind eye on it and prefers to choose the more profitable option.

As mentioned before, lack of effective fair monitoring can lead to illegal competition between players. Especially in the complex contracting relationship, such monitoring is difficult to attain as so many sub-subcontractors are in fact subsidiary to their subcontractors. The interest between these players will intervene with each other and make the circumstance more intricate. Under this context if the higher level delivers harder work with unsound conditions to the lower level, the latter would probably tend to act strategically to cover up the true story in the construction and management process, if the truth matters to their own short-term profits. But in the long run, this behavior is harmful for the whole project as small problems will remain and very likely to cause big troubles in the future. Safety issues would be undetected if this trend goes on and the consequence would be immeasurable.

5.6. Value Tradeoffs

The organizational structure and contractual arrangements have demonstrated the hierarchical context where Line 10 was built, which fits what Rasmussen’s concept of a social-technical system. In this concept, stakeholders are stimulated by certain incentives to trade off project’s safety for other values, resulting in crossing the safety boundary. Usually there are four key basic values in a project: time, scope, budget and quality (Maylor, 2010). In next paragraphs I am going to identify how these values are traded off for each other.

5.6.1. Incentives of Time Compression

As said in the Line 1 case, time compression has always been a common phenomenon in construction projects in China, especially under Chinese central government’s stimulations for national economics. These stimulations include “Four Trillion Plan” in 2008 and “11th Five Year Plan” (from 2006 to 2010), both aiming to accelerate the pace of constructing public
infrastructure and transportation in Chinese big cities. Shanghai metro is no exception. Since Line 1 opened to public in 1995, Shanghai has built more than 10 operating lines in 15 years with an operating route length of 420 kilometers. Community of Metros even regards it as “A miracle in world’s metro construction history” (L. Li, 2011).

The economic stimulations lead to the consequence that a lot of contractors have too many orders in a short period of time, causing them to have no capacity to finish a certain one on schedule. To solve this problem these contractors would prefer to contract out the assignment to other small subcontractors, usually without a sound qualification to guarantee the work to be finished on time. In the Line 10 case, sub-subcontractors contract out their duties to smaller companies, though information is not available here. This behavior causes trouble not only for the project’s safety, but quality as well (C. Sun, 2011).

Incentives for this metro “Great leap forward” pageant are not only of blindly pursuing economic development while neglecting project’s quality, but also of some important local events during the Line 10’s construction period. Because the Shanghai World Expo opens in May 2010, Line 10, regarded as the golden line in the city, should meet the demands for tourists. Shanghai government then decides to accelerate the process of construction: a six month ahead of target finishing time (Figure 10). Actually the original planned finishing time October 2010, right before China’s 61th National Day has already been a little bit tight for the whole construction process. But due to “Saving face” is China’s tradition, Line 10’s completion before important dates matters more than other things. So time compression is inevitable. According to relevant experts, the early phase of construction has been delayed for 8 months, causing the follow-up construction phase and the simultaneous signal system debugging process to be finished in such a hurry. To ensure signal system debugging has enough time, CASCO applies a scheme that operating 24 hours a day, which admittedly is much in a rush (Wei, 2011). As a result, 14 months are saved for signal system debugging, the vital part for the whole metro system, creating great potential risk for the accident to happen.

![Figure 10 Time compression of Line 10’s development](image)

**Conclusion:** Like Line 1 case, time compression in Line 10 is common as well. The incentives for time compression are mainly economic stimulations from government and schedule push of important events. The outcome is that the project’s quality is traded off for time.
5.6.2. Dilemma in Scope Change

In the route design of Line 10, too many values need to be considered at the same time, causing dilemma to local government. The Shanghai government sometimes has to trade off scope for project safety and sometimes vice versa.

In the construction of Yili Station, scope is traded off for project safety. The station is designed with no entrance on the Hongqiao Road’s side to avoid pipeline underneath. This makes local public transport extremely inconvenient. Residents living in the south of the station have no choice but across Hongqiao Road to get into the station. Also as Line 10 passes through many historical buildings and schools, the government decided to adopt detours in the route to avoid unnecessary demolition.

Conversely, at some point project safety is traded off for scope expansion. In the northern extension part of Line 10, five extra stations are added, the furthest even extending to Huangpu River and the west coast of Yangtse River. The truth is the part between Huangpu River and Yangtse River has been one of Shanghai’s most potential real estate places in the last five years. Many real estate projects and commercial skyscrapers are built there, making it an attractive place for growing number of investors and residents. However the ground condition near the Yangtse River is worrying because of its unique location: the mouth of Yangtse River Delta, which means that the ground layer is fragile. Anyway the government still cannot resist the temptation of real estate income and choose to take the risk, extending the scope and sacrificing project safety.

**Conclusion:** Basically the local government is always put into a dilemma of balancing different values. Project safety is traded off for scope sometimes and scope is traded off for project safety sometimes. In the circumstances as other values are not that conflicting, the decision maker will keep some considerations for project safety. In the situation where potential income is possible, project safety could be sacrificed: budget is the key value to pursuit under the extension of scope.

5.6.3. Shrunk Budget: A Multi Factor Result

Similar to Line 1, the first factor influencing budget is inflation in material price. In Line 10’s construction period from 2005 to 2010, the price of steel rises from 3200 to 4900 RMB per ton, not to mention other materials. The year 2008 saw global financial crisis affecting the price as well. As a whole, though the inflation rate is unpredictable for local government before the construction starts, local government still should bear the risk of extra budget brought about by inflation. The burden forces the profit-driven local government to trade off other values (time, scope, quality, and safety) for a tighter budget.

Another factor is excessive subcontracting, which is barely seen in the Line 1 case. As mentioned before, the main contractor usually distributes its work to several subcontractors, and subcontractors to sub-subcontractors. In every contracting process, a certain amount of management fee is subtracted from the project’s budget. What’s more, these profit-driven sub-subcontractors might not have good qualification in completing the work. For example, they
may purchase cheaper materials and equipment in order to gain more financial profit. Here we can also find quality and safety are traded off for budget.

**Conclusion:** Inflation and excessive subcontracting are main reasons for a shrunk budget. Under the social context of profit-driven, it’s no wonder why budget has the first priority in everything, giving rise to the potential risks in project’s quality.

### 5.6.4. Sacrifice of Quality

**Project safety:** Excessive subcontracting, unqualified workers and subcontractors and time compression force project’s safety to be sacrificed. Supervision seems abundant this time but the effectiveness and efficiency of the supervision department: Rail Transit Management Office still remains doubtful. Without good supervision all last guarantee on project quality is just illusion. Scope extension also threatens project safety by exposing the project in fragile ground conditions.

**Environment safety:** Since China’s *Environmental Impact Assessment Law* was published in 2002, an environmental impact assessment report is necessary for all infrastructure projects. According to *Environment Impact Assessment Report of Shanghai Metro Line 10*(CRSSDG, 2008), the noise and vibration of construction and operating has seriously interfered the neighborhood’s daily life. Considering there are many environmental sensitive spots nearby Line 10 like schools, historical buildings and resident houses, Line 10 inevitably becomes a big problem for local citizens. The positive side is that the government is highly aware of protecting historical buildings compared to Line 1.

**Public participation:** Though public cannot make their voices heard in the decision making process, they have opportunity to join in the environmental impact assessment process according to China’s *Environmental Impact Assessment Law*. In the law, “proper public involvement” is “encouraged” but not “compulsory”(PeopleNet, 2002b). In the environmental impact assessment process of Line 10, the information is chosen by Shentong Metro, and published by China Railway Siyuan Survey and Design Group Co. Ltd; the latter is responsible for environmental impact assessment for Line 10. Then questionnaires are distributed by Shentong Metro to local households. Public can participate also through telephone, email and fax. It can be implied that decision makers don’t wish real public participation and the public can hardly get true information about how the construction impacts on the environment.

**Conclusion:** In Line 10 quality is always traded off for budget and scope under stringent time compression because of excessive subcontracting, unqualified workers and missing supervision party. Unlike Line 1, decision makers have shown an improved awareness of protecting environment (historical buildings) in the construction process, but still not doing it best (construction noise is not well controlled). Public participation is only a formality due to opacity of information.
6. COMPARISON & ANALYSIS

This chapter mainly consists of two parts. In the first part Line 1 and Line 10 will be compared to Beijing, Hangzhou and Dalian cases in terms of value tradeoffs and subcontracting issues. The second part will thoroughly analyze the core reasons for what is shown in the comparison part regarding to Rasmussen’s theory with indicators like regulations, environmental impact assessment, public values, etc. All indicators are closely connected to construction process and might contribute to the metro tragedies.

6.1. Comparing Line 1 and Line 10 with Previous Cases

In Chapter 4 and 5, cases of Line 1 and Line 10 are depicted from planning history, organizational structure, contractual arrangements and value tradeoffs. In previous research of Ma, de Jong and Koppenjan, three Chinese cities of Beijing, Hangzhou and Dalian are analyzed as well. So I am going to make the comparison from value tradeoffs and subcontracting in chronological sequence.

6.1.1. Value Tradeoffs

<table>
<thead>
<tr>
<th>CITES OF ACCIDENT</th>
<th>Beijing Line 10</th>
<th>Hangzhou Line 1</th>
<th>Shanghai Line 1</th>
<th>Dalian Line 2</th>
<th>Shanghai Line 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>TIME</td>
<td>Incentives for time compression</td>
<td>Pressure from government; time push of Olympic Games (high penalties will follow for overrun)</td>
<td>Different deadline in contract and government documents; delays in demolition works</td>
<td>Pressure from government; time push of Spring Festival</td>
<td>Pressure from government; time push of Spring Festival</td>
</tr>
<tr>
<td>Tradeoffs</td>
<td>Quality loss; regulations violated</td>
<td>Quality loss; complaint by workers</td>
<td>Quality loss</td>
<td>Quality loss</td>
<td>Quality loss; budget saved</td>
</tr>
<tr>
<td>SCOPE</td>
<td>Incentives for scope change</td>
<td>Stringent functional requirements and constraints of Olympic Games</td>
<td>Real estate development</td>
<td>Real estate development; protecting historic buildings</td>
<td>Real estate development; protecting historic buildings</td>
</tr>
<tr>
<td>Tradeoffs</td>
<td>Quality is traded off for high demand of scope</td>
<td>Geological environment is traded off for scope expansion</td>
<td>Not much conflict with other values</td>
<td>Quality is traded off for scope</td>
<td>Quality is traded off for scope and sometimes vice versa</td>
</tr>
</tbody>
</table>
Table 7 Comparison of three cities in value tradeoffs

From Table 7 we can see that all the five cases have time compression in the construction process, mainly due to pressure from the powerful local government. The Beijing case and Shanghai Line 10 case are similar in sharing an incentive for time push of important events (Olympic Games and World Expo Exhibition) while Shanghai Line 1 case and Dalian case for time push of Spring Festival. The result is, all cases suffer from quality loss because of stringent time requirement.

Except Beijing case whose motive for scope change is strict Olympic requirements and constraints, the other cases are all driven by real estate development goals. The essence reason is profit driven. The consequences are a certain extent of quality loss, on the cost of local environment and residents’ safety), and often the decision making is a headache for governments. But in the Beijing and Shanghai (Line 1 and Line 10) cases, route design has some considerations for protecting historical buildings which is quite a remarkable thing.

As for the incentives for a shrinking budget, inflation and unqualified workers occur in all cases. Excessive subcontracting is missing in Line 1 case due to its unique organizational structure, but common in the other cases. One thing is certain after all: In all the cases, a higher profit is what
decision makers seek and quality is usually traded off for this goal.

In the quality category, unqualified workers again become a reason to have negative effect on project safety in all cities. Also insufficient monitoring is what all cases share. Illegal subcontracting is significant only in Beijing and Dalian. In the environment safety part, all cases are not doing a good job in preventing noise and vibration of metro construction which arouse complains from neighborhood. In Shanghai and Beijing cases, historical relics are protected but in Dalian and Shanghai Line 10 cases geological environment is harmed to some extent because of scope extension. In 2002 China’s first Environmental Impact Assessment Law was published, in which public participation in the environmental impact assessment process is “encouraged”. However the law fails to elaborate on in what way this involvement can be guaranteed legitimate and effective. As a result, the metro company or other parties can easily interfere with the public participation process and the public cannot get what they want. In the Line 10 case the questionnaire and information publicity activities are organized by Shentong Metro. In this way public involvement is just namely. The same applies in Beijing, Dalian and Hangzhou cases as well. As a natural outcome, project quality is always traded off for all other values.

6.1.2. Subcontracting

The subcontracting mode that Hangzhou applied is public-public-private mode in which Hangzhou government delegates work to the large state-owned enterprise as the main contractor (China Railway Group Co. Ltd), and the main contractor to small-medium private firms as subcontractors (like China Railway No.4 Engineering Group Co. Ltd), subcontractors to sub-subcontractors (like Sixth Civil Engineering Co. Ltd of the CTCE Group) and this chain keeps going in this way. It is funny that the monitoring unit is Shanghai Tongji project management consulting Co. Ltd which is attached to one of the builders (de Jong et al, 2013).

In the Beijing case, BT mode is applied with excessive subcontracting similar in Hangzhou case. Here the main contractor is China Railway 12th Bureau Group Co. Ltd; subcontractor is The 2nd Engineering Co. Ltd which is subsidiary of the main contractor, followed by an unknown sub-subcontractor and then a sub-sub-subcontractor. Monitoring appears not strong and independent enough for Line 10 and section 2 of the construction which was not on the contractual list with the worst conditions is even not within government’s monitoring.

Same pattern in subcontracting can be observed in Dalian as well. Twice subcontracting happens as the main contractor China Railway 10th Group Co. Ltd, subcontractor Zhongtian Urban Transit Construction Company and sub-subcontractor Project Department for Section 201. Insufficient monitoring again affects project quality.

In Shanghai Line 1, there is no real subcontracting. As Line 1 is the first metro line in Shanghai, Shanghai government has made Shanghai Metro Company as its agent to cover duties of planning, construction, operating and maintenance. The role Shanghai Metro Company plays is not a contractor but an agent who represents Shanghai government’s will to construct and manage the metro project. The company itself didn’t expect to get benefits from this duty. So in about 20 years ago, there is not much work pressure on the main project developer, the
government takes more responsibility.

However the situation is the opposite in Line 10. As the development of Line 10 is 10 years after Line 1 when a whole new organizational structure is already established, excessive subcontracting exists with no doubt. The “four separate administrative mode” has delivered the jobs to different departments and companies, and these companies subcontract their work to smaller companies. There even could be three or four times of subcontracting. In each subcontracting, a certain percentage of management fee is needed, adding pressure to the budget. Also the smaller the company is, the more risky of the project quality becomes as more unqualified workers are and cannot be monitored properly. So in comparison both cases have its advantages and disadvantages: Line 1 is in more control of the government, which guarantees its finance but is not competent in the future commercial market. Line 10 suffers from its excessive subcontracting which endangers its quality and budget, but it is trying to survive and adapt the Chinese market, becoming a potential competent project.

From the comparison, we can see that what is carried on in Line 10’s subcontracting process is quite similar to Beijing, Hangzhou and Dalian where excessive subcontracting can be observed and the monitoring party is not that effective. Combining with value tradeoffs, Line 10 is most resemble to Beijing case.

### 6.2. Do the Shanghai Metro Accidents Tell Another Tale?

The picture of metro construction in Shanghai depicted through Line 1 and Line 10 shows how the projects are carried out under stringent time compression, shrinking budget, changing scope, insufficient monitoring and a lack of professional risk management. These extreme conditions have built a fertile environment for accidents to happen, while safety boundaries of the systems are easily crossed. The accidents may be distinguishing, but the organizational structure and contractual arrangements indicated are never new in China. From comparison with other three Chinese cities studied before, I conclude 7 main problems that trigger metro accidents.

#### 6.2.1. Profit Driven

Among all the cases concluded above, profit driven has appeared in all of them. So firstly I would like to start with this problem. China is now at the stage of fast economic development, where both government and people have increasing material needs: on one hand government is keen to invest on vast infrastructure projects in order to gain quick profit, on the other hand the people are eager to make money quick and to attain quick personal success. In this unhealthy environment, frequent time compression and scope change in metro projects become explainable. When construction schedule is shortened, budget can be saved and project companies could have time for other projects as in China construction projects are everywhere due to real estate hot. An extended line indicates extra benefits from real estate and other profits along the line, which reinforces government’s financial support. Both ways save budget and guarantee profits compared to original practice. So, metro lines are always built quickly and shoddily to fit themselves in the tight time constraint to obtain potential profit.
6.2.2. Face Saving

Another important reason to mention is “face saving”. China is a country that considers “face” to be more vital than almost everything. The word “face” means someone would like to do something that which makes others to continue to respect him. Here “face job” implies that government would do anything to maintain its “good” reputation in front of the public and in the world. Like in Line 1 and Line 10, special events and festivals are considered important dates to test a city’s political achievements. Spring Festival, National Day and World Expo Exhibition are just right opportunities for such a test. In the case of Line 10, Shanghai government made a plan in 2007 of surpassing 400 kilometers of operating length before World Expo. However in 2007 the total length of Line 10 was only 123 kilometers, suggesting 100 kilometers should be constructed per year on average. This speed is much higher than many developed countries. So when Shanghai citizens were worried about the lines were built too hastily to meet safety standards, Shanghai government seemed more afraid of that metro lines would be attacked by terrorists during the Expo. No wonder a common feeling among Shanghai’s local people is that the subway was not designed to serve them, but to enhance the status of Shanghai’s Communist Party leaders (Minter, 2011).

6.2.3. Safety Regulations: Immature and Changeable

Indeed there are various safety regulations concerning metro construction process. However as China has just started metro projects for not very long, currently the country is still in the exploratory stage of establishing safety regulations for the entire metro system. China has published its first systematic risk management regulation “Guidebook for Risk Management of Subway and Underground Projects Construction” in 2007, and it has its first revision in 2011. In the same year another law GB 50652-2011 “Specifications for Risk Management of Urban Rail Transit and Underground Projects” was published (X. Chen, 2012). The time for these regulations published is even after the construction time of Line 1 and Line 10, not to mention a long time needed to enforce these laws. But until now China cannot offer a sound and perfect law setup to ensure a reasonable and effective risk management system for metro construction merely based on these safety regulations.

Not only because safety regulations are immature, but also because these regulations can be easily modified by local government. The real situation is that preparation for construction is rather short and careless while government hastily and constantly modifies original plans and regulations in the design and construction process according to its needs. The arbitrariness and lack of scientism and responsibility in work often harm project quality and have negative impact on contractors, subcontractors and workers. When “the will of the superior” becomes higher than the regulations, the inferior will receive the idea that rules can be ignored, which overshadows project quality as well.

As a result, even though relating regulations exist, their immaturity and insufficient monitoring make stakeholders seek loopholes and not respect them. Without a mature legal system, metro construction will not have a good development.
6.2.4. In Need of Qualified Personnel

When safety regulations are endangered, the last hope could only rely on personnel working in the construction process. However the sad truth is there are not enough qualified personnel in metro projects not only in Shanghai but also in other Chinese cities. According to statistics, by the year 2050 there will be 289 metro lines in China with a total length of 11700 kilometers and an urgent need for talent of 100 thousands (Zhu, 2011). However there are always not enough competent personnel to fill this huge gap. According to a metro driver of Line 10, he has to work almost 10 hours each day from 7:50 am to 6:00 pm with only 20 minutes break at noon. Such intensive workload finally drove him to quit the job (L. Li, 2011). This busy schedule also exists in workers in the construction phase. Every day they are under tremendous working pressure, it is no wonder that mistakes happen once in a while.

High stressed workload is merely part of the question. A more serious issue is insufficient training for workers. Often workers from railway construction are called in without training to assist subway construction due to short of hands. Also many farmers are recruited with a very short period of training. Based on the same metro driver, he has only gone through two months of theoretical training and less than 6 months of practical training before he becomes a “professional”. And all he spent on the training is 6000 RMB. What is funny about it is that he had no experience with metro jobs before training (L. Li, 2011). It is fear that when time schedule shrinks, training time for each worker will be shorter. Also in the Line 10 case, it is noticeable that workers have been too much dependent on technology: when supporting system went failure and manual work was needed, accident happened within half an hour of manual work. Compared with some western countries, most metro signal systems are half auto and half manual, ensuring safety in all senses (Zhang, 2011). The negligence for manual operation practice will give rise to tragedies if not get improved.

Apart from metro workers that fit basic daily routine work, there is a more desperate requirement for high level management talent, those who are vital secure for a safer and more efficient metro operation and management. Yet it takes 5 to 10 years to grow such a talent. Metro companies will not bother to spend time on this, leading to that many managers at higher positions are not qualified at all. Also an important point to mention is that, China lacks a standard profession authentication for metro industry. Nowadays in China there are not enough colleges or universities providing courses relating to urban rail transit, mostly are in Beijing, Shanghai and other big cities. Altogether, relating talents don’t get professional education and a standard qualification authentication, causing chaos in management of metro talents.

6.2.5. Excessive Subcontracting

In the article 28 of Construction Law of People’s Republic of China published in 1997, it is forbidden to subcontract the whole project the contractor owns to a second party. Then it is obvious that excessive subcontracting is illegal in Beijing, Hangzhou, Dalian and Shanghai Line 10 cases. In these cases, many levels of subcontracting can be observed: In Hangzhou 4 levels, Beijing 4 levels, Dalian 2 levels and Line 10 case 3 levels. The more levels of subcontracting, the more management fee has to withdraw from budget, and the more difficult it is to finish work
within original schedule as many bureaucratic procedures are in the subcontracting processes. In the end, time is wasted, budget shrinks and quality cannot be guaranteed. Additionally liabilities are distributed to various parties making it hard to find somebody guilty when tragedy happens. The illegal subcontracting cannot help but beg the question: where is effective monitoring? This is what I am going to discuss in the next section.

6.2.6. Sub Standard Monitoring, Poor Enforcement

Monitoring is the last gate to stop accidents from happening. However immature safety regulations and unqualified personnel finally lead to substandard monitoring and poor enforcement. China’s construction project monitoring system was promoted in 1987. Yet after decades, this system is still not fully implemented because the basic principle of the system remains unenforced. This principle proposes the absolute independencies from three parties: project owner (local government or metro company), contractor, and monitoring party (W. Li, 2008). In both Shanghai cases, monitoring company is Shanghai Metro Consultant Supervision Co. Ltd, a subsidiary company of Shentong Metro. In this way the monitoring can hardly be unbiased and objective. Though Rail Transit Management Office is also supervising construction and operating processes of Line 10, we could imagine this would just be another empty shell as firsthand information is in control of Shanghai Metro Consultant Supervision Co. Ltd. Incompetency of personnel makes monitoring ineffective and poor enforcement of safety regulations follows. Workers and subcontractors will take advantage of this, cutting corners. To a certain extent, projects’ quality could only count on “conscience of construction team” (Pei, 2009). Isn’t it sad?

6.2.7. Low Public Involvement

Basically public participation in the decision making process is minimum in the Shanghai cases. In the blueprints of Line 1 and Line 10, usually parties who participate are local government, Shentong Metro, specialists, etc. In the Line 1 case, Local government acts to design the main route for each line based on the needs of local urban development. Specialists act as consultants to help to conduct a feasibility study of the project to provide advice on technical terms. In the Line 10 case, Shentong Metro takes up the leading role in designing route for Line 10 in consultancy with specialists. Then the company subcontracts the work to various subcontractors. No public opinion is involved in the designing processes in both cases. In the environment impact assessment process of Line 10, there are twice announcements to public and public is asked for advice from the environment impact assessment company. The feedback methods include telephone, emails, letters and questionnaire (CRSSDG, 2008). However this so-called public participation always becomes formality. Local residents are seldom aware of what is really going on in the construction site due to opaque of information so they cannot offer constructive advices. Even a useful advice is received, no department can guarantee the advice to be accepted or well dealt with. To conclude, public acts as a spare role in this game. In the Line 1 case we see intellectuals are doing a good job. But it is really a hard job as the government is not willing to change its mind. To conclude, legitimate public participation still has a long way to go in China.
6.2.8. Conclusion

The “seven sins”: profit driven, face saving, immature safety regulations, unqualified personnel, excessive subcontracting, substandard monitoring and law enforcement and low public involvement which are so distinctive in Shanghai cases have almost followed the same patterns in Beijing, Hangzhou and Dalian cases. It is not a coincidence considering the current situation of China’s metro construction. Under a profit driven and a high hierarchical political environment, values of time, scope and quality are always traded off for a better budget. The hierarchical structure threatens transparency of decision making, consequently leading to low public participation and ambiguous liability distribution. Imperfect legal system and loose monitoring mechanism deteriorate the problem. Fundamentally level of management in metro system needs to improve to catch pace of development of technology; otherwise the imbalance will cause more severe tragedies in the near future.
7. CONCLUSION & RECOMMENDATION

In the last chapter, conclusions will be made in two parts: empirical conclusions and theoretical conclusions. Chapter 7.1 summarizes what empirical experiences are from the research based on Chapter 6 and in Chapter 7.2 advices for policy practice will follow. Chapter 7.3 gives light on how Rasmussen’s theory is applied in the cases and 7.4 reflects on research methods used in the study.

7.1. Empirical Conclusions

In Chapter 6 Shanghai cases are compared with previous cases in China, and analysis is made in terms of “seven sins”. To summarize, Shanghai cases are not unique in general regarding to Beijing, Hangzhou and Dalian cases. Almost all cases show a certain level of characteristics of profit driven, face saving, immature legal framework, unqualified personnel, excessive subcontracting and low public involvement. These common characteristics reflect many problems in metro construction in China. The real situation in metro development is, due to absence of a mature and well functional legal system, decision makers at higher level (usually local governments) can easily disregard the basic regulations and interfere in any processes of metro project pushed by strong incentives of profit driven and face saving. The substandard management level in the company caused many unqualified workers to be recruited, endangering the project’s quality. A lack of independent monitoring and excessive subcontracting worsen the issue. As a result, in most cases quality is always traded off for budget, time and scope, and accidents are waiting to happen.

However still some shining points are revealed in the analysis: Shanghai cases show a concern for environment in the construction process. Local historical buildings and residents’ safety are more considered than the other cases, which is a good thing. We can see Shanghai government is making efforts to improve its management level by restructuring Shentong Metro and adopting a “Four Separate Mode” in organizational structure. Though Shentong Metro is still belonging to Shanghai government, the government’s power is becoming less influential in decision making as the former government-monopoly pattern is slowly replaced by a market-oriented pattern as described in Chapter 5. Shanghai metro still has a long way to go.

7.2. Recommendations for Policy Practice

Based on the problems emerging in the analysis, some recommendations for policy practice are generated in three levels: the country’s level, the city’s level, and the company’s level. The recommendations have limitations due to insufficient inside information. At last I will also provide advice for other minor cities in their metro development.
7.2.1. On Nation’s Level

On nation’s level, frequent metro accidents is becoming more and more common in Chinese cities. The central government is busy approving metro projects in the country, and a great number of construction companies are busy competing for such projects. However a sound legal framework ensuring project safety is missing, not to mention how such framework is enforced in reality. As mentioned in 6.2.3, safety regulations have just been put forward in the last ten years, needing time and space to get mature. So my first suggestion is that the central government should make more efforts to improve the current legal system from legislating safety regulations and law enforcement. Once regulations are legislated, no party (including central government and local municipalities) has privileges to rewrite or redefine them at will. In the law, monitoring should be stated clearly that the monitoring party should be completely independent from government and contractors involved in the construction process. Only by strictly limiting government’s power can metro projects be guided and monitored under an effective legal context. Otherwise if government overrides the law, lots of factors threatening project safety will come up and endanger the project.

The second suggestion is less monopoly in high technology. CASCO is just a good example. In chapter 5.5, it is described that CASCO has almost monopolized 60% signal system contracts in China, due to its close relationship with China Railway Signal & Communication Corp, with many specialists of high authority in the signal system field. CASCO’s monopoly will strongly affect effectiveness of monitoring and authenticity of investigation report, as many specialists in China Railway Signal & Communication Corp have dominating power in assessing metro safety in China. Though the situation of CASCO’s monopoly in China’s metro market cannot be changed overnight, the country is responsible to develop its own core technology instead of relying on western’s. Only in this way an open and independent market in metro projects can be attained, making it possible to achieve a more subjective, unbiased monitoring and control in metro projects.

7.2.2. On Shanghai’s Level

As analyzed before, both cases in Shanghai share a common background of profit-driven and sacrifice of project quality and other important values. So the first suggestion for Shanghai is for the local government: to slow down the pace of economic development while adopting more concern on environmental issues and local people’s living quality. The planning of metro lines should take into consideration of geological conditions, residential needs and cultural value of buildings. If geological condition is fragile, decision makers can never risk locals’ lives to carry on the project. Residential needs indicate that if the line cuts across too many residential areas, the route should be changed to largely avoid endangering local's living. Also environmental indicators like pollution, noise and vibration during metro construction should be controlled under a standard level so that neighborhood won’t be affected. Cultural value usually means historical buildings should be protected. So this suggestion is to urge Shanghai government make a good balance between values in the decision making. Also advanced experiences from other big cities around the world in metro construction could be followed to enforce Shanghai’s own.
Another important issue to advocate is active participation of local public in both decision making and environmental impact assessment processes. Public involvement in major affairs in a city is a significant indicator of a civilized society. Shanghai is no doubt a national leader in economic development and creating an open and civilized society. The city also has gathered China’s most elite class with highest educational level and citizen consciousness. Then it is not hard to organize intellectuals and social force to put pressure on local government when public interests are threatened. And now it is information age, meaning that more and more locals can contribute to this by initiation. It is only everyone is striving for a better future can there be the possibility to have one. I hope in the near future locals in Shanghai can actively join the process, defend their own rights and help to monitor what government is doing in metro development.

7.2.3. On Company’s Level

On the level of company, three recommendations are given. The first is prohibition of illegal and excessive subcontracting. The negative impact of illegal and excessive subcontracting which has been illustrated in chapter 6.2.5 is that liability of the project is distributed and cost and time are lost. To totally prevent this, effective monitoring is required, regarding to the nation’s level.

The second recommendation is to recruit qualified personnel both on managerial positions and workers. Cost for training workers shouldn’t be reduced to save budget, as more cost will be spent if accidents happen because of lack of training. The company should update personnel to maintain a high standard. Here management experience from international metro companies should be consulted.

The last is to improve management skill for metro management. Though in the construction of Shanghai metro, the world’s most advanced technology is used, the management level is rather low. When accident happens, the whole company is in chaos and it is difficult to find the exact party to blame. This is because decision makers at high levels have more or less put more focus on using the shortest time to complete to project, instead of creating a well-organized legal based company. The emergency response system is poor as well but not much effort is made.

All three recommendations on the company level are closely related to the other two levels. Without enforcement for the nation’s level and Shanghai’s level, suggestions for the company level will be hard to implement.

7.2.4. For Minor Cities

Currently many second tier and third tier cities in China have started building their own subway lines, like Ningbo, Wuxi, Hefei, Changchun, and etc. Shanghai as a representative city in terms of metro construction, is not a very good example to follow for those cities. If Shanghai government doesn’t improve management on metro system and let accidents happen, those cities will probably do the same thing. Especially in many minor cities where monitoring and regulations are not strict enough and local municipalities with a have higher extent of bureaucracy, the future for them is worrying with no doubt. So for these cities, there is still a very long way to go.
Not only Shanghai is thirsty of qualified personnel, minor cities are desperately in need of such talents as well. Second and third tier cities which just started their metro projects don’t have talent pool for metro industry; those talents with specific knowledge on metro management and technology are mainly gathering in major cities like Beijing and Shanghai. As said before, professional education on metro is almost provided in big cities. Minor cities have limited training and education resources. Though minor cities are eagerly attracting talents, big cities are making efforts to prevent talents outflow. At present and in the near future, fighting for metro talents will be continued.

For these cities, the priority is to have a clear self positioning in metro development. If applying development mode of big cities mechanically, tragedy will happen. These cities should also learn from lessons of Shanghai to fumble out their own way of metro development.

### 7.3. Theoretical Conclusions

In Chapter 2 Rasmussen’s theory is illustrated from its conceptual development, hierarchical organizational structure and dynamic immigration of safety boundaries. Also how the theory is applied in previous study is demonstrated. Generally speaking, the theory matches well in all the cases in question (Beijing, Hangzhou, Dalian and Shanghai Line 1 and Line 10) besides some slight differences in some cases. All cases have successfully interpreted a multi-layered socio-technical system into their own organizational structure where at each level different values are traded off for each other under various environmental stressors. The top-down hierarchical model described by Rasmussen which is formed by six levels (government, regulators, company, management, staff and work) can be reflected in the four cities. However the first difference is in the case of Line 1 of Shanghai. Because Line 1 is developed much earlier than the other cases, its organizational structure at “company” level is not entirely independent: Shanghai government is doing financing for it instead of it is doing on its own. Also at that time, relevant safety regulations are not established yet so the socio-technical model cannot be fully applied to Line 1. But the “future version” of Line 1’s organizational structure, which is Line 10’s structure, is well fitted for such system as Shentong Metro is comparatively independent from Shanghai government with well defined functional departments and subsidiary companies. The second difference from Rasmussen’s theory to all cases is the environmental stressors of public opinion. In the model public opinion is directly acting on the government, but in reality this is not true in all cases. Though in Line 1 we see social intellectuals driving local government to change the original route plan, this is still not amounting to anything. In law, how public could express their thoughts and how their suggestions could be accepted are just specifically written in detail. Even if they are written in the procedures of environmental impact assessment, the party who implemented is from the company itself (Line 10 is just an example). So Rasmussen’s social-technical map still has some flaws to be fully applied to Chinese context.

Another important part of Rasmussen’s theory is dynamic safety model where three boundaries are introduced to model how accidents are formed in the construction process: economical failure boundary, acceptable performance boundary and unacceptable workload boundary. It is easy to relate economic failure boundary to the value of budget, and acceptable performance
boundary to the value of project quality. But it is a little difficult to relate unacceptable workload boundary to the value of time and scope, as I was making my analysis mostly based on the four core values. Unacceptable workload may refer to many things: the quality of personnel (quality), excessive working time (time) to save budget (budget). So I don’t know how this boundary is translated: in previous study I don’t see it very clearly (maybe it is overlapping of too many things). But the shift of economic failure boundary is clearly interpreted as a decreasing budget for a quality loss. So frankly speaking in general, the dynamic safety model depicts a vivid picture of how accidents are formed under different influences but should have a closer connection with the four values or explain more on that to make readers clear.

To conclude, Rasmussen provides an interesting and useful angle for both previous researchers and me to look at metro accidents in China. His model generally fits all cases except some minor parts mostly due to China’s unique institutional context and immature organizational structure of Line 1. The two cases I studied are similar to previous cases; while Line 10 resembles Beijing case (they share same environmental stressors as important events and government pressure) and Line 1 resembles Dalian case (government pressure and push of Spring Festival as environmental stressors). But in terms of dynamic safety model, it is too metaphorical as one of the boundaries is hard to interpret into simple terms. Though with some disadvantages, Rasmussen’s theory still can be regarded as useful to reference.

7.4. Reflection on Research Method

In my research, the method I applied is replicative study in which example researches are observed under the same Rasmussen theoretical background. As already mentioned in Chapter 1.5, the way I collect data is mainly Internet search, university data base in China and TUDelft, Chinese newspapers and information from my relatives and friends. However difficulties and obstacles exist in this process, which limit my research result.

The main limitation is the insufficiency of my information source. I was planning to interview people working in metro industry in Shanghai, both workers and decision makers. First it turns out that it was not easy to get access to workers in metro construction as I was in Europe which made face to face interview impossible. Within my resource, I managed to get in touch with one of my distant relative who used to work in Shentong Metro at Department of Rail Transit Operation Management Center and was now retired. We communicated through online chat and emails. He gives me detailed information about organizational structure of Shentong Metro (as illustrated in Chapter 2), official reports of the two accidents, an article about lessons learnt from Line 10 accident published within Shentong Metro, and an introduction on emergency response system applied in Shanghai metro system. From his information I was able to structure the three hierarchical levels within Shentong Metro, matching Rasmussen’s theory. Also official reports and lesson learnt provide me with a perspective to look at the case from company angle. However he fails to provide me more detailed information on how monitoring is done and decision making is carried out in the construction process of the two lines just because he couldn’t. He explained it as bureaucratic settings in the company makes decision making opaque and various departments know very little about what the others are doing. This made me think about Rasmussen’s model
of socio-technical map. In a hierarchical system, every stakeholder knows who the big boss is, but doesn’t necessarily know what others in the same level are doing.

I also interviewed two of my friends who have been living in Shanghai for a long time. I asked them how they think about Shanghai metro. They are generally satisfied with the metro but express a certain extent of concern on the frequent accident rate in the last five years, and how government acts after each accident. They both think government is more profit-driven than environment protecting in developing more lines. I consider their opinions very useful when I analyze public participation in the project. It is noticeable that public is merely involved in the decision making process, which may cause misunderstanding between local government and public. A sound system of information sharing is in need for the present and future. Apart from getting information from real people, I did a lot of online search and literature reading which contribute to the most data base of my research. In this way I get access to articles written by both Chinese and western journalists or reporters on these cases, editorials by experts and scholars, etc. In this way I was able to look at the problem from various perspectives.

Reflecting on my research method which is concluded above, some comments could be made. The insufficiency of resource could be improved if I had chance to go to Shanghai and conduct an onsite interview and if more inside information was obtained. Also a questionnaire for local people will add to my research. However, even if I was in China, these improvements would not be easy as far as I could imagine. An opportunity to go to construction site and get the real information is difficult as constitutional barriers exist: Whether workers will tell the true story is unknown. So collecting facts and causes is always a hard job. Looking at Netherlands, an independent transport safety committee is established to help investigate accidents with almost 100% transparency in information sharing. Dutch government doesn’t have the right to interfere in the investigating process and all parties should put their information into sunlight to help the committee in any stage of investigation.

At last, I have many thoughts after this significant research. Though still many problems exist, I have to say that it is a valuable experience for me to look at the how construction projects (especially metro projects) are carried out in China, from a project manager’s perspective. I not only have gained deeper understanding for various processes in the project, but also realized institutional background and cultural characteristics are key deciding elements in a project. In China the government is the king, so many problems boom out because of this. Also I came to know a country’s “software ability” should match its “hardware ability”, which software means management and hardware means technology. I sincerely hope one day China’s metro development level can be on the top of the world’s best.
# APPENDIX

## Appendix 1: Metro accidents in major cities around the world in the last 15 years

<table>
<thead>
<tr>
<th>CITY</th>
<th>ACCIDENT TYPE</th>
<th>DATE</th>
<th>CONSEQUENCE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Singapore</strong></td>
<td>Road surface collapse</td>
<td>20/4/2004</td>
<td>4 dead and 3 injured. Project delayed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electricity failure</td>
<td>15/12/2011</td>
<td>No one injured. 127 thousand people affected; traffic paralyzed for 5 hours; the biggest accident in 24 years</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Technical failure</td>
<td>17/12/2011</td>
<td>No one injured. Traffic affected for 7 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Concrete slab fall</td>
<td>11/3/2012</td>
<td>1 dead. first casualty in Downtown Line construction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cement roof collapse</td>
<td>18/7/2012</td>
<td>2 dead and 8 injured</td>
<td></td>
</tr>
<tr>
<td><strong>London</strong></td>
<td>Derailment and fire</td>
<td>25/1/2003</td>
<td>32 injured; line closed for 3 months</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Electricity failure</td>
<td>8/28/2003</td>
<td>250 thousand passengers trapped</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Derailment of broken rail</td>
<td>17/10/2003</td>
<td>No one injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Derailment of poor design</td>
<td>19/10/2003</td>
<td>7 injured.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Derailment of design and operating faults</td>
<td>11/5/2004</td>
<td>No one injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Derailment of negligence of workers</td>
<td>5/7/2007</td>
<td>No one dead and 21 injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Runaway maintenance locomotive</td>
<td>13/8/2010</td>
<td>No one dead or injured</td>
<td></td>
</tr>
<tr>
<td><strong>NYC</strong></td>
<td>Derailment</td>
<td>20/6/2000</td>
<td>89 injured</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Fire</td>
<td>16/8/2006</td>
<td>15 injured and 4000 evacuated</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collision</td>
<td>24/4/2007</td>
<td>1 dead</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collision</td>
<td>29/4/2007</td>
<td>1 dead 1 injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Derailment</td>
<td>5/4/2008</td>
<td>No one dead or injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Derailment</td>
<td>13/2/2009</td>
<td>No one dead or injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Landslide</td>
<td>3/4/2012</td>
<td>1 dead 4 injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unknown</td>
<td>20/2/2013</td>
<td>1 worker trapped in the concrete</td>
<td></td>
</tr>
<tr>
<td><strong>Washington</strong></td>
<td>Collision</td>
<td>3/11/2004</td>
<td>20 injured</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Collision</td>
<td>22/6/2009</td>
<td>9 dead and more than 70 injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collision</td>
<td>29/11/2009</td>
<td>2 injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Derailment</td>
<td>7 times</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HK</strong></td>
<td>Derailment 5 times</td>
<td>1995-2007</td>
<td>No one dead or injured</td>
<td>Around</td>
</tr>
<tr>
<td></td>
<td>Several cases</td>
<td>1/2004</td>
<td>Unknown</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Electricity failure</td>
<td>3/5/2012</td>
<td>About 1000 passengers affected</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Electricity failure</td>
<td>23/7/2012</td>
<td>About 1000 passengers affected</td>
<td></td>
</tr>
<tr>
<td><strong>New Delhi</strong></td>
<td>Concrete block fell because of technical failure</td>
<td>28/8/2007</td>
<td>1 dead</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Water tank collapsed</td>
<td>21/1/2008</td>
<td>1 dead</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crane dropped</td>
<td>18/7/2008</td>
<td>2 injured</td>
<td></td>
</tr>
</tbody>
</table>
## Appendix 2: Metro accidents in major cities in China from 2007 to 2013

<table>
<thead>
<tr>
<th>CITY</th>
<th>ACCIDENT TYPE</th>
<th>DATE</th>
<th>CONSEQUENCE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beijing</td>
<td>Collapse</td>
<td>3/29/2007</td>
<td>6 person killed</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Machine falling</td>
<td>7/21/2009</td>
<td>5 workers severely injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Support system falling</td>
<td>7/14/2010</td>
<td>2 person killed, 8 severely injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical fault</td>
<td>4/26/2011</td>
<td>1 person killed, 2 severely injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collapse</td>
<td>6/01/2011</td>
<td>1 person killed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Machine falling</td>
<td>2/23/2012</td>
<td>Nearby traffic interrupted for 8 hours</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collapse</td>
<td>3/26/2012</td>
<td>1 person killed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collapse</td>
<td>5/22/2012</td>
<td>1 person killed</td>
<td></td>
</tr>
<tr>
<td>Dalian</td>
<td>Collapse</td>
<td>2011</td>
<td>3 person killed</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Machine falling</td>
<td>4/01/2008</td>
<td>3 person killed, 2 severely injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fire</td>
<td>3/09/2009</td>
<td>10 households evacuated, over 330 households negatively affected</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Gas poisoning</td>
<td>7/06/2009</td>
<td>2 person killed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collapse</td>
<td>7/19/2009</td>
<td>1 person killed, 1 injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collapse</td>
<td>9/04/2009</td>
<td>1 person killed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collapse</td>
<td>10/13/2009</td>
<td>1 person killed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collapse</td>
<td>10/26/2009</td>
<td>1 person killed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical fault</td>
<td>2/09/2010</td>
<td>2 person killed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mechanical fault</td>
<td>4/04/2011</td>
<td>1 person killed, 2 injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas poisoning</td>
<td>5/09/2011</td>
<td>2 person killed, 4 injured</td>
<td></td>
</tr>
<tr>
<td>Xi’an</td>
<td>Fire</td>
<td>5/26/2009</td>
<td>1 person severely injured</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Collapse</td>
<td>8/02/2009</td>
<td>2 person killed</td>
<td></td>
</tr>
<tr>
<td>Nanjing</td>
<td>Collapse</td>
<td>2/5/2007</td>
<td>Over 5000 households evacuated; one building nearby damaged by explosion</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Landslide</td>
<td>5/28/2007</td>
<td>1 person seriously injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collapse</td>
<td>5/27/2009</td>
<td>A power distribution substation destroyed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Collapse</td>
<td>8/8/2012</td>
<td>No person injured or killed</td>
<td></td>
</tr>
<tr>
<td>Hangzhou</td>
<td>Collapse</td>
<td>11/15/2008</td>
<td>21 person killed, 19 injured</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Landslide</td>
<td>11/25/2010</td>
<td>1 person killed, 1 severely injured</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Landslide</td>
<td>12/06/2012</td>
<td>1 person killed</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix 3: The winning bid (contractors) of Shanghai metro Line 10 (civil construction)

<table>
<thead>
<tr>
<th>Section No.</th>
<th>Bidding Winner</th>
<th>Price (million yuan)</th>
<th>Starting Date</th>
<th>Construction Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shanghai Construction Group (SCG) General Co.</td>
<td>517.38</td>
<td>2005-12-20</td>
<td>757</td>
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<tr>
<td>2</td>
<td>Shanghai Urban Construction Group Co.</td>
<td>368.45</td>
<td>2005-12-28</td>
<td>558</td>
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<td>3</td>
<td>Shanghai Construction Group (SCG) General Co.</td>
<td>331.20</td>
<td>2006-2-28</td>
<td>1146</td>
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<tr>
<td>4</td>
<td>Tengda Construction Group Co. Ltd</td>
<td>235.9</td>
<td>2006-8-8</td>
<td>699</td>
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<td>5</td>
<td>Hongrun Construction Group Co. Ltd</td>
<td>309.89</td>
<td>2006-7-20</td>
<td>680</td>
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<td>6</td>
<td>Shanghai Urban Construction Group Co.</td>
<td>662.28</td>
<td>2006-7-20</td>
<td>778</td>
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<td>7</td>
<td>Shanghai Construction Group (SCG) General Co.</td>
<td>588.21</td>
<td>2006-7-20</td>
<td>806</td>
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<td>8</td>
<td>Shanghai Urban Construction Group Co.</td>
<td>58.20</td>
<td>2006-10-1</td>
<td>541</td>
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<td>9</td>
<td>Shanghai Urban Construction Group Co.</td>
<td>635.88</td>
<td>2006-8-10</td>
<td>831</td>
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<tr>
<td>10</td>
<td>Hongrun Construction Group Co. Ltd</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Hongrun Construction Group Co. Ltd</td>
<td></td>
<td>2006-7-1</td>
<td>678</td>
</tr>
</tbody>
</table>
BIBLIOGRAPHY

For books:
Hans de Bruijn. (2007) Law Enforcement: The Game Between Inspectors and Inspectees

For journals:
Huang, Q. (2012). Begging CASCO.

For journals:
Huang, Q. (2012). Begging CASCO.

Websites: