How Front End Factors Affect Project Outcomes: A Look at Four Infrastructure Projects in Asia

Suzenne Margareth Tee Tang

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Abstract

In the development of infrastructure projects, current trends are for increased private financing for the delivery of infrastructure projects especially in Asia. This trend is indicated by a gradual shift from the government to the private sector for financing, building, managing, and sometimes, owning infrastructure. The research described in this thesis focused on the impacts on project goals because of the shift in responsibilities. The study uses four current infrastructure projects in Asia, specifically in Taiwan, Philippines, Thailand, and Lao PDR, to focus on the effects of early decisions to the end results of the construction phase. In the course of the study, the researcher identifies developmental or front-end factors, particularly the contractual agreement between host government and sponsor, construction delivery method, planning activities, and monitoring systems, and establishes their link to quality control, cost control, schedule control, and selection of construction means and methods. Through extensive analysis of the available information regarding the four projects studied, the researcher was able to identify the actual contribution of front-end factors to determining the outcome of project goals. These are presented as conclusions to the thesis; and at the end of the thesis, the researcher provides some recommendations to project proponents on how to improve future infrastructure projects.
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<tr>
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<td>BOHSR</td>
<td>Bureau of High Speed Rail</td>
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<td>BOT</td>
<td>Build-Operate-Transfer</td>
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<td>BOOT</td>
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<td>Circumferential Road 5</td>
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<td>Construction Notice to Proceed</td>
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<td>DB</td>
<td>Design-Build</td>
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<td>DED</td>
<td>Detailed Engineering Design</td>
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<td>JV</td>
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<td>Lao Holding State Enterprise</td>
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<td>MLR</td>
<td>Minimum Loan Rate</td>
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<td>Acronym</td>
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<tr>
<td>MNTC</td>
<td>Manila North Tollways Corporation</td>
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<td>MOTC</td>
<td>Ministry of Transportation and Communication</td>
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<td>MSS</td>
<td>Movable Scaffolding Method</td>
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<td>Montgomery Watson Harza</td>
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<td>NATM</td>
<td>New Austrian Tunnel Method</td>
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<td>NCR</td>
<td>Non-Conformance Reports</td>
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<td>Non-Government Organizations</td>
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<td>NLE</td>
<td>North Luzon Expressway</td>
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<td>NPA</td>
<td>Nationally Protected Area</td>
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<td>Nam Theun Electricity Company</td>
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<td>Nam Theun 2</td>
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<td>O&amp;M</td>
<td>Operations and Maintenance</td>
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<td>OR</td>
<td>Owner’s Requirements</td>
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<tr>
<td>PB</td>
<td>Parsons Brinckerhoff</td>
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<td>PBAC</td>
<td>Prequalification and Bidding Awards Committee</td>
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<td>Pre-Construction Agreement</td>
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<td>PDR</td>
<td>People’s Democratic Republic</td>
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<td>PEWC</td>
<td>Pacific Electric Wire and Cable Co., Ltd.</td>
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<td>PNCC</td>
<td>Philippine National Construction Corporation</td>
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<td>POE</td>
<td>Panel of Experts</td>
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<td>PPA</td>
<td>Power Purchase Agreement</td>
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<td>PPP</td>
<td>Public Private Partnership</td>
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<td>PSM</td>
<td>Pre-Cast Span Method</td>
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<td>QA/QC</td>
<td>Quality Assurance / Quality Control</td>
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<td>RAMS</td>
<td>Reliability, Accessibility, Maintainability Study</td>
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<tr>
<td>RCC</td>
<td>Roller Compacted Concrete</td>
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<tr>
<td>RE</td>
<td>Resident Engineer</td>
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<td>RFI</td>
<td>Request for Information</td>
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<td>RFQ</td>
<td>Request for Qualifications</td>
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<td>ROT</td>
<td>Rehabilitate-Operate-Transfer</td>
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<td>ROW</td>
<td>Right-of-Way</td>
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<td>SES</td>
<td>Sequential Excavation and Support Method</td>
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<td>SEZ</td>
<td>Special Economic Zone</td>
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<td>SMEC</td>
<td>Snowy Mountain Engineering Corporation</td>
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<td>SOBR</td>
<td>Southern Outer Bangkok Ring Road</td>
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<td>SONO</td>
<td>Statement of No Objection</td>
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<td>Unexploded Ordinance</td>
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<td>Variation Order</td>
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<td>VP</td>
<td>Vice President</td>
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CHAPTER 1
INTRODUCTION

Infrastructure projects are continuously under development everywhere in the world; however, since the 1990s, much of this development has been approached in a new way. Infrastructure projects are no longer solely government-procured. The new approach calls for more and more private involvement in the development of infrastructure projects. Prior investigations of this trend have identified new roles of project participants, new interests in infrastructure projects, and the formal process of infrastructure development. What these studies fail to point out is how these changes or additions in infrastructure development impact the actual projects developed. This thesis argues that these changes in the development process, especially its critical components greatly influence project results.

The main goal of the chapter is to help the reader understand the researcher’s motivation for conducting this research and to give an overview of what to anticipate in the succeeding chapters. This chapter introduces the thesis through the Executive Summary which highlights the major areas of interest and key findings from this research. The research agenda follows which describes the researcher’s methods for gathering, reducing, and analyzing the data and finally drawing and verifying the conclusions of this thesis. The last section is the Reader’s Guide to assist the readers find the sections in the thesis of particular interests to them.

Executive Summary

Because of the important contribution of infrastructure to economic growth, further development of this key resource continues especially in growing countries. Infrastructure possesses underlying factors which support economic growth thus spurring the continuous need for new infrastructure projects. But with this continuing demand for infrastructure, the development efforts of governments are becoming insufficient. Infrastructure development has become a new market for entrepreneurs.
This increased involvement of the private sector has changed the characteristics of infrastructure projects. These changes affect the implementation of the project and eventually its outcome. By analyzing the development processes and results of four infrastructure projects in Asia, the researcher identified the critical factors of development, called front-end factors, which directly affect project costs, quality, and schedule. The results of the analysis provide the foundation for developing the conclusions of this research and support the recommendations for future project developers.

**Infrastructure and Economic Growth**

Infrastructure is an important factor in the development of a country through its direct and indirect contributions to economic growth. However, the quality and efficiency of the infrastructure is more important in promoting economic growth. World Bank-initiated studies as well as some research by US Federal agencies support the connection among infrastructure, productivity, and quality of life. Kessides, from the World Bank, and Aschauer and Eberts, researchers for the US Federal Highway Administration, independently noted the following three factors of infrastructure which fosters economic growth:

- Infrastructure directly or indirectly reduces costs in the production process.
- Infrastructure induces structural change which influences production and consumption trends.
- Infrastructure contributes to sources of income and better income levels.

Because of infrastructure’s important contribution to economic growth, countries continue to invest to increase the effectiveness of their infrastructure in meeting the demands of the nation. However, to do so, developing infrastructure projects has shifted away from a government responsibility because of its inability to fulfill the demands for efficient infrastructure and slowly moved toward the private sector in the past decade. Besides designing, constructing, and providing consulting services to infrastructure projects, the private sector’s influence now reaches the financing and developing of current infrastructure. The researcher believes that a connection exists between these revised development approaches and the results of infrastructure
projects and argues that increased involvement of the private sector changes project goals and the development process.

**Characteristics of International Infrastructure Projects**

Some of the background material describing the complexities of studied projects includes identification of: different project participants in current infrastructure projects and their interests; inherent risks in infrastructure development necessitating complex risk allocation in contractual agreements; and various contractual agreements called Private Public Partnerships (PPP) to foster private sector involvement in the development process.

Because of the changing nature of infrastructure development, some of the major development roles have opened up to the private sector. The major participants in most infrastructure projects are: Private Sponsor, Project Vehicle, Lenders, Host Government, Public Sector, and Construction Contractors. As part of the changes in development roles, the government distributes the risks which it previously shouldered to the different project participants. These risks are the completion risk, the credit risk, the marketing and operating risk, the financial risk, the political risk, the legal risk, the environmental risk, and the social risk. Of the mentioned risks, the completion risk is the major risk passed on by the Government to the Private Sponsor embodied in the PPP. There are several variations of the PPP with two more commonly used: Build-Operate-Transfer and Build-Own-Operate. The different participants, risks, and forms of agreements will be fully explored in Chapter 2.

The researcher discovered that with increased involvement of the private sector in infrastructure development, the process itself has become more formalized and transparent in the industry. This process is divided into three development phases: Project Origin, Negotiation, and Implementation. Under each phase, critical activities must be completed for the successful development of a project. Chapter 2 also details the project development process and its major components.

With this as background information, the researcher developed a framework for investigating four major infrastructure projects in Asia that used different financing schemes and private sector involvement. These projects were the Taiwan High Speed
Rail (THSR) Project, the North Luzon Expressway (NLE) Project in the Philippines, the Southern Outer Bangkok Ring Road Chao Phraya River Bridge (SOBRR) Project in Thailand, and the Nam Theun 2 Hydropower (NT2) Project in Lao PDR.

This thesis reports findings regarding the effect of the development process on the implementation side of these four projects. The researcher conducted numerous interviews with key personnel from various groups in each of the four projects visited. Through recounting events, situations, and decisions made in the projects, the researcher pieced together the development timeline of each project and eventually identified seven developmental or front-end factors which critically shape project outcomes.

**Front-End Factors and Project Outcomes**

Common to the four studied projects were seven factors based on their individual development processes which affected the project end results or project outcomes. These factors are identified as: Ownership Form, Project Delivery Method, Terms of Reference, Contractor Selection, ROW Acquisition, Project Quality Management System, and Financial Arrangement. The affected project outcomes are Cost Control, Schedule Control, Quality Control, and Selection of Construction Means and Methods. Some examples of major impacts of front-end factors on the outcomes of different projects are:

**Ownership Form**

The privately-led projects, the NLE and NT2 Projects, exhibited greater cost control because of the limited source of funding.

**Project Delivery Method**

The design-build approach worked well for the NT2 Project’s quality control because of the EDF’s primary involvement as the developer and a contractor as a secondary role. However, the design-build approach negatively affected the NLE Project’s quality control because Leighton was primarily a contractor and then a developer.
Terms of Reference

The lack of preliminary studies for the NLE Project negatively affected its quality control. The other three projects with extensive studies did not experience as much negative impact and were able to anticipate and mitigate some of the quality issues.

Contractor Selection

The THSR and SOBRR Projects experienced more successful quality control over the projects because of extensive contractor evaluation compared to the NLE and NT2 Projects which only pre-qualified contractors.

ROW Acquisition

ROW acquisition was positive for both cost control and schedule control of the THSR Project because of its early acquisition in the development. As for the other three projects, each experienced negative impacts on cost control, schedule control, or quality control because acquisition was concurrent with other project phases, i.e., design or construction.

Project Quality Management System

The THSR and NLE Projects relied greatly on self-certification which negatively impacted quality control.

Financial Arrangement

Having liquidated damage clauses in the contracts positively affected the schedule control of all the projects.

Each factor individually affected the four outcomes of the project, but the outcome was the result of the aggregated impacts of the factors. In determining the construction means and methods for the project, Terms of Reference, Contractor Selection, and Project Delivery Method (except for the SOBRR Project) affected the method selection. As for the other outcomes:
o the THSR Project exhibited both medium cost and quality controls and high schedule control;
o the NLE Project’s schedule and cost controls were high but the quality control was low;
o the SOBRR Project had high cost control, medium quality control, and low schedule control;
o finally, the all controls in the NT2 Project reached medium levels.
These results fit the actual costs, quality, and schedule results for the individual projects and validated the connection between front-end factors to project outcomes.

Conclusions
The researcher identifies seven generalizable conclusions based on extensive analysis of the development process for four distinct infrastructure projects:
o Private financing increases the priority for schedule.
o Design-build delivery increases cost control if the project remains on schedule.
o Right-of-Way may positively or negatively affect the cost, quality, and schedule of a project depending on the timing of acquisition.
o Sponsors can influence the selection of construction methods through details included in the Terms of Reference (TOR).
o Contractor self-certification is not adequate for quality control.
o Preliminary studies facilitate cost control in projects.
o A liquidated damage clause in a contract is used as schedule control.

Recommendations
To improve future international infrastructure projects, project participants should concentrate their efforts on identifying the needs of the project at the precise stages of development where there is greatest impact. The following recommendations are made for future project developers:
o Perform as many preliminary studies as possible prior to construction.
o Address technical issues during concession award and financial closure.
o Contractor experience should not preclude extensive evaluation for selection.
Design-build contracts are not the cure-all for all completion risks.
3rd Party technical consultants should be empowered to address quality issues.

Related Topics for Future Research

As this research only introduced the link between the front-end factors and project results, future investigations are needed to learn more and go deeper into the topic. The following are some areas that would benefit from future investigation:

- One BOT framework
- Factors for effective design-build
- Standardize design-build contracts
- Contractors’ Dual Role

Research Agenda

Research Goal

The research followed a process similar to that shown in Figure 1. The following section discusses identification of the research problem and the researcher’s methodology for conducting the study including steps taken to gather, reduce, and analyze data as well as drawing and verifying conclusions from the research.
Identification of the Research Problem

Learning about international infrastructure projects was the primary interest for this research. The early stage of the research looked into the beginnings, development, and implementation of international infrastructure projects with a focus on the decision-making aspects particularly regarding the construction process. After identification of the research interest, the next step was to conduct a review of written works about international projects.

While reviewing literature for this thesis, the researcher discovered that the study of international infrastructure projects comes in two distinct and discrete aspects: the technical and the financial. Publications were available related to both project aspects but only few discuss the impacts of one on the other and usually not in depth. Financial literature focuses on project financing and describes a formalized
development process flow for infrastructure projects. In contrast, technical publications, journals, and papers focus on the design, construction, and operational management of these infrastructure projects.

During the course of the review, the type of financing for these international infrastructure projects surfaced as a dominant factor in the development process. Its influence started as early as project origination but continued on to implementation. It affected not only financial decisions but also decisions about the technical requirements of these projects. As this trend became more obvious in the available literature, the researcher decided to focus on identifying categories of project development, i.e., public or quasi-private project ownership, construction delivery method, which have impact on the actual outcome of projects. Having the research focus defined, the researcher then selected the type of methodology to use.

**Methodology**

The background literature review assisted in developing the framework for the study, but there was a need to perform field research to pinpoint the development factors and determine their actual existence in infrastructure projects. The resulting characteristics of this study fit the recurring features of “naturalist” studies or qualitative research that, according to Miles and Huberman, are: capturing data from the perceptions of local actors, the researcher being the main “measurement” device, and data analysis mostly done through words (5-7). The researcher decided that qualitative approach was the most appropriate method to use. The question now turned to how structured the approach should be for undertaking the actual fieldwork. The structure depended on the amount of prior instrumentation (i.e., research questions, devices for observing and recording event) which greatly depended on whether the study would be more exploratory or confirmatory (Miles and Huberman 35).

Since available literature only hint on the existence of these development factors but do not identify them or discuss their significance to project outcomes, the study will be primarily exploratory in terms of identifying the front-end factors but confirmatory with regards to the actual existence of these factors and links to
outcomes. Therefore, the researcher decided that pre-set instrumentation would be advantageous prior to field data collection.

Data Collection

In selecting the projects for cases in this study, the researcher looked into the common factor of having private financing and involving foreign or international participation. Access to such projects was initially a main concern. Fortunately, Stanford professors were well-connected to the construction industry and contacts for the Taiwan High Speed Rail (THSR) Project and Southern Outer Bangkok Ring Road Chao Phraya River Bridge (SOBRR) Project were provided. For the North Luzon Expressway (NLE) Project and the Nam Theun 2 Hydropower (NT2) Project, the researcher had personal contacts who gave access to these sites. The researcher’s previous employer was connected to the Manila North Tollways Corporation (MNTC), the NLE project sponsor, and was able to provide contacts in the organization. As for the NT2 project, the Asian Development Bank’s (ADB) website was an adequate resource which assisted the researcher in finding the NT2 project as a candidate project. An ADB representative provided contact information to the NT2 Project and the researcher gained access to the project.

According to Pettigrew, good access to projects is important to the successful completion of a field study. After establishing contact, the researcher immediately suggested the option of visiting the project sites and setting schedules. The actual site visit was not as important as gaining access to information that could only be gathered from interviews. Since the projects were all in Asia, the researcher planned the visits such that travel from the United States would only be done once to optimize use of funds. Before embarking on the trip, the researcher gathered as much information about the candidate projects and started developing field questions.

Time was limited to a few days in each project. The prepared field questions assisted in starting the interviews. Interviewees came from the owner’s organization, designers, consultants, and sometimes, contractors. With consent, the researcher recorded interviews which were later transcribed for data analysis. Interviews were usually one-on-one and only rarely in groups. The only time the researcher conducted
a group interview was in the SOBRR project where more than five people were present during the interview. From this experience, the researcher concludes that group interviews are highly ineffective. The group dynamics affect the participants’ willingness to share more sensitive issues about the project and this diminishes the quality of gathered information.

Each interview revealed only bits and pieces of the reasons why the project reached its outcome. Rarely was the big picture of development factors affecting the project outcome brought to surface. The interviews usually covered the project activities from the time the interviewee became involved in the project to the present. This varied across informants as some were senior personnel who had been involved in the earliest development phase while others were only involved at the start of construction or the implementation phase. Consequently, the type of information gathered from each informant spanned the whole project timeline. This is important for the research as the purpose is to verify the impact of the development factors to the project outcome. The interviewing approach was similar for all four projects and the content of each interview needed transcription for further reduction and analysis.

Data Reduction

Data reduction is the invisible aspect in research presentation but plays a vital role in supporting the research conclusions. How the researcher decides to code the information, compartmentalize it into ‘families’ for cross-case comparison (Miles and Huberman 174), and process the information affect the validity of the final conclusions. As such, the researcher took extra care to preserve the gathered data. As a first step, interviews originating from one project were consolidated to form one case study report. To preserve the quality of the data, the researcher limited initial data filtering to syntax modification to make the English more comprehensible in direct quotes and classified information from interviews into observed themes or families. In addition, the researcher refrained from taking sides when contradicting statements existed in a case study and presented both viewpoints as objectively as possible in the final report. Consequently, the case study reports ended up to be very lengthy.
As seen in Figure 1, data reduction, data display, and drawing conclusions are interrelated and iterative activities. Data reduction was continuous even after the first display (case reports) was completed. These case reports are found as Appendix A to D of this thesis. The second iteration for data reduction resulted in the identification of the common themes present in each case and comparable across cases. Each project went through a development process with the project origin, negotiation, and implementation phases. In each phase, some important components (i.e., sponsor qualifications, contract, monitoring system) were fulfilled and these were common among the projects. After sufficiently reducing data, the researcher then presented the information systematically through a visual format as presented in Table 1 from which to base the analysis and then draw conclusions (Miles and Huberman 91).

**Data Display**

The researcher chose the case study report format as the first data display to preserve the quality of gathered information. However, after learning that other researchers consider the case study format as a cumbersome form because of dispersed information, sequential rather than simultaneous format, and poorly ordered and bulky display (Miles and Huberman 91), the researcher decided to apply a more refined display that allowed viewing of the full data set systematically (Miles and Huberman 92).

The second display, called a checklist matrix, enables the researcher to explore new domains, develop ideas about the key variables, verify and compare comparability across projects (Miles and Huberman 109). Table 1 highlights the major components of the four projects at different development stages. The leftmost column identifies the different development stages as well as the important factors to be fulfilled at that stage and the top row of the table indicates the specific project. This table is a summary of the key elements in Chapter 3.
Table 1

Project Development Summary

<table>
<thead>
<tr>
<th>Project Phases</th>
<th>THSR</th>
<th>NLE</th>
<th>SOBRR</th>
<th>NT2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Origin</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Sponsor Qualifications</td>
<td>Government (BOHSR), Engineering (CEC), Financial (Fubon), Railway Development (TSC)</td>
<td>Tollway Operation (Egis, PNCC), Construction (Leighton), Development (FPIDC)</td>
<td>Project Management (DOH), Expressway Operation (ETA), Financial (Bank)</td>
<td>Government, Engineering (EDF), Development (EDF), Construction (ITD)</td>
</tr>
<tr>
<td>b) Project Financeability</td>
<td>Tripartite Agreement</td>
<td>Limited Recourse</td>
<td>Construction Loan payable by Government Budget</td>
<td>Limited Recourse with Power Purchase Agreement</td>
</tr>
<tr>
<td>c) Technical Feasibility Results</td>
<td>Feasibility studies and soil investigation, Acquired ROW pre-PPP</td>
<td>Traffic Forecast, Acquired ROW pre-implementation</td>
<td>Feasibility Studies, Acquired ROW during construction</td>
<td>GoL feasibility studies, Acquiring ROW during construction</td>
</tr>
<tr>
<td>d) Development Timeline</td>
<td>8 years Gov’t + 3 years Private (award to construction)</td>
<td>5 years Private (award to construction)</td>
<td>8 years Gov’t (feasibility to construction)</td>
<td>11 years Private (feasibility to construction)</td>
</tr>
<tr>
<td><strong>Negotiation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) EPC Contract</td>
<td>Civil Contracts (Design-Build), Sponsor assumes overall completion risk</td>
<td>Full turnkey</td>
<td>Design Contract, Construction Contract</td>
<td>Full Turnkey</td>
</tr>
<tr>
<td>c) Contractor Selection</td>
<td>Pre-qualify, Technical, Legal, and Financial Evaluation</td>
<td>Pre-qualify</td>
<td>Pre-qualify (loan), Technical and Financial Evaluation</td>
<td></td>
</tr>
</tbody>
</table>
Table 1 is the basis for determining the front-end factors discussed in detail in Chapter 4. Some of the identified front-end factors are already mentioned in this table such as the Terms of Reference, EPC Contract, and Contractor Selection. The project outcomes are based on the three common construction goals of cost, schedule, and quality as well as selection of construction methods. As further data analysis, the case-ordered predictor-outcome matrix which is primarily explanatory in nature is used to link the front-end factors to the outcomes. Predictor-outcome matrices array cases on the main outcome variables and provide data for each case which are the most important contributors to the outcome (Miles and Huberman 213). This research reveals that each outcome is either positively or negatively affected by the individual factors. A plus (+) or minus (-) sign indicates a positive or negative effect. Each effect is supported by events, decisions, or activities in the project. A plus sign is assigned when the factor helps the project in achieving its goals in terms of cost, quality, or schedule while a minus sign is assigned when the factor inhibits the project from achieving goals. To arrive at the aggregated effect of the factors on the outcomes, the researcher tallied the number of pluses and minuses to indicate levels reached. Zero to one minus sign per outcome means High, two to three minus signs indicate Medium, and four or more minus signs means Low. To validate the results of the analysis, these are compared to the actual outcomes of the project. As each predicted outcome corresponds to the actual result of the project, the researcher’s analysis becomes more valid.

**Conclusion Drawing and Verification**

The researcher analyzed data through iterative reduction and display and gathered preliminary findings through case comparisons. The multi-case approach is apt for this research to increase the generalizability of the conclusions and to observe processes and outcomes from different cases (Miles and Huberman 172). Also, the researcher’s use of pre-instrumentation (preliminary questions) is complementary to the purpose of having multiple cases as it not only emphasizes generalizability but also internal validity of findings (Miles and Huberman 36).
The researcher used the results of the analysis as groundwork for developing general findings about the current effects of development factors on project outcomes. The actual project outcomes are able to validate the results of the analysis and these are useful for drawing conclusions from the research. Some of the conclusions are compared and contrasted with information provided in current literature to determine if the findings are in agreement. Moreover, the researcher used some interesting observations and insights to develop the recommendations that proponents of future privately financed infrastructure projects may potentially integrate into their development plans. Finally, as this research is more exploratory than confirmatory, potential topics for future research are identified.

**Reader’s Guide**

The succeeding sections of this thesis are divided into three chapters and four appendices. This is to provide convenience to the readers in accessing only sections of interest to them. The contents of the remaining sections are as follows:

**Chapter 2: International Infrastructure Projects**

Chapter 2 covers the background literature about infrastructure mainly its importance to economic growth, its current characteristics, and the existing trend for infrastructure development in current times. The main point of the chapter is in identifying the paradigm shift in the development process due to private financing of infrastructure projects.

**Chapter 3: Cases of Privately Financed Projects**

Chapter 3 describes the individual development processes for four privately financed infrastructure projects in Asia with focus on identifying the similarities and differences. The four projects are summarized according to the different major categories in the development process used as a starting point for analyzing the effects of developmental factors on project outcomes in Chapter 4.
Chapter 4: Analysis, Conclusions, and Recommendations

Finally, Chapter 4 discusses the emerging factors from the development process as well as project outcomes and highlights the possible correlations. This chapter covers the analysis section and the conclusions and recommendations portion of the thesis. In the analysis, each factor is presented as having a positive, negative, or no effect to the different outcomes. In addition, the analysis identifies the link between these factors and the selection of construction means and methods. The results from each project are then tabulated and contrasted across projects. As results from the analysis are presented, the researcher compares and verifies them to each project’s actual outcome. The chapter also highlights the general findings of the research and develops conclusions about the current impacts of infrastructure development on project completion. The researcher also makes some recommendations to future project sponsors on how to influence or shape the development process such that its impacts on the project outcomes may be positively controlled. At the end of the chapter, some possible areas for future research revealed during the course of this research are presented.

Appendix A through D

The appendices are the consolidated version of interviews from the four projects – THSR Project, NLE Project, SOBRR Project, NT2 Project – formatted according to key topics (Ownership Form, Project Delivery Method, Preliminary Studies, Project Monitoring Systems, Construction Means and Methods) discussed during the interview sessions. Each case study is a more detailed recounting of the information summarized in Chapter 3.
CHAPTER 2
INTERNATIONAL INFRASTRUCTURE PROJECTS (IIP)

This chapter will cover the available literature about IIP and will highlight how this research would fit in the current body of knowledge. Through the review of the existing literature, the researcher’s intent was to learn how much of the trend for changes in the process of developing infrastructure projects, occurring over the last decade, has been captured in written works. This provided a basic understanding of infrastructure projects to prepare for the field work ahead.

Infrastructure is initially defined and then followed by the sections discussing infrastructure’s contribution to economic growth, emerging characteristics of current infrastructure projects, project participants and their interests, current contractual relationships in infrastructure development, and the current and desirable path to infrastructure development.

Definition of Infrastructure

This study will be limited to projects characterized by the subsequent definitions of infrastructure. According to Stone:

Infrastructure is closely related to public works, which has been defined by the American Public Works Association (APWA) as physical structures and facilities that are developed or acquired by the public agencies to house governmental functions and provide, water, power, waste disposal, transportation, and similar services to facilitate the achievement of common social and economic objectives. (Qtd. in Hudson, Haas, and Uddin 7)

Moreover, the Associated General Contractors of America (AGCA) defines infrastructure as:

A nation’s system of public facilities, both publicly and privately funded, which provide for the delivery of essential services and a sustained standard of living. This interdependent, yet self-contained, set of structures provides for mobility, shelter, services, and utilities. It is the nation’s highways, bridges, railroads, and mass transit systems. It is the sewers, sewage treatment plants,
water supply systems, and reservoirs. It is the dams, locks, waterways, and ports. It is the court houses, jails, fire houses, police stations, schools, post offices, and government buildings. Infrastructure is the base upon which society rests. (Qtd in. Hudson, Haas, and Uddin 8)

In the book Infrastructure Management, Hudson, Haas, and Uddin further categorized infrastructure into specific facility assets described as (12-15):

- Transportation including ground, air, waterways and ports, intermodal facilities (rail/airport and truck/rail/port terminals), mass transit
- Water and waste water such as water supply, water structures, agricultural water distribution, sewer
- Solid, hazardous, and nuclear waste management
- Energy production and distribution including power production and distribution, gas pipeline, petroleum/oil production and distribution, nuclear power stations
- Communication networks such as telecommunication, television/cable, wireless/satellite, information highway

The abovementioned scope of infrastructure suggests its great potential in affecting peoples’ lives. In fact, the World Bank has taken the active role of studying the infrastructure and its significant contribution to current times. From the World Bank’s extensive database of studies, the researcher found Kessides’ work, The Contributions of Infrastructure to Economic Development. It details how infrastructure contributes to economic growth particularly in uplifting the quality of life. She utilized various studies conducted by Canning, Fay, Lakshamanan, Elhance, and Fox to support her view that infrastructure plays a major role in the economic development of a country. Furthermore, the Federal Highway Administration (FHWA) of the United States conducted numerous studies to “develop a better understanding of the linkage between investment in highways and bridges and the Nation’s capacity to sustain economic performance and growth” (Batten and Karlsson 50). Binder and Smith explain the FHWA’s three research approaches: macroeconometrics, microeconomic industry analysis, and highway system assessment, in “The Linkage between Transportation Infrastructure Investment and Productivity: A U.S. Federal Research Perspective.” Munnell, Aschauer, and Eberts’ works, all under the
macroeconometrics category of the FHWA studies, as well as Kessides’ work will be cited in the following section to emphasize why countries need to continue investing in infrastructure.

**Infrastructure and Economic Growth**

According to Evans, earlier theories in urban development describe infrastructure as promoting growth through the building of “new towns” and “growth poles” (Kessides 12). This urban development concept is manifested by the building of great bridges especially in the developed countries in the world. Through infrastructure, society distributes resources and essential services to the public. Roads and bridges, such as the Humber Bridge connecting Yorkshire to Lincolnshire in the United Kingdom, the Akashi Kaikyo or Pearl Bridge in Japan, and the soon-to-be completed Messina Bridge connecting the mainland to the island of Sicily in Italy, can foster economic activity in slowly progressing areas by connecting them to already economically progressive regions.

Infrastructure’s actual contribution to economic development is through improvement in the quality of life (Kessides 7) and its positive effects on private sector output and productivity (United States Senate 13). Batten and Karlsson conclude that recent studies relating infrastructure and national output show that the “durable and efficient system of infrastructure seems to be a good thing for an economy” (11). Kessides, in her study of developing countries, emphasizes that the real contribution of infrastructure to economic growth is measured by the amount of improvement on the quality of life (7). When infrastructure can provide the needed service, the impact is felt on the quality of life, the well-being of the social system, and the continual growth of economic and business activity. As for infrastructure positively affecting productivity, Munnell, during her presentation to the United States Senate, stated that public capital positively affects the private sector in terms of output, investment, and employment growth (United States Senate 36). Munnell claims that both Aschauer and her findings were consistent and related the positive and statistical significance of public capital to private economic activity (United States Senate 37).
However, economic growth requires not only the existence of infrastructure but also, more critically, the quality and efficiency of the existing infrastructure. Mere presence of infrastructure is not relevant if the availability or accessibility of services to users is impeded due to congestion or severe deterioration. Kessides confirms that the “marginal productivity of private capital is affected not only by the availability of the infrastructure but also by the type of service which can be derived from it” (5). Munnell adds that a highway in poor condition reduces productivity by hastening depreciation of equipment and incurring more costs to compensate the driver (United States Senate 35).

Other factors of infrastructure contribute to economic growth such as its ability to influence production costs, promote productivity, and attract private investments. Kessides, Aschauer, and Eberts independently identify the following factors as important to fostering economic growth:

*First, infrastructure directly or indirectly reduces costs in the production process.*

Infrastructure has the ability to affect costs of the production process not only by its presence but also by the existing services it provides. As a direct input in production, infrastructure’s presence dictates its effects on production costs. Eberts argues that without transportation services there would be no means of delivering the inputs or distributing the outputs of any production process (United States Senate 41-2). On the other hand, infrastructure through its provided services indirectly affects production costs when other inputs to production are affected. Kessides confirms that industries in India, Ghana, and Nigeria confronted with the unrealized benefit and insufficiency of efficient infrastructure services were forced to seek alternatives at higher cost and this contributed to undesirable impact on profits and levels of production (13-31). In addition, Aschauer claims that improved infrastructure “reduces or removes production bottlenecks.” He even highlights the considerable cost savings of 67 percent of the Campbell Soup Company by just-in-time delivery programs and efficiency gains from improved transportation systems (United States Senate 49).
Infrastructure also affects the firms’ access to the labor pool. Ebert points to the infrastructure’s ability to accommodate commuting patterns as the limiting factor to accessing the pool of potential employees a firm may hire (United States Senate 43). Aschauer adds that an upgraded infrastructure allows a firm to have access to a larger labor pool ensuring that a job was well-matched to the right skill (United States Senate 50).

Second, infrastructure induces structural change which influences production and consumption trends.

Infrastructure creates structural change when it affects the movement of firms and households consequently affecting the resource base of a region. According to Eberts, public infrastructure which enhances available amenities can attract more firms and households therefore prompting other resources to move into that region (United States Senate 44). As a result, new jobs can be created therefore increasing the income level and spending rates in that region. Kessides lends support with studies conducted in Bangladesh showing villages with more developed infrastructure having significantly improved situation in terms of agricultural production compared to those underdeveloped villages. In another study, Kessides shows that the improvement of transportation infrastructure in Thailand affected the consumption trend and local demand which shifted from cheap locally-produced goods to competing manufactured goods since transport costs were reduced.

Infrastructure also affects the production trend of private firms. Aschauer claims that with sufficient infrastructure a firm could adopt “flexible manufacturing” techniques which allow a firm to shift its product line while retaining the same inputs and outputs, but at the same time have the flexibility to respond to changing supply and demand (United States Senate 49). He also adds that firms could take advantage of economies of scale and efficiency gains from larger production facilities (United States Senate 50).
Finally, infrastructure contributes to sources of income and better income levels.

Infrastructure, which Kessides calls the “unpaid factor of production” (5), has an impact on labor productivity and availability of employment. A worker’s access to basic services affects how he or she can utilize time and resources. If much time is spent in going to the primary source of income, then the ability to engage in other income-generating activities is limited and has a big impact on the household’s overall welfare. Eberts also suggests that workers in urban areas who spent much time commuting in and out of their workplace may be less productive (United States Senate 43). However, his emphasis is more on citing infrastructure as a source of income during its construction wherein personal income may increase by 11% for every 10% increase in public expenditure depending on the extent of employment in projects. On the other hand, Eberts considers that infrastructure has greater effect on income levels as a factor of production than a construction activity (United States Senate 45).

Although Kessides’ work was focused on the effects of infrastructure on economies of developing countries and Aschaur and Eberts’ works were based on the US economy, the factors identified were similar across countries. This suggests that generally as people look for a higher standard of living and expect more from public services, the demand for efficient and quality infrastructure increases. Therefore, continued investments have to be made in infrastructure so that provided services bring about economic benefits to the end users and the allocation of resources in a particular sector of infrastructure must be directly correlated with the effective demand for it.

In fact, the development trend of current infrastructure concurs that the demand will dictate the next project to be built. This is clearly indicated by the characteristics of international infrastructure projects including their current development process which will be discussed in the proceeding sections.
Characteristics of IIP

Countries are constantly trying to find ways to improve their infrastructure services; however, the government, especially in Asian countries, has ceased to solely provide infrastructure and, in some cases, has even gradually detached itself from both financing and structuring infrastructure project deals. Governments now face the new challenge of creating incentives and establishing institutional arrangements to attract the private sector to take the developmental roles for infrastructure delivery (“Issues” 26). Attached with these roles are the inherent risks of project development that were previously shouldered by the Government as the developer. As a consequence, new contractual arrangements are needed to motivate these private entities to take on the roles and the risks. The project participants, project risks, and contractual arrangements will be further discussed in the next sections.

Background of IIP

In the 1990s, Asian infrastructure projects began using private financing. The Government provision of infrastructure shifted to the private sector and oftentimes involved foreign entities, thus creating international infrastructure projects (IIP). For a project to be considered an IIP, it had to be large enough in scale to attract private financing and have the complexity to attract global contractors. Because of the huge amount of financing needed, these privately-financed projects are now commonly run like businesses with the goal of ‘making a profit.’

Private participation has been encouraged to make use of the private sector’s operational efficiency. Through these efforts, private investments in developing countries have increased and private entities have started assuming the financing and development role of infrastructure provision but usually in cooperation with governments through ‘off-take agreements.’ As of 1995, private financing accounted for 7% of infrastructure project finance in developing countries and this was anticipated to reach 15% by the year 2000 (“Issues” 29).

The type of projects usually targeted for private financing are: (1) projects that could be attractive to the portfolio of multilateral agencies such as the World Bank, (2)
projects that could be considered business opportunities with a cause, i.e., preservation of the environment, poverty alleviation, which are attractive to entrepreneurial entities, (3) projects that reinforce and complement sectoral reform and promote the transfer of appropriate technology which could be eligible for International Bank for Reconstruction and Development or International Development Association (IBRD/IDA) project financing ("Issues" 34), and (4) projects that have ‘limited recourse financing’ or are self-liquidating and able to recover their costs after a certain time frame and thus are attractive to private entities (Khan and Parra 3).

This change in financing structure ushered in the involvement of new project participants and shifted some of the primary goals in project delivery to address the different interests. These new participants and their interests will be discussed in the next section.

**IIP Participants and Their Interests**

As innovative structures for project financing emerge, the number of entities involved in these projects increases and each additional participant brings in new interests to be addressed. The following are the six (6) major roles in current infrastructure development (financing) and their respective interests:

*Private Sponsor*

Khan and Parra identified the Sponsor as the entity who has the project experience from in its track record for operating and maintaining facilities of the type being built or operated (7). The Sponsor is usually a party from the industrialized part of the world such as a Japanese, European, or American.

Upon award of a project to the Sponsor, it is given ownership rights and expects immediate processing of government consents and permits to build and operate the facility. A Sponsor takes on a project to have the opportunity to make returns and to diversify its investment portfolio. One major concern of the Sponsor is the ability to implement terms and conditions stipulated in contract agreements, especially easy access to modes of alternative dispute resolution if needed (Khan and Parra 12).
For privately-financed projects, a special-purpose vehicle, either incorporated or unincorporated, is licensed in the host country to implement and operate the project. The Sponsor and shareholders or joint-venture partners agree upon the conditions under which the corporation or partnership has been formed. Terms regarding rights and obligations of funding, administration, profit sharing, transfer of interests, termination, and other issues are stated in the by-laws or partnership agreement. The project vehicle is headed by the “Lead Sponsor” who usually has the largest equity share in the consortium or the head partner (Khan and Parra 7). The interests of the project vehicle reflect those of the Sponsor/s as they are almost one and the same.

**Lenders**

Multilateral and bilateral agencies (i.e., World Bank, Asian Development Bank, International Finance Corporation) provide funding only to projects aligned with their current development goals. Commercial lenders (i.e., private banks, insurance companies, credit corporations) are concerned with the returns and are currently the biggest provider of financing for projects in emerging and developing countries. Export Credit Agencies (ECA), such as the US Eximbank, Export Credit Guarantee Dept (ECGD) of UK, Japan Bank for International Cooperation (JBIC), provide financing to new projects under the condition that their exports such as design and construction services are given preference because they are aimed at helping their own export compete in new international infrastructure markets (Khan and Parra 8).

Although different types of lenders are usually aggregated into one entity in a project, each one has a different procedure and purpose for providing financing. Conditions attached to the loans could be more stringent for one lender than the other. An example would be the World Bank’s stringent environmental requirements that other lending institutions do not require from Sponsor/s. As a collective unit, lenders expect a predictable cash flow during the project’s life and its ability to service the debt. These lending institutions anticipate being able to
enforce security interests as well as step-in rights if a project is failing (Khan and Parra 12).

**Host Government**

In developing countries, the Government plays a big part in assisting project development. As the ceding authority (Khan and Parra 11), the Government provides the indirect credit support to the Sponsor or project vehicle through ‘off-take’ agreements, i.e., being the sole purchaser of project output for a power project, or by offering fiscal incentives. To attract Private Sponsor/s, the Government has to create a positive environment for efficient mobilization and allocation of resources (“Issues” 32).

The Government’s primary role is to serve public interest. It has to ensure that besides providing continuous infrastructure service to the public, these services are provided at a price considered fair by the consuming public. In addition, the Government has to provide the appropriate level of information dissemination regarding project activities to keep the public informed and supportive of the project. In soliciting projects, the Government is interested in matching the project purpose to the current and anticipated market structure without sacrificing the standards in environmental, safety, health, security, and quality (Khan and Parra 12). To do so, the Government must ensure that the basic conditions for mobilizing infrastructure finance such as macroeconomic stability, appropriate tariff policy, and reduced risk factors are present (“Issues” 32). Even though all the mentioned conditions are in place, the Government must still possess the flexibility to adapt to any variation that may occur in the progression of the project.

**Public Sector**

When the Government procures a project, it has to do so with the knowledge that the public sector is essentially the main source of funding through realistic tariffs or user charges for the project services. This is particularly true in roads, sanitation, water works, general-use railways, ports and airports, urban transit, power transmission, and large-scale power generation (“Issues” 32).
Construction Contractors

For privately funded projects, the lender’s preference is for a single Engineer-Procure-Construct (EPC) contractor to be the single-point responsible party (Khan and Parra 7). These EPC contracts usually guarantee a fixed price for delivering the project, provide the performance specifications that fit the needs of the client, and define the schedule of project construction and commission within the timeframe allowed by the client. Aside from a liquidated damage clause in the terms of an EPC contract, the contractors are required to procure performance and retention bonds (Khan and Parra 7). Similar to the Sponsor’s concerns, the contractor wants to implement terms and conditions of the contract and have easy accessibility to modes of alternative dispute resolution in the event dispute arises between the parties.

Although the increased number of participants brings new interests to the project, this increase allows better diversification of project risks that were once solely shouldered by the Government. Involved parties will have to assume risks according to their respective capabilities for managing these risks. The next part will explain the risks present in the project and who best manages them.

Risk Allocation in IIPs

Due to the presence of diverse interests in a project, each participant approaches the concept of risk allocation from the perspective of its own interest. Identifying, analyzing, allocating, and mitigating risks inherent in most infrastructure projects are critical to the failure or success of the project.

According to Khan and Parra, the types of contract agreements emerging from IIPs are governed by the concept of risk sharing or allocation. Through contract agreements, risks are allocated to parties who are able to best mitigate or control these risks. Khan and Parra enumerate the following major project risks and the responsible project participants below (14-17):
**Completion Risk**

This risk is associated with any failure for the project to be delivered as needed or to be performed as specified. The Sponsor ultimately faces this risk but has the ability to pass it on to other project parties such as the construction contractor. The contractor assumes construction risks, i.e., delays, overruns, and even risks associated with performance of the facility if the EPC contract is used. Sponsor/s, the equity investors in the project risk, not only commits the initial equity but also, provide for a contingency equity as a safeguard against completion risks.

**Credit Risk**

The credit risk is related to the project’s ability to service its debt and consequently, affect a project’s ability to raise financing. The lenders assume this risk after the loans have been granted but the Sponsor has to present assessments of off-take agreements or revenue generation which assures the lenders that this risk can be surmounted.

**Marketing and Operating Risk**

Selling the project’s product or services is linked to the marketing and operating risk. There is a correlation between the marketing risk and the credit risk. Factors affecting marketing risks could predict the project revenues and thus, translate to the capacity to service existing project debt. As a mitigation measure, the Sponsor can form an Operating and Maintenance (O&M) contract with a third party, O&M operator, for operation-related risks, i.e., inflation rates of consumables, which then pass the risk to the operator. Nonetheless, the Sponsor or Project Vehicle is mostly able to ease this risk by stipulating contract conditions, i.e., no competing service, in the public-private partnership agreement.

**Financial Risk**

Uncontrollable financial events affecting the project create financial risk. Both lenders and Sponsor/s deal with this through various financial transactions, e.g., forward sales and option contracts.
**Political, Legal, Environmental and Social Risks**

These risks are associated with the existing conditions of the host country. Some Public Private Partnership agreements require that the host government take responsibility for these risks but the trend has been toward governments not assuming these risks to give lenders and Sponsor/s the incentive to select only good projects and run them as efficiently as they can. On the other hand, the lenders and Sponsor/s still require the government to provide the protection against political risks through contract agreements. The legal risk is addressed through careful risk allocation among the project parties. To address environmental and social risks, lenders such as the World Bank and ADB implement Environmental Impact Assessments (EIA) and related costs are integrated in the project.

From this set of identified risks, the completion risk is the most conspicuous one to be addressed in the project. With the involvement of Private Sponsor/s in infrastructure development, the Government has been able to shift the project’s completion risks to the private sector but not without concessions made between the parties. The Government and the Public Sector are the end beneficiary of developing the infrastructure. As such, the Government will need to work with the Sponsor to achieve completion of the project. From this mutual interest, a partnership between the Government and the Sponsor is formed and this will be discussed in the next section.

**Public Private Partnerships (PPP)**

The term “Public Private Partnership (PPP)” mentioned in the previous section pertains to a contractual agreement between the Host Government (public) and the Sponsor/s (private) which allows the Sponsor to participate in major investments previously reserved for the government such as infrastructure development. This shift from pure public provision of infrastructure to privatization was triggered by (“Issues” 26 – 27): (1) deficiency or failure to deliver public services, e.g., power outages, slow phone connections, poor water quality, unsafe transportation systems, (2) need for a better alternative from public inefficiency, and (3) utilization of private efficiency in operation and management of infrastructure services.
Actually, the formation of PPPs has increased significantly since 1990s; this has been due to the willingness of more than 100 countries to involve the private sector in infrastructure provision. Between the years 1990 to 1996, the overall increase in private funding for all sectors has been US$200 Billion. Within the same timeframe, private financing in developing countries rose from US$38 Billion to US$200 Billion (Irwin et al 12).

As the number of partnerships grew, the number of contractual agreements that emerged out of these PPP also increased. Khan and Parra have identified the major contractual agreements currently being used and these will be detailed as to how these privatization types serve the parties’ interests (30-32):

*Build-Operate-Transfer (BOT)*

The BOT contract is a mode employed by governments who do not want to entirely relinquish involvement in providing infrastructure services to the public. The project will be developed, constructed, and operated by the Project Vehicle or Sponsor for a fixed term but will eventually be acquired and transferred to the Host Government. The Government grants to the Sponsor the rights to construct and operate a specific project for a fixed term, e.g., 30 years for toll highway, 20 years light rail system. Examples of projects under the BOT contracts were the Puerto Vallarta in Mexico and various power plants in the United States and the Philippines (Klein 1).

Since the project will be handed over to the Government at the end of term, risks, particularly in the future operability of the project after the term, need to be addressed in the contract. The BOT contracts should provide incentive to the Private Sponsor/s to ensure economical and efficient operation of the project even after project transfer. In addition, the Private Sponsor should also make certain that the Host Government has the managerial expertise and technical capability for good project control and operation at time of transfer.

In a BOT contract, the Private Sponsor usually has the option to use an EPC or turnkey contract for the design and construction phase of the project. Lenders are
usually favorable with this arrangement as the ‘completion risk’ associated with construction is allocated to the contractor who can best manage it.

*B**uild-O**wn-O**perate (**BOO**)  

By using a BOO contract, the government attempts to disassociate itself from the provision of services and transfers all rights to a private entity. No transfer of ownership from private entity to the government or off-taker occurs and the contract remains continuous unless violated, thus the Government does not own the project in the end. As such, the Private Sponsor also assumes full ownership risks, i.e. long term project operation, which in a BOT contract is assumed by the Government.

Khan and Parra further elaborate on the above-mentioned privatization types by providing variations which present both governments and private entities further options in project development.

*S**upply O**perate T**ransfer (SOT)*  

Under this contract, the project is usually a plant where manufacturers of equipment and machinery build and operate the facility. Sponsor provides training to the nationals and facilitates technology transfer before turnover to the host government.

*B**uild-T**ransfer (BT)*  

This contract is used when a Construction Management firm finances and assumes all risks for the construction of the facility until commissioning before turning over to the Government. The Government selects this system for projects involving facilities that it alone has to operate.

*B**uild-L**ease-T**ransfer (BLT)*  

In this contract, the private entity finances the project but upon construction completion, legal title is transferred to the government while a sale and lease-back
of the facility is agreed between them. At end of the lease, the Government assumes ownership and operation of the facility.

_Build Transfer Operate (BTO)_

This usually involves a turnkey contract with a Construction Contractor who builds the facility which is turned over to the Government. The same or different private entity then enters into a separate operating agreement with the Government for the facility.

_Build Develop Operate Transfer (BDOT)_

The contract, in addition to the design of the facility, grants the private entity supplementary rights to make the concession more attractive, i.e., developing the land beside the built road into a commercial space for added revenues.

_Rehabilitate Operate Transfer (ROT)_

Under this contract, an existing facility is rebuilt or refurbished then operated by a franchisee and the fully operational facility is transferred to the government after the concession period. An example of this type of contract is for importing, rehabilitating, erecting, and operating an existing facility such as a plant from abroad to be used in the host country.

_Rehabilitate Own Operate (ROO)_

The contract grants the private entity the rights to refurbish and operate an existing facility for an unlimited time unless violations have been made in the terms and conditions stipulated in the contract agreement.

These contracts between the Government and the Sponsor actually occur at a latter stage in infrastructure development and result from going through the development process. This project development process has become formalized, especially where private financing is needed, because of the focus on project financing that is required. In the next section, this formalized process of infrastructure development, particularly
applicable to international infrastructure projects, will be discussed.

**Infrastructure Project Development Process**

Although every project has its unique challenges, the development process for infrastructure projects, especially those undergoing project financing, is similar in both industrialized and developing countries (Khan and Parra 105). Each process phase requires distinct deliverables to be addressed before the project could proceed to the next phase. The development process described in the latter section makes use of Khan and Parra’s development phases based on project finance (105-33) with the difference being in the focus of the development phases. Besides having the only focus on the financing aspect, technical requirements used in infrastructure management will also be presented. With the combination of these two aspects in a development process, the following sections describe the process and factors needed for successfully completing an infrastructure project.

For the purpose of this study, the discussion of the implementation stage will conclude with the final construction completion of the project and will not look at the operation part of the project. Also, the term *project goals* are those anticipated in completing a construction project.

**Project Origin**

The ceding authority, usually the Host Government, gives conditional right to the Sponsor to build the facility. Conditional right is attained through competitive bidding wherein the Host Government “solicits” proposals or through acceptance of an “unsolicited” proposal made by the Sponsor who identifies an unforeseen need to be fulfilled by the proposed project (Khan and Parra 105-6). In the early stages of project development, guidelines set forth by the multilateral agency such as World Bank must be followed to ensure funding. Separately, the Sponsor and the Government check the viability of the proposal and declare the worthiness of pursuing the project. Some key factors considered in the project origin stage are (Khan and Parra 110-18):
Sponsor’s Qualifications

The Sponsor must gain the confidence of the Host Government. It must demonstrate the capability of implementing the proposal. Sponsor/s who have never worked in the host country usually take on a local partner.

Project’s Finance-ability

The Sponsor must consider the aspects of the project that would make it attractive to lenders or prospective equity holders. These would include the existence of an off-take agreement, formation of project agreements, e.g., EPC contract, particularly on the aspect of risk allocation, and project cash flow considerations.

Technical Feasibility Results

Input from technical consultants or short-listed EPC contractors are critical to determining the “fit for purpose” of the proposed project. Study must be conducted to reveal the ‘hard’ construction costs of pursuing the project including preliminary construction schedule and results of project lifecycle and sensitivity analyses. The technical feasibility results guide the Sponsor in accounting the uncertainties present in the project. These also serve as the basis of the Terms of Reference (TOR) for the solicitation of project contracts. The completeness and accuracy of these technical studies will guide the project’s eventual design and construction phases.

Development Process Timeline

The Sponsor has to make a fairly accurate estimate of time between award and financial closing. If the Sponsor can predict with certainty when financial closure will be reached, none of the proceeding project phases will need to be time-constrained to fulfill end project goals.

After fulfilling the key elements in the project origin phase, the Sponsor can move on to the next level of project development which Khan and Parra call the negotiation phase.
**Negotiation**

At this point, the Sponsor negotiates the contract agreement, e.g., BOT contract, with the Host Government as well as other agreements such as the EPC contract. This stage discusses the activities focused on contract formation, formalizing the Terms of Reference through market and technical studies, and development of the financial model.

*The EPC contract*

The Sponsor’s main reason in using an EPC contract is to transfer most of the project’s completion risk to the contractor (Khan and Parra 429), although this usually results to 15 to 20 percent higher costs than the traditional construction contract. Lenders particularly look for the following six key characteristics in an EPC contract (Khan and Parra 230-32):

- **Full turnkey contract**
  
  The Contractor takes full responsibility for the entire construction phase. Even if the Sponsor provides the specifications and plans, the Contractor still assumes “ownership responsibility.” This includes subcontractors or equipment recommended by the Sponsor.

- **Lump sum, fixed price contract**
  
  The Contractor binds itself into performing a preset scope of work for a predetermined amount that could not be changed unless subject to variation orders usually approved by the lenders.

- **Single-point responsibility**
  
  The EPC Contractor assumes sole responsible for the completion of the entire scope of work. If multiple contractors fulfill the EPC contract, these contractors are to furnish the Sponsor with cross-guarantees which warrant other contractors’ work. In case one contractor defaults, the others will take over its part and still assure work completion.

- **Provision of performance and delay liquidated damages**
  
  The Contractor agrees to pay liquidated damages (LDs) for non-performance to specifications of the contract and/or failure to deliver the
project on the scheduled completion date. The LD is to compensate the Sponsor/s for reduced revenues, increased operating and financing costs, and other costs related to the non-performance or delayed delivery of the project.

- **Payment by milestone**
  The Contractor receives payments based on actual progress and achieved milestones which are pre-defined in the contract.

- **Performance bonds**
  The Contractor must be guaranteed by a creditworthy third party unless the contractor can provide necessary proof of being financially solvent and unquestionably capable of fulfilling its obligations under the EPC contract.

Next to the PPP contract, the EPC contract is the most important contract in the project because: (1) it has the tendency to be the largest cost component in the project and constitutes the bulk of the project’s capitalization, (2) the end quality and efficiency of the design and construction affects project expenses and revenues throughout its lifetime, and (3) completion of the EPC contract is even specified in the PPP contract agreement (Khan and Parra 228). Having the EPC contract fully effective and comprehensive affects the successful completion of the project. The Sponsor is then required to formulate the Terms of Reference and conduct the EPC contractor selection aligned to project goals of the EPC contract. These two important components needed to arrive at the EPC contract will be further discussed in the following sections.

**Terms of Reference (TOR)**

The Sponsor/s have to focus on both ‘strategic planning’ and ‘tactical planning’ (Hudson, Haas, and Uddin 45). These modern concepts of planning, i.e., ‘strategic’ focusing on the financial and business aspects and ‘tactical’ focusing on technical aspects of the facilities and facility management, are necessary in achieving the desired project goals. The planning stage has the greatest influence over the lifespan of the project. As the lead, the Sponsor/s can affect the project as early as the planning stage but, at the same time, be the most affected when the
project is in the commissioning stage. This influence curve is illustrated in the diagram (Figure 2) below.

![Influence Curve Diagram](image)

Fig. 2. Influence Levels on Total Costs, Infrastructure Management (New York: McGraw, 1997) 41.

The best way the Sponsor could exert its influence in the project is through a clear and comprehensive Terms of Reference (TOR) that the EPC contractor has to comply with. This is usually the only official document that the Sponsor or Project Vehicle can use to communicate what is required of the project. Besides stating the project scope and performance specifications, the TOR could include conditions meant to address the following concerns (Hudson, Haas, and Uddin 190-204):

- **Be specific about facility and design process objectives and constraints**
  
  Defining objectives and constraints assist the designer to focus on the requirements of the project. This will lead the designer to think innovatively and offer alternative designs when possible.

- **Provide the information needs of design**
  
  The information needed in design is mostly available from the network level of infrastructure management. The planning activities take place at this level when the Sponsor takes the lead. Most of the information gathered at this level is usually very preliminary and still need to be augmented with further studies. However, having preliminary studies available provides the starting
point for gathering other needed information which could be: (1) results of environmental and social impact assessments, especially if agencies such as the World Bank require fulfillment of stringent environmental standards, (2) site conditions especially topography, soils, existing utilities, site boundaries, (3) projected use, loading, or traffic forecasts for making design assumptions, and (4) material characteristics through physical testing of strength, stiffness, and deformation.

- Define design evaluation criteria

  Evaluation criteria could be formalized at the beginning of the design process to gauge the effectiveness of the design. The criteria must consider only elements which directly impact the accomplishment of project objectives. Preferably, the criteria must be quantifiably measured instead of subjectively rated (Hudson, Haas, and Uddin 200). An example criterion could be the accuracy of design documents. This could be evaluated based on the project’s performance requirements. Having design evaluation criteria is meant to bring out issues earlier than the construction phase.

After defining the TOR, the Sponsor then considers the contractor selection process to implement such that the best contractor is chosen to fulfill the project goals.

**EPC Contractor Selection**

When the project is funded by the World Bank (WB), the Sponsor is usually required to adopt the International Competitive Bidding (ICB) process in selecting contractors. The ICB process is the WB’s preferred selection method because of the transparency it affords the selection process. This process is applicable to all contracts involving procurement of goods and services regardless of size or scope including turnkey projects. Some key features in implementing the ICB process are (IBRD 11-35):

- Pre-qualify bidders
All bidders are pre-qualified especially for large and complex projects where the bidding costs can be prohibitive, i.e., custom-designed equipment specialized services based on their experience and past performance, technical and personnel capabilities, and financial condition.

- **Conformance to specifications**
  
  Bidders are expected to conform to the technical requirements delineated in the bidding documents including evaluation of alternative bids.

- **Quantitative evaluation**
  
  Bid evaluation is strictly based on monetary terms. Factors other than price such as early completion, safety, and environmental benefits must be expressed in cost terms to be considered for evaluation.

- **Domestic preference**
  
  A margin of preference is usually granted to domestically manufactured goods and domestic contractors which alters selection of the winning bidder.

The Sponsor is encouraged to use the selection process similar to the ICB but should include the following features to be more comprehensive in its evaluation (USACE):

- **Existence of quality systems**
  
  Contactor Quality Control (CQC) system should be a ‘live’ management system during the entire project duration. The CQC system should encompass all phases of the contractor’s work such as the process of approving submittals, procurement, material and equipment storage, coordination activities, inspection or tests requirements, and other quality control activities.

- **Personnel evaluation**
  
  Check qualifications of project personnel including the project managers, construction managers, and key personnel in the contractor’s organization.

During the evaluation process, the Sponsor must form a board of evaluators familiar with the design and construction of projects similar to the one being undertaken as well as knowledgeable of the operations and maintenance of the
project. This could be similar to the United States Army Corps of Engineer (USACE) procedures of forming its selection team made up of highly qualified professional employees of the USACE, who have Architect-Engineer-Contractor (AEC) and acquisition experience, and personnel from the operating and maintaining agency of the project. The board of evaluators then proceeds to review the proposals and later on conducts interviews of the pre-selected contractors to validate claims made about their experience, capabilities, organization, quality management procedures, and planned approach for the project.

The Sponsor also makes all sensitivity analyses for potential areas of weakness, i.e., construction delays, cost overruns, currency depreciation in the negotiation phase. Now, having concluded all transactions for the project agreements, the Sponsor moves the project to the implementation phase.

**Implementation**

The financing of the project is finalized at this stage of development. Construction normally commences until after the Sponsor has closed financing with project and finance counterparts. Project implementation begins with the proper monitoring controls set to check the progress being made during project implementation. Since payments will depend on project progress and will be output-based, the Sponsor will need to strictly supervise compliance of the EPC Contractor and all other parties to the contract.

Also addressed in this stage is the completion risk. Lenders require that the “physical” completion of a project be ascertained by an Independent Engineer (IE). The project should reach satisfactory completion as well as be valid for a takeover certificate confirmed by the IE. Projects without off-take agreements have the additional condition of passing a “financial” completion wherein the project must arrive at the breakeven point at a negotiated date to be considered completed.

Through the three phases of the development process, the Sponsor is able to influence the outcome of the project. The Project Origin Phase allows the Sponsor to focus on the desirability of the project considering the Sponsor’s own qualifications
and capabilities and the project’s appeal to the lenders. In the Negotiation stage, the Sponsor is made aware of the weight of a good EPC contract to a successful project. Maximizing the advantage of an EPC contract would mean having the Sponsor create a clear and comprehensive TOR and chose the best contractor for the project. The Implementation stage coincides with the financial closure and triggers the formal commencement of the construction phase. By this phase, the Sponsor’s ability to influence the project outcome has greatly decreased. The remaining tasks are to monitor and supervise the construction phase. If the requirements have been fulfilled at each phase of development, then the Sponsor can expect the project to reach its successful construction completion.

**Relevance to Research**

In each section of this chapter, the complex nature of international infrastructure project was gradually revealed. The introduction of new participants in project development has altered the way of developing these projects. The current literature has shown that changing the financing structure for these infrastructure projects has caused a new development process to emerge. This new process clearly shows a greater focus on the financial aspect of the project rather than the technical aspect. Development goals are more financial than technical and this translates to changes in the overall project goals. This research intends to connect changes made in the development structure to the project outcome related to its goals. At the same time, the research will try to confirm that these changes can also alter the initial development goals of the project.
CHAPTER 3
CASES OF PRIVATELY-FINANCED PROJECTS

The previous chapter identified the three development phases of privately-financed infrastructure projects: project origin, negotiation, and implementation. These phases will in turn be used to describe the diverse development processes of four infrastructure projects in Asia. Each project illustrates a different use of financing. This chapter summarizes these projects in the chronological order of the researcher’s visits and extracts only key and relevant points from Appendices A to D. The reader is encouraged to peruse the Appendices if detailed information is desired about the following projects.

The first project is the Taiwan High Speed Rail (THSR) Project, which was the first transportation project in Taiwan to use the Build-Operate-Transfer (BOT) form of contract. The second is the North Luzon Expressway (NLE) Project in the Philippines, which was awarded “Project Deal of the Year” in 2000 for having acquired project financing during the time of the Asian financial crisis. This is followed by the South Outer Bangkok Ring Road Chao Phraya River Bridge (SOBBR) Project in Thailand. This project differs from the others because, although fully government-procured, it is financed by a local Thai bank, thus establishing its affinity with the other privately-financed projects. The last project is the Nam Theun 2 Hydropower (NT2) Project in Lao People’s Democratic Republic (formerly Laos), which was the first hydropower project endorsed by the World Bank after a decade of disassociation with these projects.

The focal point for this chapter is to examine how each studied project implemented the development process and made decisions to fulfill the requirements for each phase. Observed similarities and differences across projects will provide a basis for the succeeding chapter to identify key factors that have the underlying effect of shaping the project outcomes.

The discussion for each project follows the structure of infrastructure development process from the previous chapter. This includes the key development components in
each phase of the process. A simplified timeline (Figure 3) of all projects is provided to help visualize the development process of each project as well as across projects.

### Timeline

<table>
<thead>
<tr>
<th>Year</th>
<th>THSR Project (Civil Works)</th>
<th>NLE Project</th>
<th>SOBRR Project</th>
<th>NT2 Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2010</td>
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</tbody>
</table>

**Legend:**

- Project Origin
- Negotiation
- Implementation

Note: Overlapping patterns mean simultaneous stages.

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**Fig. 3.** Project Timelines of THSR, NLE, SOBRR, and NT2 Projects.

**Taiwan High Speed Rail (THSR) Project – Civil Works**

The THSR Project began with an initial feasibility study by the Government but was later on transferred to the Private Sponsor for financing and implementation. This project had more known variables up front and had to deal with fewer uncertainties. In addition, this project manifested a working partnership between the Government and the Sponsor in project delivery.
The THSR Project had several core components: core system, electrical and mechanical works, track works, stations and depots, and civil works.

For the course of the study, the focus would only be on the civil works of the 345 kilometer rail alignment comprising of 39 kilometers of bored tunnels, 8 kilometers of cut-and-cover tunnel with 2.8 kilometers for the approaches, 251 kilometers of pre-cast, pre-stressed box girder viaducts, and steel truss bridges, and 32 kilometers of cut-and-fill embankments (Gillam and Townsend 52). The civil works alone amounted to USD 15 Billion (NTD 180 Billion) worth of contracts managed by the THSRC. Figure 5 illustrates the major participants involved in the origin to the implementation of the THSR Project and indicates the contractual connections and reporting responsibilities of the participants.
The succeeding sections discuss the development of the THSR Project detailing fulfillment of the key requirements at each project phase. Some project results are described at the end of the section and linked to situations that occur at the different project phases.

Project Origin

In 1989, the THSR Project was conceptualized by the Taiwanese government agency, Bureau of High Speed Rail (BOHSR). The Taiwanese Government solicited for private participation in 1997. There were two respondents to the invitation, one of which was the THSR consortium (Kao). The Sponsor and the Government jointly expended efforts to fulfill the following four different requirements:

Sponsor Qualifications

The THSR consortium was made up of several Taiwanese firms, namely the CEC, EVA, FUBON, PEWC, TECO, (see Appendix A for full names) with varying expertise in financing, transportation operation and maintenance, information systems, mechanical and electrical works, and civil construction (Lin). The Taiwan Shinkansen Corporation (TSC) also became a partner to add
specialization in the high speed rail industry. Individually, the sponsor companies had well-established reputations in Taiwan while Shinkansen was established as a railway provider and operator in Japan. In addition, the Government had a share in the project vehicle as well as a major partner in developing the project.

*Project Finance-ability*

Even before the Government solicited private involvement, it had already studied the feasibility of the project and only needed proposals that were acceptable. The financial reports, financial indicators (NPV, IRR, Payback period), and financial curves were evaluated to check the validity of proposals (Chang and Chen 216). The THSR consortium presented the most acceptable proposal to the Taiwanese Government, initially requiring zero equity investment from the Government to develop the project (Tan). Actual financing for the project had a debt versus equity (D/E) ratio of 2.33 with 70% of the financing coming from bank loans (Fleming “Contractual” 236). Consequently to achieve financial closure, the newly established THSRC (THSR Corporation) and more than 25 lenders signed a syndicate loan and tripartite agreement with the Government as guarantor. The tripartite agreement required the Government to pay off the loan price to the lenders in case the THSRC defaulted (Tan).

*Technical Feasibility Results*

The BOHSR took the lead in conducting technical studies including soil or geotechnical investigations, alignment selection, and preliminary civil design considerations needed for the THSR Project. With the provision of this information, the THSRC was able to decide on the best types of civil structure (viaducts and tunnels) to be built for specific sections across Taiwan (Gillam and Townsend 53). This allowed the THSRC to estimate the project’s hard costs with more certainty.
Development Process Timeline

The THSRC spent a relatively brief time on developing the project since the Government assumed the developer role for eight years prior to selecting the THSRC as the “best applicant” in 1997. Notwithstanding the shortened role of developer during preconstruction, between 1997 and 2000, the THSRC was able to relocate the existing utilities and utilize the time to look for design-build civil contractors. It was also in 2000 that the first civil contracts were awarded, which was almost concurrent with reaching financial closure.

With the framework for the THSR Project already developed, the proponents ushered in the formalization of the contractual agreements which was the next step to finally implementing the project.

Negotiation

The most important agreement in the THSR Project was embodied in the Construction and Operation Agreement (C&OA) between the Taiwanese Government and the THSRC. This agreement, also known as the BOT, gave rights to the THSRC to build and operate the railway project for 35 years before transferring the project back to the Government. It also included development rights over specific areas surrounding the infrastructure for 50 years (Lin). The C&OA became the backbone of all other contract or agreement made in the THSR Project.

In this particular project, the Sponsor assumed overall project completion risks. Although the EPC or design-build contracts were used for the civil works and core systems, these covered only specific scopes of work which were all managed by the THSRC. The civil work had 12 contract packages awarded to multiple international contractors while the core systems used two separate EPC contracts (both with TSC).

In the discussion of the contract type below, the focus will be on the design-build contracts. These contracts may not fulfill the exact requirements of the EPC contract discussed in the previous chapter, but the THSRC formed them such that construction risks were allocated to the contractors.
The Design-Build Contract

Each design-build contract had a defined scope of civil work and responsibilities. Some major conditions in these contracts were (Fleming, “Contractual” 242-55):

- Contractors were ultimately responsible for both design and construction.
- Contractors had to manage integration and coordination at common boundaries as detailed in the Master Interface Agreement.
- Project performance was subject to “fit for purpose” clause.
- Payments per completed milestone were associated to price centers.
- Defects occurring five years after commercial operation or 15 years after issuance of completion certificate were subject to latent defect clause.
- Liquidated damage clause covered construction delays.
- No time extension was given to ground- and weather-related issues.

Besides risk allocation, the THSRC also used these design-build contracts to simultaneously produce and manage the final design and construction of the entire 345 kilometer railway alignment. Before the award of these contracts, the THSRC first had to prepare the Terms of Reference as a basis for the contractors’ proposals and selection of the best contractors.

The THSRC was assisted by the Government in formulating the Terms of Reference since the Government already produced very detailed reference designs. As for contractor selection, the THSRC utilized the extensive process of proposal evaluations which was common practice for most government-procured projects. Details of both the Terms of Reference and contractor selection process for the civil works will be presented in the following sections.

Terms of Reference

The THSRC included a great deal of information in the Terms of Reference such as:

- **Very detailed design specifications and site investigation results**

  The contractors were provided with design information such as
100 year design life (Schultz), civil structures (viaducts, tunnels, bridges, and embankments) for designated topography (mountainous or alluvial plains) (Gillam and Townsend 53), optimal span length (35 meters) for viaduct span (Kao), results of geotechnical studies showing areas with high water table, and unstable ground condition and areas of medium hard to medium soft ground (Hemphill 221).

- Clauses excluding the contractors from relocating utility and acquiring ROW and standard construction permits

  The Government and the THSRC already completed ROW acquisition and utility relocation before start of the civil contract. As for the permitting, the THSRC led the acquisition of permits with the assistance of the Government (Fleming, “Contractual” 249-50).

- Design review process with 45-day processing time

  The THSRC had an established review process, which averaged 45 days to complete excluding resolution of objections. This process ensured that the Construction Independent Checking Engineer (CICE) was able to independently certify, but have no responsibility over, the conformance of the design to contract requirements as well as allow the THSRC Engineering Division to comment on designs before implementation (Hsieh and Lankaster 162).

- Contractor self-certified quality assurance and control

  The THSR Project used a self-certification system where the contractors certified the quality of their work and administered site inspections and testing through their own quality control and assurance teams.

  After formulation of the TOR, the THSRC started the invitation to bidders and proceeded with the contractor selection process.
Contractor Selection

The THSRC selected civil contractors through evaluation of the financial, legal, and technical aspects of the proposals. The selection process was administered by experienced construction personnel – project managers and resident engineers from other projects – who checked the soundness of the technical proposals; while the overall tender was evaluated by the procurement department. After initial evaluation, key personnel from the contractor’s team were interviewed to clarify issues about the proposal. The THSRC Board of Directors gave final approval for all contractor selection (Mues).

The evaluation process was administered in two tiers: pre-qualification and proposal levels. According to THSRC’s Ricardo Tan, contractor qualification was based on the experience of the contractor’s group (design, construction, and CICE); the firm’s design management capabilities; and its working capacity in Taiwan. On the other hand, technical proposals were evaluated based on (Kao) experience and competence of key personnel; expertise with the proposed construction means and methods; logic of construction schedule; conformance of quality plan to the ISO 9000 standards; adequacy of the safety plan; implementation of RAMS (reliability, accessibility, and maintainability study) on designing the civil structures; adequacy of design and shop drawings; and method statements.

The THSRC’s contractor selection process was comparable to the government process of evaluating proposals. This process was appropriate to the project since the Terms of Reference already had a vast amount of information, i.e., detailed designs, provided to the contractors.

The next phase after all contract awards was the construction of the project. This is one of the most important phases in privately-financed projects since it brings the project closer to finally operating and generating the anticipated revenues. For this project, the THSRC predicted that the THSR Project would be the only HSR for Taiwan thus should be built to the highest standards to perform even after the 35-year
BOT agreement. As a result, the Government, the THSRC, and the lenders ensured that the necessary monitoring systems were in place during the implementation phase.

**Implementation**

The THSRC allowed the contractors to utilize construction methods of their choice as long as found that they could adequately perform the selected methods. For the viaduct construction, several methods were employed by the different contractors namely the Free Cantilever Method, the Full Span Launching or Pre-Cast Method, and the Movable or Fixed Scaffolding System. As for tunnel construction, most tunnels were excavated and monitored using the New Austrian Tunnel Method (NATM), also known as the Sequential Excavation and Support Method or Shotcrete Method, and the Tunnel Boring Method was only used in five out of 42 tunnel sections. The selection of the construction method was dependent on several factors:

- According to THSRC, there was a limited number of interested and qualified civil contractors for each contract worth NT$10 to 20 Billion.
- The THSRC administered a thorough selection process which disqualified contractors who did not show logic in the work sequence and did not have the supporting cash flow for the proposed work.
- Geotechnical issues affected the selected tunnel construction method. The changing condition of the existing Taiwanese soil dictated the use of the NATM method.
- The construction schedule was set for four years from award therefore requiring the contractors to implement methods which could deliver the project within the set schedule.

As for project monitoring systems, the THSR Project utilized a two-level monitoring system to ensure the physical completion of the project. The first level was fulfilled by the Independent Verification and Validation Engineer (IV&VE), Lloyd’s Register, which was a C&OA requirement. The IV&VE’s ultimate responsibility was validating the HSR fit for operations (Kao). Other responsibilities included reporting
to the THSRC, the lenders, and the Government regarding project progress (Schultz) and checking the adequacy of the ICE/ISE level monitoring system (Tan).

The Independent Checking and Supervising Engineer (ICE/ISE), IREG, and the THSRC Resident Engineers (RE) fulfilled the second level of monitoring. The ICE/ISE provided another level of independent checking and also augmented the THSRC’s technical manpower to check the design process and supervise site quality with the RE (Kao). However, the IREG possessed less authority over the site compared to the RE (Fleming, “Contractual” 233). The RE administered the conditions of the design-build contract and could decide on issues relating to contract administration except for those with commercial implications and contractual impacts (Rothenburger; Mues).

The THSR Project employed a development process manifesting qualities of the government procurement process except for the aspect of risk allocation. This was not surprising since the Government and the THSRC were working very closely. The project benefited from the close partnership and extensive government involvement, but ultimately the project was the THSRC’s responsibility and the results reflected the THSRC’s attempts at reaching its goals.

**Project Outcomes**

The THSRC focused on finishing the civil contracts on schedule and achieving a quality project. Through the design-build approach, the civil contracts were able to finish as scheduled even with abrupt changes in the design code occurring in the middle of the construction phase. In terms of quality, the availability of site information and thorough design criteria assisted in defining the expected quality of the final designs. However, the self-certification process did not always achieve the expected quality. In the THSR Project, the combination of the schedule pressure and implementing self-certification caused some civil contracts to experience issues about quality. With regards to risk allocation that was critical to privately-financed projects, the THSRC assumption of the overall project completion risks resulted in its shouldering costs related to the overall delay in the THSR Project.
The project is currently experiencing delays due to the uncompleted core system and the THSRC is shoulderling the burden of bringing the project back on schedule and shoulderling the penalties associated to the delay, i.e., interest payments, loss of revenues. For the civil works, the contracts were all completed on time with minor quality issues, but these were eventually rectified over the course of the project.

**North Luzon Expressway (NLE) Project**

The NLE Project is an example of a limited recourse project with the unique characteristics of a “brownfield” site (Bautista). This became a trademark project that provided the template for forming future transportation deals in Asia (“Asia” 39). The difference between the NLE Project and the THSR Project is that the private sector led the development of the NLE Project with minimal government involvement in financing or structuring the deal while the THSRC and the Taiwanese Government worked together to finance the THSR Project. In addition, the Philippine Government and the MNTC went through a negotiation process for NLE Project (“Asia” 39) while the THSRC had to competitively bid for the THSR Project before the Taiwanese Government awarded the contract.

One of the challenges for the NLE Project was the need for the toll road to be open to traffic while the project was ongoing. The project comprised of the rehabilitation and expansion of existing facilities and construction of new interchanges, toll platforms, operations and maintenance facilities, and the design and installation of fixed operating equipment (“Philippines”).
The project consisted of the existing 83.7 kilometer NLE or 295 lane kilometers connecting Metro Manila at Balintawak to the Sta. Ines, a town close to the Clark’s Special Economic Zone (SEZ) and the 8.8-kilometer segment from Tipo to the Subic SEZ also known as the Segment 7. The NLE lanes were increased to eight lanes for both directions from Balintawak to Burol and six lanes from Burol to Sta. Rita. All existing toll booths were replaced with the latest computerized tollway management systems (Project Scope). The NLE project amounted to approximately USD 367 Million with 32% provided as equity by sponsors: First Philippine Infrastructure Development Corporation (FPIDC), Egis (France), Leighton, and Philippine National Construction Corporation (PNCC) (Finance). Figure 7 illustrates the major participants in the NLE Project.
The following sections will detail how the MNTC managed the development process and how the MNTC or other parties who became involved in the project fulfilled the required elements at each phase. Parallel to the discussion with the THSR Project, the segment will conclude with a summary of project outcomes.

**Project Origin**

The NLE’s current franchisee was the Philippine National Construction Corporation (PNCC). In 1997, without any public bidding, the PNCC formed a Joint Venture with the FPIDC to expand, rehabilitate, and improve the existing NLE (Project Overview).

After the formation of this joint venture, the Sponsors initiated the project origin phase lay the necessary groundwork for project financing. This is unlike the THSR Project where the Government provided a great deal of upfront project information. In the NLE Project, the Sponsors were responsible for conducting technical studies and fulfilling project financing requirements. This included involving Leighton as both Sponsor and EPC contractor very early in the development process to provide construction-related information.
**Sponsor Qualifications**

The MNTO, Project Vehicle, was composed of the following sponsors with their respective contribution to the project (Partners):

- **First Philippine Infrastructure Development Corporation (FPIDC):** toll roads company with developer role for the completed Segment 7, a completed segment of the NLE Project

- **Philippine National Construction Corporation (PNCC):** incumbent NLE operator and concessionaire with extensive experience in roadway construction and other infrastructure projects

- **Egis Projects S.A.:** a leading company in transport infrastructure engineering

- **Leighton Asia Limited:** experienced firm in development and contracting with operations spanning the Asia-Pacific region

**Project Finance-ability**

The NLE Project was proposed to be completed on a limited-recourse basis. Funding was initially supposed to be fully shouldered by the Lopez Group of Companies, a holding company of the FPIDC, but due to the Asian financial crisis and massive scale of the project, multilateral support was eventually needed (“Asia” 39). Financing was from loans (68%) from multilateral credit and export agencies and commercial lenders and equity (32%) from the Sponsors (Finance). The financing structure imposed the following caveats on the project:

- Investment recovery from collection of direct-user fees
- French-based toll operating system for the Fixed Operating Equipment (FOE) to fulfill a loan requirement
- Substantially completed ROW acquisition
- Fixed-price and date-certain construction delivery

Besides being limited-recourse, the NLE Project did not need to be guaranteed by the Philippine Government unlike the THSR Project where the Taiwanese Government was a guarantor under the tripartite agreement.
Technical Feasibility Results

As already mentioned, the Sponsor facilitated the preliminary technical studies for the NLE Project. However, unlike those in the THSR Project, these studies were focused on fulfilling financing requirements and not on arriving at the best technical specifications for the project.

The MNTC commissioned Halcrow Fox to conduct traffic forecasts while Parsons Brinckerhoff (PB) reviewed the results to verify consistency of the predicted volume of traffic (MNTC Information 13) to the actual traffic conditions. The results provided the groundwork for selecting the most efficient toll system – open and closed system – for the project. The open system levied a fixed toll fee to the user at the entry of the toll road and did consider the actual mileage traversed by the user, therefore reducing the number of exit toll lanes needed. As for the closed system, toll charges were based on the length of road traveled and the users made payments at the exit point thus needing toll lanes at exit points. Other studies determined the most desirable interchange type, applicable design codes, and pavement rehabilitation means and methods. These were all incorporated into the preliminary performance criteria set by the MNTC’s key technical personnel. The MNTC also involved Leighton, the EPC contractor, quite early in the development phase to assist in the formulation of cost estimates and construction schedule needed for project financing.

Development Process Timeline

The MNTC signed the Supplemental Toll Operation Agreement (STOA) in 1998 and the project reached financial closure in 2001. This is similar to the THSR Project which also took three years to close financing. However, for the NLE Project, the MNTC needed to fulfill Conditions Precedent (CP) before construction began in February 2003. A five-year gap existed from award to implementation which the MNTC could have utilized to address design issues and perform pre-construction activities. Although some part of this time was used to acquire the needed ROW, the MNTC did not focus on other construction-related activities such as determination of existing road conditions. Also, Leighton did not improve
the preliminary detailed design while the project was waiting for financial closure. However, since the EPC contract covered all construction-related aspects of the project, all potential issues depended on Leighton for resolution.

The big difference between the THSR Project and the NLE Project is that the THSRC was able to utilize the pre-construction time to facilitate the construction phase while the MNTC could not because it passed on the responsibility of performing preliminary works to Leighton.

For the NLE Project, the project origin and negotiation phase overlapped since the EPC contract was awarded before activities for the project origin phase concluded. This is an example of a difference in the projects’ development process. Although phases in the NLE Project were clearly defined, no distinct demarcation existed between the beginning of one phase and the end of another.

**Negotiation**

The STOA was the basis of all other contracts in the NLE Project. This agreement between the Philippine Government and the MNTC was a 30-year Rehabilitate-Operate-Transfer contract which allowed the MNTC to finance, rehabilitate, and operate the project for 30 years before transferring the rights back to the Government.

For project construction, the MNTC utilized one EPC contract to pass all construction completion risks to Leighton (Bautista). This is dissimilar to the THSR Project where the THSRC assumed the overall completion risks. The reader can refer to Table 1 in Chapter 1 to see the various characteristics of the contract used across the different projects. Initially, the MNTC wanted to have two separate EPC contracts for the civil works and for the FOE, but with the advice of the lenders, a single EPC contract was awarded to Leighton with the combined scope of FOE supply and installation and civil works (Bautista). The NLE Project’s EPC contract exemplifies the EPC contract discussed in Chapter 2. The characteristics of the EPC contract will be detailed in the succeeding section.
The EPC Contract

The lenders required the use of a full turnkey contract to transfer all construction risks to the EPC contractor for the MNTC’s easier contract management and administration. Consequently, Leighton was awarded the EPC contract and Egis Project SA was relegated to subcontracting the supply and installation of the FOE. Some key features of the EPC contract included:

- **Fixed price, lump sum contract with a liquidated damages** clause of USD$225,000 per day of delay and a bonus clause for early completion;
- **Date-certain completion schedule** of February 2005 or 24 months from start of construction;
- **Progress payments** per kilometer of completed roadway;
- and **issuance of variation orders with approval** from both the MNTC and lenders.

Unlike the THSR Project which used an amended design-build contract standard, the MNTC created the EPC contract from scratch. This resulted in some aspects of the contract being less than “ironclad” (Killick); however, the contract was still sufficient in terms of risk allocation (Bautista).

Before the EPC contract was awarded, the MNTC provided a basis for the contract and performed a contractor selection process adequate for the needs of the project. The Terms of Reference were represented by the Employer’s Technical Requirements (ETR) in the NLE Project. The NLE Project’s TOR was more flexible as compared to that used in the THSR Project. A further comparison is the MNTC’s selection process which was less extensive than that of the THSRC’s. The succeeding sections detail the ETR and the process by which the MNTC selected Leighton as the EPC contractor.

Terms of Reference

The Employer’s Technical Requirements (ETR) covered the performance standards and basic design of the project structures. Most of the standards used in the ETR were based on AASHTO guidelines, particularly the pavement design. However, the actual pavement design guideline was the Australian design code for
road pavements, AUSTROAD. This was through Leighton’s recommendation that was actually contractually allowed but had to be approved by the Independent Design Checker and the MNTC (Maunsell 1). This indicates the TOR’s flexibility in the NLE Project as compared to that of the THSR Project’s.

While the General Contract Conditions (GCC) in the THSR Project exempted the contractors from ROW acquisition and advance works, the ETR in the NLE Project was the complete opposite and made Leighton fully responsible. The ETR required Leighton to gather project-related information as well as conduct advance site work and preliminary activities. These included: identifying the area to be acquired for ROW and obtaining approval from the Land Management Bureau before requiring the MNTC to acquire the necessary parcels; checking the existing condition of the NLE and detail the rehabilitation process to be performed; and diverting existing utilities and coordinating with the affected agencies (MNTC Employer’s 11-18). The ETR also lacked any specific Employer’s review and approval process for evaluating recommendations made by the contractor. This could have been similar to the Design Review Process in the THSR Project.

Although the ETR facilitated technical evaluation of proposals, the award of the EPC contract was mostly dependent on the qualifications of the bidders as detailed in the following section.

Contractor Selection

The MNTC’s method of selecting the EPC contractor was geared toward providing the contractor flexibility in implementing design-build. This is unlike the THSRC’s process which evaluated even method statements.

Parallel to the THSRC’s approach, the MNTC formed an evaluation group, called Prequalification and Bidding Awards Committee (PBAC), composed of senior financial, commercial, and technical personnel (Bautista). However, this group was limited to evaluating the bidder qualifications and not proposals. In addition, only qualification for the civil component was evaluated since the FOE supply and installation was already pre-negotiated with Egis (Punzalan). Leighton was selected over three foreign firms for further negotiations.
Qualification was evaluated based on the firm’s experience and financial capability. The PBAC checked track or performance records, financial statements, bank certificates, company profile, and ISO-certified quality systems. As already mentioned, the evaluation process did not consider the detailed design, site quality plans, construction methods, and other details showing the contractor’s strategies to building the project.

Since an overlap between the project origin and the negotiation phases existed, completion of CPs for project financing rather than award of the EPC contract, prompted the start of the construction phase (Bautista).

For the NLE Project, the MNTC focused on getting the project completed by February 2005 or 24 months after the issuance of the Construction Notice to Proceed (CNTP) and having the project perform for at least 25 years of toll road operation. These goals were covered under the EPC contract and as a result, monitoring systems in place for the NLE Project were minimal when compared to those in the THSR Project.

**Implementation**

The selected pavement rehabilitation process was the crack-and-seat method. This method transformed the existing pavement into fragments to the size of large crushed stone base. The method was applied to all slabs where significant cracking reflected through the asphalt and the Falling Weight Deflectometer indicated rocking slabs (Maunsell 40). The selection of the crack-and-seat method was dependent on the following factors:

- The crack-and-seat method was one of the limited rehabilitation processes for existing pavement (Killick).
- The crack-and-seat method was an economical choice for rehabilitating the existing NLE. The materials from the existing pavement were reused for the new pavement instead placing new concrete.
- The ETR specified the use of the crack-and-seat method for rehabilitating the road pavements which was also recommended by Maunsell, Leighton’s designer.
Leighton had implemented the crack-and-seat method in a Chinese project and showed knowledge of implementing the method. In addition, Leighton was involved early in the development phase and recommended the method to the MNTC.

In terms of project monitoring, Norconsult reviewed the detailed engineering designs prior to issuance of the CNTP. Actual project monitoring depended on the PB and the MNTC’s in-house technical arm, Project Controls Group. The PB oversaw project quality, administered contracts, and issued instructions and change orders. However, its authority only included all technical aspects of the project that did not affect schedule and costs. The PB could cite Leighton for quality non-conformances but could not issue work stoppages to address these quality issues. This is very akin to the role of the ICE/ISE in the THSR Project. Meanwhile, the Project Controls Group monitored project costs and schedule; but since the contract fundamentally allowed Leighton to administer self-certification, the most effective controls for the project were the liquidated damages clause, the latent defect clause, and the performance bonds (Baustista). The MNTC could use these as leverage when either schedule or quality was being compromised.

The NLE Project underwent a typical development process in the project financing context. The MNTC was the lead for the entire project and the Government had very little involvement in the project except for acquiring land for the ROW.

**Project Outcomes**

The MNTC’s main objective was to finish the project by the proposed schedule and immediately start operations. The use of a full EPC contract enabled fast revision and implementation of the design without coordination issues that usually inhibit fast delivery of traditional projects. However, this approach when paired with a lack of a formal design review process inhibited monitoring of project quality. Although quality was also a priority especially from the maintenance point of view, the specifications included in the ETR and the clauses in the contract were not able to support quality goals and prompted the following events:
The liquidated damage clause drove the contractor’s focus on completing the project on time but decreased the quality of the work.

Although an existing pavement condition report was available that identified areas in the road to be rehabilitated and replaced; Leighton, focused on meeting the construction schedule, opted to use the crack-and-seat method even for areas that should have been replaced.

The implementation of a code locally untried (AUSTROAD) brought out quality issues since the monitoring teams were unfamiliar with requirements for adequate testing and interpreting test results.

Due to the resulting quality issues, the MNTC was able to demand that the latent defect clause be extended for two years thus protecting the MNTC from incurring costs associated to early road deterioration.

Currently, the NLE is already in full operation. Leighton was able to substantially complete the project within the required timeframe but with quality issues. Killick commented that the asphalt overlay was already showing reflection cracks and the toll road was not up to international standards.

**SOBRR Chao Phraya River Bridge Project**

The SOBRR Project is a typical government-procured project except for the project financing structure used. This project is most closely related to the THSR Project; however, the Thai Government was fully involved in the development of the SOBRR Project while the Taiwanese Government was only involved in the initial development phase. The Thai Government assumed the Sponsor role in this project except for financing the construction phase. This project represents a variation to the use of private financing in infrastructure development.
The SOBRR Chao Phraya River Bridge Project was the last leg of the major expressway to complete the connection around Bangkok.

Fig. 8. Computer rendering of the SOBRR Bridge, roadtraffic-technology.com (http://www.roadtraffic-technology.com/projects/chao/chao1.html).

The bridge was designed with four lanes in each direction, 36.5 meters wide with a main span of 500 meters and side spans of 220.5 meters. After completion, it would be the longest cable-stayed bridge in Thailand (Hsu, “Southern”). Additional considerations for the design were the 55 meter undercarriage clearance for navigational purposes, 3% maximum gradient for the bridge deck, and a design life of 100 years (Hsu, “Southern”). Figure 9 illustrates the different participants involved in the SOBRR Project.
The succeeding sections will discuss how the Government handled the development of the SOBRR Project and fulfilled the requirements for each phase. As previously discussed projects, this segment will conclude with a discussion of the project’s outcome.

**Project Origin**

The SOBRR Chao Phraya Bridge was the last segment to complete the Outer Bangkok Ring Road which started construction in 2000. Its completion is scheduled to coincide with the opening of the new international airport in Bangkok in 2007.

The Thai Government led the preliminary works and development activities for this project. Except for private financing, this project limited private participation to the roles of designers, consultants, and contractors. As the Sponsor of the project, the Government took the lead in almost all aspects except for structuring the financing for the construction phase. All of these will be discussed in the succeeding sections.

**Sponsor Qualifications**

The Department of Highways (DOH) and the Expressway and Rapid Transit Authority (ETA) assumed the Sponsor roles. The DOH spearheaded this project
and is the current supervising agency for the design and construction phases. On the other hand, the ETA (as the operator of Bangkok’s highway systems) has the ownership rights to this project and would be in charge of the operation and maintenance upon completion (“Expressway”). These government agencies hold the same roles as the different Sponsors in the previously discussed projects. Krung Thai Bank holds the role of the lender by providing financing for the construction of the bridge. Mirroring Leighton’s roles in the NLE Project, the Ch KarnChang holds both Sponsor and Contractor roles; however, the Ch KarnChang serves as a construction contractor and not as an EPC contractor. The Ch KarnChang proposed the financing structure used for the SOBRR Project and provided the capacity for the project to be financed.

**Project Finance-ability**

The only component of the SOBRR bridge project to be privately financed was the actual construction. Selecting the design-bid-build approach was the DOH’s necessary first step to getting the project financed. Then, the DOH invited contractors to propose for both financing and construction of the project. This would have been implemented in the design-build contracts of THSR Project except for the THSRC’s hesitation to add more risks to the contractors. (Fleming, “Contractual” 234). In the case of the SOBRR Bridge Project, this was the only way of financing the bridge construction. The contractors initially had to present a financing structure that fulfilled loan requirements without any government guarantees (DOH; TAP). After loans had been made, the ETA would pay through budget allocations and collection of user fees guaranteed by bonds issued to the bank (DOH). This guarantee is parallel to the tripartite agreement in the THSR Project except that the guarantee covered the Government and not a third party.

**Technical Feasibility Results**

Unlike the MNTC that focused on studies to fulfill financial requirements, the DOH focused the feasibility studies on determining project needs and the appropriate project location. The 1975 Inter-city Motorways Network Study
identified the OBRR as a major route to improve traffic in Thailand, but it was not until 1996 that the DOH selected the project location (DOH). With the assistance of a group of consultants led by Parsons Brinckerhoff (PB), a bridge, rather than a tunnel, was selected based on soil condition, accessibility of waterways during construction, construction cost, and Right-of-Way (ROW) needs (Hsu). The Government already started preparation for construction by acquiring the ROW during the project’s design phase (1999) and finalizing its acquisition before actual construction (2004). The Government also engaged the PB to work on the contract drawings for cable-stayed bridge design under DOH supervision and set a 30-month construction schedule (DOH).

**Development Process Timeline**

The Government had started the project in 1996 but implementation began in 2004. The 8-year gap was used to: decide on a construction delivery process with the greatest financial advantage; determine the type of structure to cross the Chao Phraya River; and negotiate the ROW for the bridge. This shows some similarities to how the THSRC was able to utilize the development time to facilitate the construction phase. The bridge completion by February 2007 meant start of the ETA’s revenue generation through toll collection as well as payment of the construction loan to Krung Thai Bank.

After the contractors proposed financing for the project, the DOH started evaluation of the proposals in the negotiation phase. Although no contract for the ownership of the project was negotiated, the following phase involved the award of the construction contract used in the project.

**Negotiation**

Multiple contracts comprised the design and construction phases, which was usual for government-procured projects. The THSRC used a similar system for the depots and stations of the THSR Project although it was not discussed previously since the focus was on the civil works. The designer and the contractor had separate contracts with the Government. The designer assumed design risks for the bridge while
contractor assumed construction risks. The Thai Government shouldered overall completion risk which is comparable to how the THSRC assumed risks for the THSR Project. Since the emphasis of the discussion is on the privately-financed component of the project, the succeeding section will focus on the construction contract.

*The Construction Contract*

The Ch KarnChang was awarded the fixed price, lump sum construction contract for SOBRR Chao Phraya Bridge project. The winning contractor’s responsibility covered only the construction risks of delivering the project on time and with the prescribed quality. The construction schedule was set for 30 months from time of award or until February 2007, and the quality was indicated in the design specifications and drawings supplied by the designer, the PB. The following are six features of the construction contract (DOH; TAP):

- Liquidated damages imposed for construction delays and non-compliance to environmental restrictions payable to Krung Thai Bank to as much as 0.1% of the construction cost per day
- Provision of a 24-month latent defect warranty for completed works after final acceptance of from TAP Consortium
- Payments based on the actual progress to be approved by the Acceptance Committee, representatives from the DOH and the ETA
- Change orders approved by the DOH Project Director for values below 50 Million Baht and by the ETA Board for amounts over 50 Million Baht
- Changes in disbursement schedule consulted with Krung Thai bank
- Changes in design approved by the PB and accepted by the DOH

Before the construction contract was awarded to Ch KarnChang, the DOH had already commissioned the PB to formulate the design for the cable-stayed bridge (Hsu). These became the contract documents used by the Government to solicit the construction proposals and basis for evaluating the best contractor to implement the project. The difference between these documents with those provided to the THSR civil contractors is that the contractors were not allowed to innovate or
optimize the design unlike in the THSR Project, where the contractors were encouraged to do so.

Terms of Reference

The DOH provided 100% complete design drawings and design criteria, and assumptions prior to actual construction. Design assumptions considered the method to be used in actual construction. In this case, the PB designer based assumptions on a balanced-cantilever method (Hsu). All other information, such as size of ROW and soil conditions, was also provided to the contractors. The PB needed to approve execution plans before construction. The DOH was very hands-off to managing the design process pre-implementation and during construction. The design did not undergo a formal evaluation process from the Government such as reviews for 30%- , 60%- , and 100%- completed designs for its approval (Hsu). Parallel to the NLE Project, the SOBRR Project also does not have an established process for resolving design issues during construction such as addressing Requests for Information (RFI) and reviewing shop drawings.

Nonetheless, the TOR was the contractors’ basis for formulating the proposals and the DOH’s basis for evaluating proposals as manifested in its selection process.

Contractor Selection

The DOH implemented a two-phase selection process: pre-qualification and proposal evaluation. This is a mirror of how THSRC administered its contractor selection process. The first step required the contractors to fulfill the following three pre-qualification guidelines (“Matichon”):

- Partnerships especially with foreign firms were not allowed.
- Completed projects should amount to Seven Million Baht with at least one project worth 1.5 million Baht.
- Contractors must be eligible for bank loans without any Government guarantee.
When a contractor was pre-qualified, its proposals were evaluated based on technical and financial merits. The technical evaluation covered the contractor’s experience, personnel, construction methodology particularly method statements for building the project, environmental plans, type and capacity of equipment to be used, and suppliers for the bridge’s cable system. As for the financial aspect, the evaluation not only covered the cost of construction but also the creditworthiness of the contractor and the type of financial package (e.g., Minimum Loan Rate, payment structure) proposed (DOH). This is the same extent of evaluation conducted for the civil contracts of the THSR Project except for the coverage of the financial evaluation since the THSR civil contractors did not have to finance project construction.

The Ch KarnChang was awarded the contract because it was the lowest-priced bidder with acceptable technical and financial proposals. Immediately after, the construction phase commenced with the DOH and TAP consultants closely monitoring the quality of the project.

**Implementation**

The Ch KarnChang implemented the balanced-cantilever method for installing the bridge deck (Hsu). This method temporarily fixed the deck at the towers during the erection and then superstructure segments were lifted on both sides of the tower to keep the balanced cantilevering. As for the pylon construction, the Ch KarnChang used self-climbing scaffold which assisted in shortening the construction schedule due to continuous concrete casting of the towers (Ch Karnchang). These construction methods were selected because:

- The design assumed that the bridge deck would be installed using a balanced-cantilever method and the Ch KarnChang decided to adopt it in actual.
- The cantilevering over the Chao Phraya River was necessary to keep the waterways open for navigational purposes. A supported system could have been used for construction but this would have obstructed the use of the river.
The use of the self-climbing scaffold was not only becoming common in Thailand but it was also very efficient in speeding up production. The SOBRR Project only had 30 months to complete the construction phase and the Ch KarnChang used all means to increase project progress.

During implementation, the Ch KarnChang had ultimate responsibility for completing the project on time and with the desired quality (TAP). The DOH and TAP relied on the Ch KarnChang’s capability for interim schedule control since its company policy prohibited it from being more than 5% behind schedule for any project it was undertaking (DOH; TAP). In addition, the liquidated damage clause in the construction contract was the ultimate schedule control measure. Similar to the previously discussed projects, the liquidated damages clause is cited for providing the schedule control needed in the project. As for maintaining quality in the projects, the designer, the PB, commented on proposed design changes with the final decision depending on the DOH (Hsu) while both the DOH and TAP (3rd party consultant) monitored site quality especially in witnessing testing and ensuring the contractor’s conformance to specifications. The DOH and TAP were authorized to stop work if a quality issue was cited. This is unlike the role of the PB in the NLE Project or IREG in the THSR Project where both did not have the power to enforce resolution of quality issues and only acted on an advisory level. With regards to monitoring of costs, the Acceptance Committee checked and approved the payment applications made by the contractor based on actual completed work (DOH).

The SOBRR Bridge Project underwent a development process fully implemented by the Government. Surprisingly, there is much similarity to the THSR Project on how this project was developed but the difference lies in the priority of project goals. For the THSR Project, the schedule drove the implementation of the project. The THSRC took every measure to ensure that the contracts would be completed on time. On the other hand, the DOH focused on assuring project quality even though it claimed that schedule was a project driver.
**Project Outcomes**

The private financing provided in this project did not add any requirements to completion of the project (DOH). Krung Thai Bank’s interest in the project is mostly commercial unlike multilateral export agencies or the World Bank which imposes restrictions to project implementation. In addition, no separate bank representative was assigned to the project and the Acceptance Committee was fulfilling the role of both owner’s and lender’s representative.

Although the project is yet to be completed, the schedule has experienced some delay from design issues. The Government expects the liquidated damage clause to cover the interest costs incurred by the loan in the event the project gets delayed and the Ch KarnChang ends up to be at fault. Otherwise, the Government stands to absorb the additional costs if the delay is linked to the owner. If this becomes the case, the Government’s assumption of lower costs from using the design-bid-build approach may not be realized; however, the project still benefits because of the greater control over the end quality.

**Nam Theun 2 Hydropower (NT2) Project**

The NT2 Project is an example of a greenfield limited recourse project, which is a new development with the ability to pay back its costs through revenue generation. This project is like the NLE Project in terms of financing except that its revenues are guaranteed through off-take agreements which were absent from the NLE Project. Another similarity to the NLE Project is the private sector’s lead in developing the project. However, the Government is a partner in the development process of the NT2 Project through significant shares in the NTPC and the Power Purchase Agreement while the NLE Project had minute government involvement. The Government and the NTPC also negotiated for the award of the BOOT contract analogous to that of the NLE Project. This project provides another variation of implementing the development process and in providing project financing.
The main features of the NT2 Project are a 48-meter high Roller Compacted Concrete (RCC) gravity dam on the Nam Theun River, a 450-square-kilometer reservoir, a powerhouse, a 130-kilometer double-circuit 599kV transmission line to Thailand, and a 70-kilometer single circuit 115 kV transmission line for domestic use in Lao PDR (“Decision” 1).

Besides completion of the technical aspects of the project, the World Bank imposed socio-environmental goals, i.e., resettlements, unexploded ordinance, to be fulfilled in the project. One of the project challenges is balancing accomplishment of these socio-environmental goals with construction completion of 54 months after financial closure. Figure 11 illustrates the key participants in the development of the NT2 Project.
The subsequent sections will discuss the development of the NT2 Project as well as how the NTPC and its partners fulfilled the various requirements at each phase.

**Project Origin**

In the 1970s, the Mekong Secretariat identified Nam Theun 2 Hydropower (NT2) Project as the most economically viable hydropower proposal in Lao PDR. The Government of Lao PDR (GOL) then started soliciting Project Sponsors. In 1994, the Electricité de France (EDF) and Italian-Thai Development Public Company Limited (ITD) of Thailand became involved and the World Bank was invited to participate in the project.

**Sponsor Qualifications**

The current project vehicle, Nam Theun 2 Power Company Limited (NTPC), is composed of the following firms (Organization; “Project Introduction” 1):
o 35% Electricite du France International (EDF): a wholly owned subsidiary of EDF which has extensive involvement in developing thermal power plants under the Build-Operate-Transfer contracts

o 25% Lao Holding State Enterprise (LHSE): owned by the GOL

o 25% Electricity Generating Public Company Limited (EGCO): first independent power producer in Thailand

o 15% Ital-Thai Development (ITD): one of the largest infrastructure companies in Thailand and one of the largest civil engineering contractors in Southeast Asia

The Sponsors came from both the private and government sectors dependent on their interests in the project.

Project Finance-ability

The project was supported by an existing Memorandum of Understanding (MOU) between Thailand and Lao PDR that included Lao PDR supplying 3000MW of electricity to Thailand. Consequently, the electricity produced in this project was subject to Power Purchase Agreements (PPA) with both Electricity Generating Authority of Thailand (EGAT) and Electricite du Laos (EDL). The development model used in this project was similar to those of other developed projects though smaller than the NT2 Project, 1070MW versus combined 500MW of previous projects) (Lao-Thai; “Project Introduction” 1). Both debt and equity were used to finance the base project cost with equity being 30% of the base cost and the rest financed by loans from more than 19 lenders including the World Bank and other multilateral agencies. The D/E ratio is comparable to that used in the THSR Project although the lenders are comparable to those involved in the NLE Project.

Technical Feasibility Results

The GOL provided flow records of the Nam Theun River which were an important basis for forecasting electricity generation. The reliability of electricity generation governed the negotiations for the PPA (Hydrology). The Sponsors were
able to gather hydrology or river flow information and geological information for the reservoir and dam areas to develop the project’s basic design and specifications. The geological conditions of the chosen areas determined whether these were suitable for constructing major civil works and for impounding water, while the predicted amount of impounded water dictated the design of the spillways (Dam). From these technical findings, the Sponsors were able to determine that the base project cost would be USD 1.45 Billion including contingency funds (Project Cost).

Development Process Timeline

From 1994 to 2005, the current Sponsors restructured the project to attract commercial lenders and gain more Project Sponsors (“Project Introduction” 1). Similar to the THSR and the SOBRR Projects, the NT2 Project utilized the time between award and financial closure to perform preliminary activities. And like the THSRC’s agreement with Taipower for performing advance works, the NTPC reached a Pre-construction Agreement with EDF to carry out preparatory works for tunnel and powerhouse excavation, dam site work, and Unexploded Ordinance (UXO) clearance. These preliminary activities allowed faster implementation of major construction activities after financial closing on June 2005 (Harrison).

The NT2 Project spent a longer time in the project origin phase compared to the other projects because of the more controversial nature of hydropower project developments. However, after the World Bank became involved, the NT2 Project became a more feasible hydropower project.

Negotiation

The NTPC and the GOL reached a Concession Agreement (CA) which embodied a 25-year Build-Own-Operate-Transfer contract consistent with the 25-year “take-or-pay” PPA with EGAT. In the agreement, both GOL and the NTPC were both responsible for enforcing the environmental and social standards particularly in the relocation of villagers. However, only the NTPC was responsible for the timely delivery of the generating facilities to EGAT (“Project Introduction” 2). In comparison
to the other projects, the NT2 Project has the most specific limitations set by lenders such as payment curves and extensive social and environmental limitations. For the construction of the project, the NTPC formed a Head Construction Contract (HCC) with the EDF, to be further discussed, to address construction completion risks. This HCC is comparable to Leighton’s EPC contract with the MNFC in the NLE Project.

The Head Construction Contract

The Head Construction Contract was an EPC contract conforming to the requirements of the CA. The HCC was then broken up into five subcontracts: three civil contracts and two electrical and mechanical contracts, but the overall construction completion risks still remained with the EDF as the Head Construction Contractor. The following were some features of the Head Construction Contract and subcontracts (Harrison):

- **Back-to-back obligations to the construction risks** and fulfillment of the design criteria provided in the CA
- **Lump sum, fixed price contracts** with set finish dates
- **Full responsibility** over the construction phase by the HC
- **Lender-approved subcontractors** for implementing major works
- **Liquidated damage for missing milestones** on specified completion dates
- **No payments exceeding the payment curve**
- **No payments for partially achieved milestones**

For the NT2 Project, the EDF was both Sponsor and HC similar to Leighton’s role in the NLE Project but with the difference that Leighton had to compete for the contract while the EDF negotiated the award. The use of the Terms of Reference was more of a contractual document to which the EDF accepted and bound itself. The details of the TOR will be discussed below while the negotiated selection process will be discussed in the succeeding sections with emphasis on the five major subcontractors.
Terms of Reference

The NTPC provided the Owner’s Requirements (reference design and design criteria) to the EDF as basis for developing the final designs for the major works in the project. Also included in the OR were the following results of different site studies that affected the end designs:

- relocation of the Roller Compacted Concrete (RCC) dam 100 meters from its original location due to the results of extensive exploration;
- boring data provided by EDL for determining the best location for transmission towers;
- and relocation of the powerhouse from underground to aboveground because of geological conditions.

The OR was extensive but not always complete, such as missing design items in the reference design. The OR focused on achieving social and environmental goals required by the World Bank in the implementation of works. In some cases, design decisions were governed by the social aspects as was the case in the final design of the downstream channel. The following were some design and construction considerations that depended on the social and environmental aspects of this project:

- implementation of Laotian preference in the selection of workforce;
- placing of sedimentation ponds to avoid contamination of waterways by runoff from the construction areas;
- designation of spoil areas with the least impact on the local community;
- and involvement of the Panel of Experts and Dam Safety Review Panel and other 3rd party NGOs.

Although the THSR Project also fulfilled conditions such as local labor requirements, the NT2 Project surpasses any of the set restrictions on the other three projects.

Resembling the THSRC, the NTPC developed formal processes for design revisions and design reviews. A deviation from the reference design resulted to issuance of a variation order (VO) which was approved by the NTPC and the
lenders especially for VO with cost implications. As for the design review process, the contractors were required to complete designs and allow the NTPC to review key drawings and method statements before construction (Harrison).

**Contractor Selection**

The negotiated procurement method was implemented for selecting the Head Contractor. The EDF was one of the longest-involved sponsors in the project and was very involved in developing the reference designs and design criteria. Also, the EDF was renowned in the development of power projects and was well-qualified as the Head Contractor. This was the only project out of the four previously discussed projects that used the negotiated process.

In selecting the five major subcontractors, the negotiated method was used especially for the civil contracts because of ITD’s involvement as a Sponsor. The EDF could choose its preferred subcontractor but needed to get the lenders’ stamp of approval. Both the NTPC and the EDF separately checked the qualification of potential subcontractors basing on each firm’s experience and past performance records. In some cases, they contacted past clients of the subcontractor to verify the company’s credentials and authenticity of provided information. The chosen contractor was not necessarily the lowest-priced but was the best bidder for getting the job done (Harrison).

After the BOOT contract, PPA, and the HCC had been finalized, the implementation of the major constructing activities began. For this project, the NTPC considered the social and environmental goals and project quality to be the utmost priorities although finishing by a set date was also important because of its commitment to EGAT. Besides the NTPC setting up its own monitoring systems to ensure achievement of these goals, the lenders also provided a great deal of oversight to the project. As a result, the project had numerous monitoring systems in place during the implementation phase.
Implementation

The gravity dam was designed to be roller compacted concrete (RCC). Before constructing the actual dam, two different cofferdams would be fronting it with the one nearest to the actual dam being made of RCC as well. This structure would be the trial structure for perfecting the design mix and developing the necessary skills for the actual dam. Behind the dam would be another structure that would contain the backflow effect from water exiting the diversion tunnel and facilitate work at the dam site. The designed capacity of the diversion tunnel was not sufficient to prevent backflow and therefore additional cofferdams were needed to mitigate the effects of big river flow (Harrison). For tunnel construction, the subcontractors either used the drill-and-blast method for hard soil and rocky conditions or used a tunnel boring machine (TBM) when the soil permitted its use. The subcontractors were using relatively ‘small’ equipment’ to implement excavation works in the NT2 Project. Factors which affected the selection of construction means, methods, and equipment were as follows:

- Subcontractors were mostly local or coming from Thailand. The available equipment was comparably smaller than those commonly used in the United States. An example would be the size of excavators. A T9 Caterpillar excavator was not common equipment in Asia and had to be directly imported from the United States (Harrison). The subcontractors chose to use excavators with 1.5-cubic-meter buckets but in greater number of equipment.

- As for tunnel construction, the soil condition dictated which tunneling method was best to use. The drill-and-blast method was used for rocky or hard soil while the TBM was used for medium soil condition.

- The climatic conditions in Lao PDR determined the type of construction activities to be performed within a given season. During the dry season, contractors planned to be most productive at the dam site because the wet season prevented any work from being completed there.
Laotian preference, a CA requirement, affected the type of equipment or materials to be used in the project. The NTPC considered locally available materials and equipment first before it could import items for the project.

The subcontractors, through their design-build contracts, were free to choose the type of construction method to use as long as the schedule was met.

Each construction activity had to be considered for its social and environmental effects. Sedimentation ponds were built to minimize contamination of waterways and other construction activities had to be scheduled such that there would be the least impact to the community or the environment.

Major construction works began almost the same time of reaching financial closure. Project monitoring was administered in two levels with the first level provided by the Panel of Experts (POE) and Dam Safety Review Panel (DSRP). The POE checked the achievement of the project’s social and environmental goals especially the relocation of villagers and sustainability programs, while the DSRP ensured the technical soundness of the project particularly that of the dam. The NTPC was required to follow any recommendations made by these parties (Harrison). These two parties have the corresponding role of the IV&VE in the THSR Project who validated the adequacy of the THSR. The second level of monitoring was administered by the NTPC’s own groups particularly the Social and Environmental Division and the Construction Division.

Overseeing the quality aspect of the project were the NTPC site representatives and the Owner’s Engineer. The NTPC site representatives visually checked site quality against the submitted quality plan, although the contractor was still expected to perform self-certification and had its own quality manager on site (Harrison). On the other hand, the Owner’s Engineer was present to witness manufacturing-related testing, equipment testing, and other tests related to the facilities, which is equivalent to PB’s role in the NLE Project.

To keep the project on schedule, the NTPC closely monitored the contractor’s progress versus its proposed schedule. However, the most influential control measure was the liquidated damages (LD) clause that the NTPC considered sufficient to cover
costs incurred in case of delays. Again, this project uses the LD clause as a schedule control measure parallel to those in the three projects discussed.

As for costs, the NTPC required proof of completed work either through pictures or testing documents that the lender’s engineer used to verify payments made. Payments could not exceed the monthly payment curve and the NTPC strictly imposed this curve because the project’s finances must comply with the limitations set by the lenders (Harrison). This project has a stricter payment scheme than the other three projects. The THSR, NLE, and SOBRR Projects required proof before providing payment but no maximum amount was set per month.

The NT2 Project’s development process is similar to that of the NLE Project in that achieving financial closure triggered the implementation phase. This project, however, experienced the most influence from lender requirements during the implementation of the project. Fulfilling social and environmental goals was a high priority although quality and schedule were still emphasized as an outcome of the project.

**Project Outcomes**

Much of the focus in implementing this project is on delivering a quality facility, achieving social and environmental goals, and meeting the schedule. However, fulfillment of the social and environmental goals may cause an impact on the final design of the project thus affecting project quality. These effects on the final quality may be mitigated if extensive planning during the design phase and quality monitoring during the implementation phase.

As for meeting the schedule, the design-build nature of the contracts facilitated faster implementation of the project. However, the combination of inherent risks in the project – excessive rainfall events, possible delay in handover of land to the contractor, and geologic uncertainties – and the effects of social and environmental concerns, i.e., evacuating villagers from areas needed for construction, could negatively affect the project schedule. On the other hand, the contingencies set up by the NTPC may be sufficient to mitigate potential impacts of these risks to the project.
Based on this summary of the four projects, each project’s development process had similarities and differences. The projects were all affected by the actions, decisions, and activities that occurred during the project origin and the negotiation phases. The requirements of private financing and fulfillment of new developmental goals affected the course of project implementation. This background served as the starting point of Chapter 4 for analyzing how developmental factors contribute to the final state of project outcomes.
CHAPTER 4

ANALYSIS, CONCLUSIONS, AND RECOMMENDATIONS

The previous chapters provide the basis for this last segment of the thesis. In Chapter 2, the definition of the infrastructure development process and key characteristics and components at each phase provides the framework for studying the cases in Chapter 3. Each case reveals a unique approach to development as summarized in the checklist matrix (see Table 1 in Chapter 1). The observable trend is that each project performed or under-performed depending on the decisions made during the development process. The results of these decisions became the factors capable of shaping project outcomes; this is the foundation of Chapter 4. In addition to defining these factors, this chapter demonstrates a means to link the factors to the individual outcomes. The main focus is to highlight the positive or negative effect of each factor for individual project outcomes and then collate and compare the results to the actual outcomes of each project. The result of this analysis indicates that early development decisions – especially to privately finance these infrastructure projects – greatly influence project outcomes. More specific conclusions will be covered in the latter section of the chapter as well as some recommendations for future infrastructure project developers. Closing the chapter and this research is a discussion of possible topics for further study in future research projects.

Analysis of Front-End Factors Affecting Project Outcomes

The development process identified factors, called “front-end factors,” which greatly impact the outcome of projects. The decision regarding the initial ownership of the project, Public Private Partnership (PPP) or fully government, is an example. This decision can affect the development goals of a project, i.e., higher priority on financial goals, since the PPP entails more involvement from the private entities who require a return on their investment. These goals then translate to how a project is expected to
Other factors which also affect project performance will be further discussed in this chapter.

In the following sections, the researcher will identify the seven front-end factors that affect four project outcomes. The researcher will enumerate how the project manifests these factors and then describe how each factor positively or negatively connects to the different outcomes. As the positive and negative impacts are tallied for each outcome, the actual results of the project are compared to the results of the analysis for validation. The analysis section concludes by the comparison of factors and their effects across cases. These findings then form the basis for the conclusions of this research.

**Front-End Factors**

In this study, front-end factors are those resulting from agreements, decisions, contract terms, and conditions formed prior to project design and construction or at the early phases of the development process. The achievement of project goals is more dependent on the decisions made during the project origin phase than those during the design phase because decisions made earlier have greater influence on the project outcome. Because the development processes for privately-financed infrastructure projects are much more defined and apparent, they exert greater influence at earlier stages where there is most effect. This is illustrated in the influence diagram (Figure 1) in Chapter 2.

After analyzing the infrastructure development process of the four projects in this research, the following seven project characteristics emerges as evident front-end factors that exhibit influence on the outcomes of a project:

**Ownership Form**

The main project promoter during the development process is either the government or the private sector. The arrangement used to facilitate the infrastructure development is PPP or entirely government procured. One impact of the ownership form is in the management of the project schedule.
Project Delivery Method

Project implementation generally begins by awarding separate design and construction contracts to different entities or by awarding both design and construction to a single design-build entity. Under the design-bid-build approach, the focus is on delivering a quality product for the specified price. In using the design-build approach, the expected impact is more on the delivery time to have the project online when needed.

Terms of Reference (TOR)

The TOR embodies the owner’s expectations of the project. The level of detail available in the TOR, such as the level of the reference design, design criteria, conducted studies, and other technical information, affects how close the actual project reach the expectations. The TOR also covers areas of limitations and responsibilities, e.g., set time to construct. Reference materials could be as comprehensive as having detailed designs and specific construction methods included in design documents or as imprecise as only having project goals and objectives contained in the TOR. The most impact of the TOR on the project is on arriving at a fitting design to the requirements of the owner.

Contractor Selection

Contractors are subject to different levels of evaluation before awarded a contract. Some awards are based only on pre-qualifications while others are based on very detailed evaluation such as evaluation of the contractor’s planned construction means and methods for the project. The rigidity of the criteria used to select a contractor affects how well a contractor could deliver the project’s expected quality.

ROW Acquisition

Infrastructure projects are usually built on a great expanse of land. When these projects are built in populated areas, the required land are usually privately owned or utilized by existing communities. Acquiring the Right-of-Way (ROW) is an
easy or difficult process depending on the result of negotiations between the acquiring agency and the landowner or user. Some negotiations never begin causing a project development to fold. In other cases, the planned and actual ROW acquired are different, which affect implementation of the planned project. The timing of ROW acquisition has an impact on the start date for a project and how much of the planned design could be followed.

*Project Quality Management System (Project QMS)*

The owner’s expected project quality is usually prescribed in the specifications. Difference in interpretation between contractors and owners can cause projects to fall short of the owner’s expectations. In order to avoid such scenarios, measures are established to monitor project quality that includes involvement of 3rd part review bodies and existence of formalized project quality assurance and control systems. These are usually set up to fulfill contract clauses or caveats placed during contract formation. The focus of these systems is on delivering a project conforming to pre-set specifications.

*Financial Arrangement*

The format and type of contract used in procuring the design and construction phases indicate how cost-related risks are allocated in the project. Most privately-financed infrastructure projects require that the construction contract be lump-sum and fixed-price. Being the private financiers, the project lenders have great control over payment disbursements and drawdown schedule. Liquidated damage clauses are also becoming common in contracts to account for costs incurred from delay in project delivery. The major impact of the existing financial arrangement is in the owner’s ability to control the costs incurred for the entire project duration in terms of change orders, quality defects, or initial procurement.

After the identification of the front-end factors and the areas which they could influence in a project, the next section will identify the specific outcomes that these front-end factors have positively or negatively impacted on the studied projects.
Project Outcomes

Although operations is an important component of most privately-financed infrastructure projects, this study will focus only on the physical completion or construction completion of the project as the end goal. In this research, project outcomes, therefore, pertain to the type of cost control, quality control, and schedule control exhibited (from the owner’s perspective) and the actual construction means and methods used in the project. The definitions below are the researcher’s interpretation of project outcomes from concluded interviews on the four studied projects.

Cost Control

Although a fixed price has been determined during contract formation, the owner possesses the ability to influence, either to increase or decrease, actual costs borne in the project through measures related to variation orders and contractor problems. When a project is completed with minimal cost additions to the owner, the owner implemented sufficient cost control over the project.

Quality Control

Quality pertains to both the actual state of the physical structure and the level of conformance to the original design intent. As a project is implemented, the degree to which the design goals and criteria are achieved forms part of the project’s quality. Quality is also associated to the project’s capacity to function according to the performance specifications during its predicted life cycle. Deficiencies in the physical structure indicate low quality control during the construction phase.

Schedule Control

For the projects studied, privately-driven projects emphasize achieving the schedule because finishing the project early or on time means immediate realization of revenues. Although owners are only concerned with the project end date and not with the entire schedule, the owner’s ability to influence the schedule
at intermediate milestones increase confidence of achieving project end dates. Even if the contractor has the ultimate control over the schedule especially for date-certain contracts, the owner could motivate the contractor, through bonus or liquidated damage clauses or linking payments to completed milestones, to finish early or stay within the project schedule. When such incentives or measures are in place, the owner possesses greater schedule control over the project.

*Selection of Construction Means and Methods*

Although contracts seldom dictate the actual construction methodology to use, there are cases that design governs the chosen method. In some instances, the preferred methods are indicated in the reference material provided by the owner and the contractor only has to concur with this or not. When the results of extensive investigation and study are presented to the contractor, the preferred method sometimes become obvious and may be selected for implementation. With several possible construction methods existing, the contractor’s experience, but more so economy, become the governing factor. Implementation of a particular construction means is possible if the owner makes the contractor aware of the preference as well as the merit of using the method as supported by the available data.

Using the four previously discussed projects as context, the succeeding sections detail how each project fulfilled the front-end factors as well as how these factors individually affected the project outcomes. The results are tabulated per project – THSR Project, NLE Project, SOBRR Project, and NT2 Project – followed by a detailed explanation of how each factor positively or negatively affected or did not affect the outcomes. Depending on the combined effects of the factors, a project could exhibit low, medium, or high levels of cost, quality or schedule controls. This, then, will be compared to the actual degree of project completion and provide validity to the result of the analysis. As for determining the effect of front-end factors on the selection of construction means and methods, the analysis will only determine whether front-end factors were correlated or uncorrelated to the decision to select the major
construction methods as indicated by the events or situations which occurred in each project.

As a visual guide to identifying the effects of front-end factors on the project outcomes, tables are presented in the succeeding sections with front-end factors on the left-hand column and the project outcomes on the top row. As each factor is assessed for its impact on the different project outcomes, a plus (+) or minus (-) sign is indicated signaling that the factor has positively (+) or negatively (-) affected that particular outcome. In assigning symbols for checking the correlation of a front-end factor with the selection of construction means and methods, a letter “C” is used to signify a correlation between the factor and the method while an “n/a” would be for no correlation. The “n/a” is also used for signifying that a front-end factor has no effect on cost, quality, or schedule control. Each table is then succeeded by a detailed explanation of how each front-end factor from a project affected the individual outcomes.

**Taiwan High Speed Rail (THSR) Project**

The cost control for the THSR Project was negatively affected by three factors: Ownership Form, Delivery Method, and Contractor Selection. The choice of Delivery Method together with the Project Quality Management System was also not supportive of achieving good quality control. However, the effects of these factors were not always negative. In this case, the negative impacts were due to the THSRC’s decision to focus more on schedule goals rather than on cost and quality. Table 2 shows the individual impacts of front-end factors to each project outcome. The table is followed by more details regarding the positive or negative effect of the factors on the outcomes.
Table 2
THSR Project Predictor-Outcome Matrix

<table>
<thead>
<tr>
<th>Front-End Factors</th>
<th>Cost Control</th>
<th>Quality Control</th>
<th>Schedule Control</th>
<th>Construction Means &amp; Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership Form</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>n/a</td>
</tr>
<tr>
<td>Delivery Method</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>C</td>
</tr>
<tr>
<td>Terms of Reference</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>C</td>
</tr>
<tr>
<td>Contractor Selection</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>C</td>
</tr>
<tr>
<td>ROW Acquisition</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>n/a</td>
</tr>
<tr>
<td>Project QMS</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>n/a</td>
</tr>
<tr>
<td>Financial Arrangement</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>C</td>
</tr>
</tbody>
</table>

Ownership Form, 35 years Build-Operate-Transfer Contract on:

- **Cost Control (-)**: The THSRC’s willingness to “inject” money into a civil contract to help the contractor keep up with the schedule meant that the THSRC emphasized less on controlling costs for the project.
- **Quality Control (+)**: The THSRC intended to build the THSR to high performance standards that would allow it to operate even after the concession period. Ricardo Tan, a THSRC Vice President, even stated that the THSR would possibly be the only HSR in Taiwan for a while. The THSRC’s focus on a long performing HSR contributed to a positive quality control for the project and manifested in the amount of project monitoring and validation systems.
- **Schedule Control (+)**: The THSRC provided positive schedule control by setting a detailed construction master schedule to which the contractors had to conform. This master schedule highlighted interface management by the different contractors and the contractors had to show that their schedules addressed all possible interfacing issues in the project.
- **Selection of Construction Means and Methods (n/a)**: not applicable

Project Delivery Method, Design-Build Approach on:

- **Cost Control (-)**: The THSRC’s decision to use design-build for the civil works meant that contractors were expected to have higher bids thus resulting to
lower cost control for the owner because the contractors needed to be compensated for taking both risks for the design and construction aspects.

- **Quality Control (-):** The nature of the design-build approach meant that the contractor was freer to make decisions about the project as long as the performance requirements were fulfilled. This resulted to the THSRC’s lessened ability to control the final quality of the project.

- **Schedule Control (+):** Because of the ability to simultaneously coordinate the design and construction aspects, the civil contractors of the THSR Project were able to still meet the original schedule even with issuance of variation orders (VO1 and VO1A) during the design phase which could have resulted to delays. The design-build approach assisted the contractors in completely utilizing the schedule for both the design and construction phases.

- **Selection of Construction Means and Methods (C):** Because only 23 bidders pre-qualified for the 12 civil contracts, the THSRC could only choose from a limited pool of contractors. The number of proposed construction methods depended on the number of qualified contractors. The smaller the pool of contractors, the fewer the options for alternative methods.

_Terms of Reference, Detailed Design, Site Information, and Design Review Process on:_

- **Cost Control (+):** The THSRC managed its costs regarding changed site conditions by providing geotechnical data, i.e., boring logs every 100 meters of the alignment, and passing ground-related risks to the contractors. These were all indicated in the general conditions of the civil contracts.

- **Quality Control (+):** With detailed studies supplied to the contractors as well as a defined design review process, the THSRC had more control over the development of the final designs of the viaducts and tunnels.

- **Schedule Control (-):** The THSRC’s design review process was time-consuming for both the reviewers and the contractors. The process normally cycled 45 days excluding time to resolve objections to the design. This process
interfered with the construction schedule and prevented the contractors from completely managing the schedule.

- **Selection of Construction Means and Methods (C):** Although the THSRC did not specify means and methods, the results of studies, e.g., geotechnical investigations, optimal span length, predicated the methods to use such as the NATM for tunneling or Full Span Launching Method for river crossings.

**Contractor Selection, Pre-qualify, Technical, Financial, and Legal Evaluation on:**

- **Cost Control (-):** The THSRC’s selection process focused on evaluating an adequate technical proposal and acceptable financial proposal. The lowest-priced bidder did not necessarily win the contract until its technical proposal met expectations.

- **Quality Control (+):** In the selection process, the contractor had to show a quality plan that conformed to ISO 9000 standards. The evaluation also considered the competence of the contractor’s entire technical group such as the designer, contractor, and the CICE. By doing so, the THSRC intended to employ contractors who could provide assurance of producing quality work.

- **Schedule Control (+):** The THSRC checked the sequential logic of the contractors’ construction schedule which had to conform to the master schedule and show adequate interfacing with the other contractors. The construction schedule was deeply scrutinized by the technical evaluators and the contractor’s key personnel were interviewed regarding the approach to fulfill the proposed schedule. As such, the THSRC controlled the contractors’ ability to conform to the schedule.

- **Selection of Construction Means and Methods (C):** The selection was based on how the contractor presented the construction process with the best use of its available equipment. Each contractor’s proposal needed to show the logic and sequence of work. The proposed cash flow and resource scheduling had to support the planned flow of construction activities. If the proposed
construction method was not acceptable, the contractor was not selected regardless of price.

**ROW Acquisition, Completed Before BOT Contract on:**

- **Cost Control (+):** The THSRC did not have to manage risks or bear additional costs to the project regarding ROW acquisition since the Government provided the full project ROW even before soliciting proposals for the BOT. There was no need for the THSRC to allocate funds to compensate affected parties for the land needed for the THSR Project.

- **Quality Control (+):** Since the ROW was already set before the designs were even made, the designs did not have to undergo any revisions to accommodate the available ROW. Having the ROW acquired allowed the THSRC to implement the alignment without any problem with the existing communities.

- **Schedule Control (+):** The project’s implementation phase was not affected by a need to redesign or relocate any planned structures because of the completed ROW acquisition.

- **Selection of Construction Means and Methods (n/a):** not applicable

**Project QMS, 3rd Party Involvement and Contractor Self-Certification on:**

- **Cost Control (+):** Since all cost-related issues in the project had to be approved by the THSRC Vice President or even the Chairperson of the THSRC depending on the cost values, the THSRC could fully control which costs were incurred in the project.

- **Quality Control (-):** The contractors’ self-certification process did not always ensure the achievement of quality. Since the contractor was contractually responsible for administering project quality, the presence of the ISE and Resident Engineers did not completely remove quality control issues. The end quality of the project depended on the contractors’ ability to administer adequate self-certification. This system prevented the THRSC from exerting maximum control over the end quality of the project.
- Schedule Control (+): By having the Resident Engineers (RE) on site, the THSRC influenced the schedule because the RE ensured that the contractors addressed project issues before causing delays to the schedule.

- Selection of Construction Means and Methods (n/a): not applicable

**Financial Arrangement, Fixed-Price, Lump Sum Contract with Liquidated Damages (LD) on:**

- Cost Control (+): The fixed-price nature of the contracts limited the THSRC’s costs of the civil works. More entities besides the THSRC were involved in the control of payment drawdown. The lenders’ engineer was involved in payment processing for achieving milestones. With so many control points for payment processing, the THSRC completely controlled which project items were actually paid.

- Quality Control (+): The payment structure included caveats such that non-conformance of quality-related milestones resulted to non-payment and freezing of a price center. When a price center was frozen, all other milestones associated to that center were not paid until the non-conformance was resolved. Also, payments had to be approved by the lender’s engineer, who verified project quality and checked project documentation (certification from the THSRC and site verification for actual values) using a checklist translated from the CO&A, before signing-off.

- Schedule Control (+): The THSRC imposed liquidated damages for schedule delays. This assisted in controlling the schedule because the contractors had the incentive to deliver the project on time to avoid paying damages to the THSRC.

- Selection of Construction Means and Methods (C): Since contracts were fixed-priced, the contractors chose means most cost effective to them. The contractors chose their construction method dependent on their available equipment and experience with the chosen method. An example was the use of multiple methods for viaduct construction namely: FSPLM, FCM, or MSS (see Acronyms page for names or Appendix A for full details). These translated to
cost savings for the contractor in terms of less investment needed for new equipment and lower learning curves of their personnel to go through.

**North Luzon Expressway (NLE) Project**

The NLE Project demonstrated the negative factors mostly for quality control. This was mainly because of the MNTE’s focus on fixing the costs of the project and ensuring the project was constructed on schedule. The ROW Acquisition negatively impacted the cost, quality, and schedule controls because the project had to accommodate the needs of completing the acquisition of ROW. Table 3 provides a visual look of which factors contributed positively or negatively to the outcomes. Similar to the discussion of THSR Project, the table is followed by more details on factors affecting project outcomes.

Table 3

NLE Project Predictor-Outcome Matrix

<table>
<thead>
<tr>
<th>Project Outcomes</th>
<th>Cost Control</th>
<th>Quality Control</th>
<th>Schedule Control</th>
<th>Construction Means &amp; Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ownership Form</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>C</td>
</tr>
<tr>
<td>Delivery Method</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>C</td>
</tr>
<tr>
<td>Terms of Reference</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>C</td>
</tr>
<tr>
<td>Contractor Selection</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>C</td>
</tr>
<tr>
<td>ROW Acquisition</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>n/a</td>
</tr>
<tr>
<td>Project QMS</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>n/a</td>
</tr>
<tr>
<td>Financial Arrangement</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>n/a</td>
</tr>
</tbody>
</table>

*Ownership Form, 30 years Rehabilitate-Operate-Transfer Contract on:*

- **Cost Control (+):** The MNTE guaranteed a fixed price to the lenders upon financial closure. This meant that the MNTE had to control project costs to stay within its financial limits especially because of the Asian financial crisis. It would have been very difficult for the MNTE to acquire additional funding if the need would have arisen.
- **Quality Control (-):** The 30-year contract did not directly support achievement of good quality for the initial rehabilitation of the NLE. Since the warranties
for asphalt and concrete pavements were for 10 years and 20 years respectively, the rehabilitation process would be undertaken more than once within the entire 30-year concession. This explained the MNTC’s decision to use the least costly rehabilitation process. The concession period was too long to guarantee maximum duration of performance of the rehabilitated pavements.

- **Schedule Control (+):** The MNTC had to optimize the project schedule to maximize its ownership of the NLE within the 30 years of the concession period. The MNTC had to minimize the construction schedule to maximize years of operation.

- **Selection of Construction Means and Methods (C):** Being one of the project sponsors, Leighton was able to recommend the crack-and-seat method (mentioned in Chapter 3) as early as the project origin phase. This method was the basis for developing the construction schedule and cost estimates proposed to the lenders for financial closing.

*Project Delivery Method, Design-Build Approach on:*

- **Cost Control (+):** The MNTC was able to use the lender-approved construction budget as the fixed price of actual construction since Leighton both proposed the budget and implemented the actual construction.

- **Quality Control (-):** Leighton was responsible for the overall project quality due to the full turnkey nature of the contract. As long as Leighton was able to deliver the project within the specified performance standards, the MNTC had limited authority over project quality.

- **Schedule Control (+):** Leighton was able to manage both design and construction simultaneously to meet the two-year timeframe of the construction schedule. The design-build approach allowed fast implementation of design updates. Since Maunsell was part of Leighton’s team as the designer, design changes made were promptly relayed to Leighton’s construction team.

- **Selection of Construction Means and Methods (C):** The design-build approach allowed the contractor to design the new toll pavement considering the crack-and-seat as the pavement rehabilitation method.
Terms of Reference, Design Criteria with Option for Contractor Preference on:

- **Cost Control (+)**: Since all responsibilities for utility relocation and existing site condition investigation were passed on to Leighton through the EPC contract, the MNTC could control its own costs related to these aspects. Leighton was also responsible for determining required ROW for the project. Costs associated to these investigatory efforts were shouldered by Leighton.

- **Quality Control (-)**: The MNTC’s ETR allowed Leighton a great deal of flexibility in providing the end quality of the project. Even without much familiarity using AUSTROAD, the MNTC approved its use as the governing code for the pavement rehabilitation which did not assist in controlling quality.

- **Schedule Control (+)**: The ETR was permissive and did not have a prescribed design review process that gave Leighton the flexibility to complete the project without much intervention from the MNTC.

- **Selection of Construction Means and Methods (C)**: Leighton’s input in developing the design and construction criteria determined the use of the crack-and-seat as a possible construction method. In addition, there were only limited rehabilitation processes for existing pavements to consider for the NLE Project.

Contractor Selection, Pre-qualify on:

- **Cost Control (+)**: Leighton was pre-qualified as both contractor and sponsor for the project. As such, it was involved in developing the financial proposal to the lenders. This allowed the MNTC to impose the same budget for Leighton’s actual costs for implementing the project.

- **Quality Control (-)**: With the MNTC’s process of contractor evaluation, only the experience, financial capacity, and the ISO certification of the contractor were considered. Since the contractor’s plans for constructing the project were not considered in the evaluation, the MNTC was unsure of how Leighton would perform the works and achieve the expected level of quality.
Schedule Control (+): Since Leighton was involved in proposing the 24-month construction period, the MNTC was able to require Leighton to deliver within that timeframe.

Selection of Construction Means and Methods (C): Leighton’s experience included a completed project in China which implemented the crack-and-seat method and so its use in the NLE Project was based on this proven experience.

ROW Acquisition, Completed Before Implementation Phase on:

Cost Control (-): The MNTC was financially involved in the ROW acquisition because the Government did not have the necessary funding capacity. This was part of the financing required for the project which the MNTC also had to manage. In addition, the MNTC lost some years of the concession period in acquiring the ROW consequently lessening the years for operations and revenue generation.

Quality Control (-): Because ROW acquisition was only completed after the initial design phase, the MNTC had to change its decision of making all interchanges into trumpet style to retaining and merely updating the existing interchanges. This change minimized the amount of ROW and funding needed for the project but at the same time the original basic design was revised.

Schedule Control (-): The MNTC could not immediately implement the project because the ROW acquisition was part of the Conditions Precedent (CP) for financial closure which took three to four years to complete. While the concession period was already running, the MNTC had to complete ROW negotiations and had no control over the time it took to finalize negotiations.

Selection of Construction Means and Methods (n/a): not applicable

Project QMS, 3rd Party Adviser and Contractor Self-Certification on:

Cost Control (+): Only the MNTC could approve cost-related changes in the project. With savings from negative variation orders for deducting items in the project scope, the MNTC was able to share in the savings from reduced construction costs. The MNTC did not have to directly hire and manage
independent 3rd parties to check on quality. All of these costs were already covered in the EPC contract.

- **Quality Control (-)**: Parsons Brinckerhoff (PB), although the Employer’s Representative, was not authorized to stop work if quality issues arose; thereby giving Leighton the ultimate responsibility, e.g., testing and inspection, for maintaining project quality. Leighton would get away with implementing work without getting a formal approval or checking from the PB. Since Leighton was not always prompt in endorsing construction documentation, the PB did not have enough time to provide feedback before work was already started.

- **Schedule Control (+)**: Since there were no formalized processes for checking and inspections, Leighton was usually able to implement its proposed construction schedule without much intervention from the MNTC or the PB.

- **Selection of Construction Means and Methods (n/a)**: not applicable

**Financial Arrangement, Fixed-Price Lump Sum Contract with LD clause on:**

- **Cost Control (+)**: With the construction costs already fixed in the EPC contract, the MNTC could control costs incurred in the project. In addition, the MNTC was able to use the liquidated damage clause regarding project performance as leverage for Leighton to increase the warranty period to two years instead of one year. This transferred the costs of rectification works to Leighton up to two years after substantial completion of works.

- **Quality Control (+)**: The contract clause regarding project performance allowed the MNTC to demand Leighton to rectify unsatisfactory works or pay the amount of liquidated damages for non-conforming works.

- **Schedule Control (+)**: The liquidated damage amounted to USD$225,000 per day of delay and this was a strong motivator for Leighton to deliver the project on time. The MNTC’s addition of the liquidated damages clause to contract was effective in making sure that Leighton stayed within schedule.

- **Selection of Construction Means and Methods (n/a)**: not applicable
SOBRR Chao Phraya River Bridge (SOBRR) Project

The SOBRR Project experienced more negative effects on schedule control which was evident even before final project completion due to the choices made for the Delivery Method, Terms of Reference, ROW Acquisition, and Project Quality Monitoring System. The low schedule control for this project is quite representative of government-led projects which are often behind schedule. On the other hand, Ownership Form and ROW Acquisition caused adverse impacts for quality control. In addition, Ownership Form negatively influenced cost control because of the government’s inability to provide public funding. Parallel to previously analyzed projects, Table 4 presents the effects of the front-end factors to the different project outcomes using the plus-and-minus convention. Following the table is the explanation of how each factor affected the outcomes.

Table 4
SOBRR Project Predictor-Outcome Matrix

<table>
<thead>
<tr>
<th>Ownership Form, 100% Government Owned with Private Financing on:</th>
</tr>
</thead>
<tbody>
<tr>
<td>o Cost Control (-): The Government could not exert great control over the initial project costs because it had to depend on the bidders to arrive at a competitive price while covering the financial risks from securing loans.</td>
</tr>
<tr>
<td>o Quality Control (-): The Government has partnered with the Ch KarnChang in implementing the project which led to some allowance being given to the Ch KarnChang to implement design changes to permit meeting other project goals.</td>
</tr>
</tbody>
</table>
Schedule Control (+): Because of the Government’s initiative, the project was set to complete at the same time with the Bangkok International Airport opening. The Government set a construction schedule of 30 months.

Selection of Construction Means and Methods (n/a): not applicable

Project Delivery Method, Design-Bid-Build Approach on:

Cost Control (+): With the use of the design-bid-build approach, the actual cost of the construction phase was known and fixed before award. Representatives from the Department of Highways (DOH) indicated that the design-bid-build prevented unnecessary costs from being incurred in the project unlike their experience with design-build.

Quality Control (+): The design-bid-build approach required completing the project design before construction began. This provided the Government full control over the final design of the project.

Schedule Control (-): Any design-related issue in the project had to be routed and approved by the Department of Highways, TAP Consortium, and the designer before the Ch KarnChang could take action. The Ch KarnChang’s construction schedule had to accommodate the impacts of design changes.

Selection of Construction Means and Methods (n/a): not applicable

Terms of Reference, 100% Completed Design Drawings on:

Cost Control (-): Since the Ch KarnChang assumed 100% complete design drawings before bidding for the project, any detail not covered in the designs were claimable against the Government. The Government had to be ready to compensate the contractor for any inaccuracy in the design drawings.

Quality Control (+): Having fully completed design drawings ensured that the Government could make the Ch KarnChang conform to its expectations of the project. In the event of any deviation from the specifications, the Ch KarnChang was liable to the Government.

Schedule Control (-): Any deficiency in the drawings needed to be resolved prior to implementation. This could adversely affect the construction schedule.
if design issues were not resolved before the need to implement the work. The Ch KarnChang would have to place construction progress on hold to resolve design issues.

- Selection of Construction Means and Methods (C): Since the project is a cable-stayed bridge, the erection sequence was governed by the design and assumptions made during the design process. The designer, the PB, recommended the use of the balanced cantilever method for bridge deck construction and this was adopted by the Ch KarnChang as the actual method.

**Contractor Selection, Pre-qualify, Technical and Financial Evaluation on:**

- Cost Control (+): The DOH representatives considered the decision to divide design and construction into separate contracts sufficient in lowering the total costs of the project due to less risks that a pure construction contractor had to assume. During the selection process, the evaluators chose the technically adequate proposal with the lowest price.

- Quality Control (+): Before the Government awarded the contract, the Ch KarnChang had to pass pre-qualification, provide technical expertise, and show capacity to build the project. In doing so, the Government controlled the award to a contractor who could produce quality work and complete the project.

- Schedule Control (+): The Government stipulated that the project had to be completed in 30 months and only acceptable proposals which supported project completion within the prescribed timeframe were considered.

- Selection of Construction Means and Methods (C): The Ch KarnChang had to indicate that its proposed construction method could be completed in the required timeframe. Its erection scheme either followed the designer’s recommendation of the balanced cantilever method or used another method that supported the project’s intended goals of on time completion and open waterways during construction. The evaluation process considered the contractor’s construction method and its impact on project implementation.
ROW Acquisition, Completed Before Construction Phase on:

- **Cost Control (+):** Having a smaller ROW provided the Government some cost savings because Ch KarnChang introduced value engineering in building the tower foundation requiring less steel and concrete consequently lowering its costs. The Government also did not have to compensate the warehouse owner for the land that would have been needed for the original bridge alignment.

- **Quality Control (-):** Because the ROW was acquired after the design was completed, the original design of the tower foundation was revised to accommodate the smaller ROW. The Government could not prevent the design changes unless a bigger ROW was provided. In addition, the designer had to change the alignment of the bridge several times to avoid parcels of land that were difficult to acquire for the ROW.

- **Schedule Control (-):** Having the ROW completed during the construction phase was unfavorable to schedule control because of the time needed to resolve issues caused by the different ROW assumption used in the design to the actual available ROW. The PB assumed a 100-meter wide ROW while the Ch KarnChang was only given 80-meter wide ROW. Resolving this issue took several months and affected utilization of the construction schedule.

- **Selection of Construction Means and Methods (C):** The size of available ROW dictated what capacities of equipment to use and the sequence of construction to accommodate working in limited space. The Ch KarnChang used smaller cranes that were moved around several times instead of using only one massive crane stationed in a fixed position to perform all the lifting works.

*Project QMS, 3rd Party Testing and Inspection on:*

- **Cost Control (+):** All cost related decisions were either made by the Acceptance Team or the ETA board depending on the specified amount of the change or variation order. In addition, payment applications had to be approved by the Acceptance Team before the bank released payments. This made sure that only completed items were paid for.
Quality Control (+): The Government controlled quality by having DOH and TAP representatives always present for inspection and testing and empowering them to stop work for quality issues.

Schedule Control (-): The DOH and TAP representatives’ ability to impose work stoppage did not promote faster construction especially when there were quality issues to be addressed. The Ch KarnChang also had to accommodate 3rd party witnessing of inspections and testings in the construction schedule.

Selection of Construction Means and Methods (n/a): not applicable

Financial Arrangement, Fixed-Price Lump Sum Contract with LD clause on:

Cost Control (+): The project costs were fixed based on the Ch KarnChang’s winning bid. Only approved change orders could be claimed against the Government. The last approved change order in the project actually lowered construction costs because the tower foundation was re-designed to be smaller than the original and also avoided additional ROW from being acquired.

Quality Control (+): Non-compliance to environmental laws or project goals was a caveat in the contract that was penalized by liquidated damages. If the Ch KarnChang was found to be non-complying, it had to pay penalties.

Schedule Control (+): A liquidated damage clause for delays bound the contractor to pay 0.1% of the contract price per day of delay, which provided the incentive to complete the project on time. The DOH and TAP representatives were all convinced that this was enough to keep the project on schedule.

Selection of Construction Means and Methods (n/a): not applicable

Nam Theun 2 Hydropower (NT2) Project

The NT2 Project’s ROW acquisition created negative effects on all three outcomes: cost, quality, and schedule. Besides the ROW Acquisition, the choices for Contractor Selection and Terms of Reference contributed unfavorably to cost control. In addition, Terms of Reference adversely affected schedule control while Contractor Selection affected quality control. However, compared to the other projects, the NT2
Project had the most balanced achievement of project goals. However, this could be true because the project was still at an early stage of implementation. Nevertheless, the impacts of the front-end factors are expected to remain the same unless the actual factors are changed as the project progresses. Table 5 indicates the positive or negative influence of a factor on an outcome. The table is followed by a detailed explanation of how these factors bring about the positive or negative effect on the outcomes.

Table 5

<table>
<thead>
<tr>
<th>NT2 Project Predictor-Outcome Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Front-End Factors</strong></td>
</tr>
<tr>
<td>------------------------</td>
</tr>
<tr>
<td>Ownership Form</td>
</tr>
<tr>
<td>Delivery Method</td>
</tr>
<tr>
<td>Terms of Reference</td>
</tr>
<tr>
<td>Contractor Selection</td>
</tr>
<tr>
<td>ROW Acquisition</td>
</tr>
<tr>
<td>Project QMS</td>
</tr>
<tr>
<td>Financial Arrangement</td>
</tr>
</tbody>
</table>

Ownership Form, **25 years Build-Own-Operate-Transfer Contract on:**

- Cost Control (+): The NTPC set a fixed cost for the project with some contingency funds. Except for the USD 200 Million for contingency, the rest had already been allocated among the different components (i.e., construction costs, socio-environmental compliance measures) of the project.
- Quality Control (+): The NTPC anticipated the project to adequately perform for at least the duration of the concession period. In addition, the Concession Agreement (CA) focused on the achievement of project quality through stipulations for strict project monitoring through independent 3rd parties, i.e., POE, DSRP.
- Schedule Control (+): The PPA between EGAT and the NTPC dictated that the project must be completed by a specific date or the NTPC would pay penalties. To avoid these penalties, the NTPC must make sure that the project would
meet milestones. The CA was also explicit about allowing preliminary activities to take place before financial closure.

- Selection of Construction Means and Methods (n/a): not applicable

**Project Delivery Method, Design-Build Approach on:**

- **Cost Control (+):** The NTPC was able to commit the EDF to the construction budget in project’s financial package for its actual construction costs since it was both lead sponsor and EPC contractor.

- **Quality Control (+):** Since the EDF led the development efforts for project as well as the EPC contractor, it was fully aware of the project quality requirements embodied in the CA. The Head Construction Contract was formed directly connected to the requirements of the CA. The EDF has back-to-back obligations with the NTPC in fulfilling CA requirements.

- **Schedule Control (+):** By using the design-bid approach, the NTPC allowed construction activities to commence in some areas while other areas were still under design. According to the NTPC Director of Construction, the approach did not need for entire project to be completely designed before construction could commence. The diversion tunnels were already under construction while the downstream channel was still being designed.

- **Selection of Construction Means and Methods (C):** The EDF had the flexibility to choose or implement the method of its choice dependent on the existing conditions on site. The GE, as a subcontractor, had the flexibility to design transmission towers according to its preferred method of construction as long as performance specifications were met.

**Terms of Reference, Basic Design, Design Criteria, Preliminary Studies, Design Review Process on:**

- **Cost Control (-):** The NTPC is already anticipating cost impacts due to the uncertainty of ground conditions especially in the tunnel areas which would add construction costs to the EDF. This would be an item under the contingency category of the NT2 Project’s financing.
Quality Control (+): Since sufficient information was provided to develop the best design, the NTPC did not foresee any major design revisions affecting the project quality. Also, the NTPC’s design review process ensured that the submitted detailed designs by the contractors conformed to the project’s design requirements.

Schedule Control (-): The NTPC required that designs be reviewed before work began. The NTPC Director of Construction has started to strictly enforce compliance to this review process and any delay experienced in submitting designs for review could potentially affect construction schedule.

Selection of Construction Means and Methods (C): Soil and climatic conditions affected the selected methods. Also, the “Lao preference” clause favored the use of less sophisticated methods to accommodate the people’s skill level.

Contractor Selection, Negotiated with Lender Approval on:

Cost Control (-): No other bidders or proposals were considered for the Head Construction Contract. The EDF was given the Head Construction Contractor role without competitive bidding. Through competitive bidding, the NTPC could have received a lower priced proposal than the current contract price.

Quality Control (-): The EDF was qualified based only on past performance, experience, and proven technical expertise. The NTPC did not evaluate the EDF’s specific plans for constructing the NT2 Project and depended on the EDF’s ability to deliver the project as specified.

Schedule Control (+): The project immediately started when the EDF was selected as the Head Construction Contractor for the project. The NTPC did not have to implement time-consuming contractor evaluation process.

Selection of Construction Means and Methods (C): The EDF was freer in selecting its subcontractors as long as they were lender-approved. Subcontractors implemented the physical work while the EDF provided design and construction management. The subcontractors’ preferred methods were
implemented as long as the schedule was met. A subcontractor’s preference for using smaller equipment was allowed as long as schedule was met.

**ROW Acquisition, Ongoing during Implementation Phase on:**

- **Cost Control (-):** By not acquiring the ROW on time for construction operations, the NTPC assumed the risks of potentially incurring added costs. The added costs would be in terms of compensating the EDF for owner-caused delays in the construction schedule due to failure to turnover lands for construction use.

- **Quality Control (-):** The design of project structures could be value engineered and constantly revised until the actual ROW is completely acquired. In the event ROW could not be acquired, original designs would have to be changed to accommodate the actual ROW.

- **Schedule Control (-):** Since the ROW needed to go through existing communities, the duration of villager’s resettlement could impact the progress of construction activities. The NTPC had already negotiated with the EDF to turnover only the critical areas needed for continuous construction progress while other areas were still unavailable for handover because of relocation issues.

- **Selection of Construction Means and Methods (n/a):** not applicable

**Project QMS, 3rd Party Consultants and Owner Representatives on:**

- **Cost Control (+):** The NTPC checked all payment application to make sure that only adequately proven completed works were paid.

- **Quality Control (+):** Through representatives and consultants, the NTPC was able to ensure that the prescribed project quality was being achieved. The POE and DSRP ensured that social and environmental goals were met and the dam was conforming to safety standards. The NTPC also appointed site representatives to make sure that the contractor was proceeding with construction according to specifications. These are in addition to the contractor’s own quality assurance and control system.
Schedule Control (+): The NTPC had the right to ask for acceleration plans and exert its influence over the schedule although the contractor ultimately controlled schedule. For concreting works that were falling behind, the NTPC already asked the EDF for its acceleration plans for recovering months of delay caused by unexpected learning curve issues with the subcontractor’s labor force.

Selection of Construction Means and Methods (n/a): not applicable

Financial Arrangement, Fixed-Price Lump Sum Contract with LD clause on:

Cost Control (+): The NTPC limited any modification to construction costs through the design revision process. Any revision, especially cost-related, passed through different levels of approval including the lenders. Also, the lenders imposed a payment curve which regulated release of payments to the contractors. The NTPC made sure that amount of payments every month stayed within the limits of the curve.

Quality Control (+): The lender’s engineer was authorized to inspect the contractor’s completed work vis-à-vis the payment application which provided another layer of oversight to the quality of the project.

Schedule Control (+): The liquidated damages clause in the contract provided the motivation to finish the project within schedule. The NTPC was confident that this clause was sufficient to keep the EDF within schedule. In addition, the EDF imposed penalties on the subcontractors for not meeting milestones defined in the subcontracts.

Selection of Construction Means and Methods (n/a): not applicable

Having shown the impacts of each factor on the different project outcomes for the individual projects, this section proceeds to aggregate the results and compare how factors may be completed in various ways and have the same effect on the outcomes of different projects.
Over the Four Projects

The previous sections show that some front-end factors do affect selection of means and methods. Across the four projects, the factors consistently affecting selection are the Terms of Reference and the Contractor Selection. Except for the SOBRR Project, the Delivery Method also affects selection of construction means and methods in the other three projects.

As for the effects of front-end factors on the other project outcomes, a summary of the positive and negative effects is shown in Table 6, which is useful in comparing and contrasting the different impacts of the front-end factors on the project outcomes across the four projects. Similar to the previous tables, the front-end factors make up the left column while the top rows indicate the acronyms for the project names and different control types, i.e., “CC” for Cost Control, “QC” for Quality Control, and “SC” for Schedule Control.

Table 6
Summary of Predictor-Outcome Matrix

<table>
<thead>
<tr>
<th>Project Outcomes</th>
<th>THSR</th>
<th>NLE</th>
<th>SOBRR</th>
<th>NT2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Front-End Factors</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ownership Form</td>
<td>CC QC SC CC QC SC CC QC SC CC QC SC</td>
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<td>Delivery Method</td>
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<td>Terms of Reference</td>
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<td>+ - + + - + + + + - + +</td>
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<tr>
<td>Financial Arrangement</td>
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</tbody>
</table>

The cited similarities and differences across projects are listed below depending on the effect of the particular factor on the projects:

Ownership Form

Although three projects were basically led by the private sector, only the NLE and the NT2 Projects manifested the positive cost control provided by the ownership form because of actual source of financing. The NLE and NT2 Projects
had limited sources of funds, i.e., private equity and loans, while the THSR Project was guaranteed and partially funded by the Government.

Project Delivery Method

Although the THSR, the NLE, and the NT2 Projects were all using the design-build approach, the NT2 Project did not experience negative effects on quality control because of the EDF’s primary involvement in setting up the project requirements and serving as the head developer for the project. This is different from Leighton’s role in the NLE Project since it was primarily a contractor before it was a sponsor.

Terms of Reference

The NLE Project faced negative quality control from the lack of preliminary studies conducted for the project. As for the other three projects which had extensive preliminary studies included in the Terms of Reference, their Sponsors were able to anticipate and mitigate issues related to site conditions which contributed to positive quality control.

Contractor Selection

For the THSR and the SOBRR Projects which used extensive contractor selection procedures, the Sponsors influenced the outcome of the project quality and thus positively affected quality control. On the other hand, for the NLE and the NT2 Projects where contractor selection was based only on qualifications, the Sponsors had less control over the contractor’s decision on project implementation and this correlated to negative quality control.

ROW Acquisition

Although each project has different methods for ROW acquisition, the timing of acquisition has considerable impact on controlling the costs and schedule of the project. The THSR Project was the only project in the study with the ROW acquired before the selection of the project sponsor, and this had a positive effect on both cost and schedule controls. With the NLE Project, because the ROW was
only acquired after the financial closure, the implementation schedule, basic design, and project costs were all negatively affected. As for the SOBRR and the NT2 Projects, issues related to ROW caused design changes thus resulting to less quality control. In addition, the NT2 Project could potentially experience additional costs and schedule delay because of ongoing ROW acquisition.

*Project Quality Management System (QMS)*

The negative quality control provided by the Project QMS is similar for both the THSR and NLE Projects because of the self-certification system used and the lack of authority of 3rd party teams to administer inspection and testing. The NT2 Project suffered less quality issues, although also using self-checking, due to the extensive oversight provided by various entities even outside the owner’s organization. As for the SOBRR Project, the impact of the Project QMS was positive for quality control but negatively affected schedule control because of the possible work stoppages to address quality issues.

*Financial Arrangement*

The private financing of the four projects positively impacted the project outcomes. Having the lenders involved in the projects assisted in the regulation of cash flow and also provided the incentives to have the contractor finish the project on time.

Finally, the positive and negative effects of the factors on the outcomes are tallied and aggregated in Table 7 according to control type and categorized as “High,” “Medium,” or “Low” depending on the number of pluses (+) and minuses (-) in each category. Zero to one negative sign in a category is assigned “High,” two to three negative signs is assigned a “Medium,” and four or more negatives will be categorized as “Low.”

<p>| Table 7 |
| Summary of Project Outcomes | | |
| <strong>Project</strong> | <strong>Outcomes</strong> | <strong>Cost Control</strong> | <strong>Quality Control</strong> | <strong>Schedule Control</strong> |</p>
<table>
<thead>
<tr>
<th>THSR Project</th>
<th>Medium</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLE Project</td>
<td>High</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>SOBRR Project</td>
<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>NT2 Project</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>

The results of the analysis as shown in Table 7 are confirmed by the end or current performance of four projects as detailed below:

- The THSR Project was able to finish the civil works within the prescribed schedule, which affirms the high schedule control. However, the project experienced some quality issues, particularly some settlement of the embankment, connected with C230 contractor self-certification. This is congruent to the result of the analysis that the quality control is in the medium range. The THSRC was always willing to input funds and although no specific amounts were mentioned, some of the THSRC’s top executives validated this information. This accounts for the medium level of cost control for the THSR Project. The project’s manifestation of a high schedule control is indicative of the THSRC’s priority of completing the project on time over other project goals.

- For the NLE Project, the MNTC accepted the project as substantially completed by the expected turnover date. This manifested the high schedule control exerted by the MNTC and Leighton to keep the project within schedule. However, the MNTC was initially unwilling to accept the project because of quality issues. This verifies the low quality control implemented for the project. On the other hand, because Leighton was willing to extend the warranty period to two years instead of one year, the MNTC was even to the last minute able to exert control over its projected costs which accounts for the high level of cost control in the project. As such, road work repairs would be administered by Leighton for the next two years and the MNTC would not incur additional project costs.

- The SOBRR Project is ongoing but some design revisions had already been implemented to address constructability issues. This confirms the medium level of quality control administered in the project. Consequently, the project experienced
some delays, as corroborated by low schedule control over the project, because of the approval needed before revisions could be implemented.

- The NT2 Project experienced some delays from non-performing civil subcontractors but this was addressed early in the project. This indicates the degree of the schedule control in the project. Because of social and environmental constraints in this project, the costs as well as quality of the end project experienced changes. This is likely to continue until the project is completed, which supports the medium levels of control for both cost and quality in this project.

The results of the analysis section provide the basis for more specific conclusions about the effects of development decisions on particular project outcomes. These conclusions are highlighted in the next section and become the basis for recommendations to future developers regarding topics which should be given closer consideration when making decisions for infrastructure projects.

**Conclusions and Recommendations**

The infrastructure projects in this research particularly those under Public Private Partnerships (PPP) have undergone the project development phases described in Chapter 2 although each project went through the process in its own unique way. Some of the projects studied, particularly the NLE Project, accurately exhibit Khan and Parra’s description of the important development components such as the EPC contract. However, other projects, i.e., THSR Project, utilized the EPC contract without using it as a single-point of responsibility. This one deviation contributes to the differences in project outcomes for these two projects. The conclusion section identifies the consistency in some of the front-end factors which clearly shaped the possible outcomes of projects.

Although only four projects are included in this research, each project is distinct and representative of a particular type. Each project used the same development flow and fulfilled the same type of front-end factors and project outcomes. Since the results of this study are deeply rooted on the development process and its components, the
conclusions and recommendations are generalizable and potentially useful for the development of other infrastructure projects.

**Conclusions**

However diverse the projects are in this study, they exhibit particular characteristics that influence the cost, quality, schedule, and selection of construction methods. These are presented as seven conclusions for this research:

1. *Private financing increases the priority for schedule.*

   Especially for projects under the PPP, private sponsors approach the development of infrastructure projects, i.e., THSR, NLE, and NT2 Projects, as business ventures with revenue generation tightly connected to project completion. Their intent is to maximize the number of years the facility would be in operation. This is congruent to what Khan and Parra had to say about the interests of Private Sponsors (see Chapter 2). The best way the Private Sponsors can make a return on their investments is to have the project productive as soon as possible. Whenever interim delays are experienced along the development timeline, the construction schedule absorbs most of the schedule impact. In the case of the THSR Project, the construction end date was not revised even if the impact of variation orders caused the design phase to overlap with the start of construction. The THSRC decided to compensate the civil contractor for work acceleration rather than move the construction end date.

   In addition, privately-financed projects set up contracts with a liquidated damages clause for missing milestones and any other completion delays on the project. This is true even for the government-procured project, the SOBRR, to cover interest costs from private financing as well as lost opportunity for revenue generation. Having the project completed earlier also addresses some completion risks, mentioned in Chapter 2, shouldered by most Sponsors because finishing the project means removal of the physical completion risk.
2. **Design-build delivery increases cost control if the project remains on schedule.**

Khan and Parra identifies the design-build as the preferred approach used in privately-financed projects because lenders and owners not only need a single point of responsibility for the construction stage, but also desire to have the facility ready for operation as soon as possible. Lenders insist on the use of the EPC contract or design-build because of its risk allocation characteristics, although it can increase the combined costs of design and construction services. This, however, is more than compensated if early revenues are generated when the facility is built and operating. From their experiences with design-build projects including the THSR Project, Townsend and Rothenburger comments, “Design-build responds to the Owner’s desire to get the project moving faster by eliminating the detailed design from the basic conceptual design and overlapping the detailed design with construction” (786). If the design-build contractor is able to complete the project in the shortest time possible, this provides the opportunity for early realization of revenues by the Sponsors which more than pays for its added capital costs.

3. **Right-of-Way may positively or negatively affect the cost, quality, and schedule of a project depending on the timing of acquisition.**

The earlier the ROW is acquired the less chance it could affect the planned schedule, costs, or quality of the project during implementation. This was manifested in the THSR Project which completed ROW acquisition at the earliest stage of development. When ROW is completed later in project development, it is more likely to cause changes to project designs and implementation schedules. This was evidenced in the NLE Project which experienced implementation delays due to ROW acquisition being a Condition Precedent to financial closure. The ROW affected the SOBBR project through design changes during implementation because the ROW assumption used in the design was different from the actual ROW during construction. As for the NT2 Project, the NTPC was aware of the risk of acquiring ROW during implementation and had set up a contingency fund to mitigate its risks. In the
development process identified in Chapter 2, the ROW is included in determining the hard construction costs of the project and in the development of the project timeline. Sponsors try as they can to address the impacts of ROW on the project, but actual impacts may only be known until ROW has finally been acquired. Although the idealized development process presents proper planning at project origin as a means to deflect unwanted impacts on the project, the negative impacts of ROW acquisition can only be completely mitigated if assumptions made in planning follow through in implementation.

4. **Sponsors can influence the selection of construction method through details included in the Terms of Reference (TOR).**

   Even if the chosen project delivery is design-build, the selection of construction means and methods becomes less contractor-dependent if owner preferences are stated in the Terms of Reference. The impacts of a detailed TOR, discussed in Chapter 2 under the Negotiation section, are in agreement with what transpired in the four projects studied. Each TOR contained reference to a particular construction method that was eventually implemented in the project. In the NLE Project, Leighton used the crack-and-seat method identified in the Employer’s Technical Requirements (ETR). Also, with sufficient pre-construction information provided upfront to the contractors as part of the TOR, the most suitable methods are immediately identified. The use of the SES method for tunneling in the THSR Project provides one example. As for the SOBRR Project, the balanced cantilever method of constructing the bridge span was proposed in the design and the Ch KarnChang decided to implement this on the project. These examples are in agreement to the premise that as the TOR becomes more encompassing, the better the Sponsor’s control on the outcome. However, there is a need for moderation in exerting control to allow contractors some maneuverability especially for contracts under the design-build approach.
5. *Contractor self-certification is not adequate for quality control.*

Even if a project uses design-build, contractors should not be given the primary responsibility for maintaining quality in the project. This was true in the THSR and NLE Projects which experienced quality issues. The major reason is the ineffective self-certification system which removes the responsibilities from the consultants to maintain quality but at the same time eliminating their authority to resolve quality issues. Currently, most government-procured works still use the 3rd party inspection as the standard basis for quality assurance and control and seldom rely only on contractor’s self-certification. This is a practice that has some merit because using only contractor self-certification places a great burden on the contractor to always achieve a balance between cost, schedule, and quality without placing the necessary monitors. The construction industry is taking a big leap by removing the quality assurance and control from independent 3rd parties and completely passing on the responsibility to the contractors through self-certification.

6. *Preliminary studies facilitate cost control in projects.*

Using the results of preliminary studies, the Sponsors for the THSR, SOBBR, and NT2 Projects were able to identify the best locations for the project structures. Preliminary studies allow establishment of existing site conditions with greater accuracy. This assists the Sponsors in forming contracts that obligates the contractors to accept and work under existing conditions. With these studies, the Sponsors are able to reduce the possibility of major changes in the project, consequently avoiding additional costs. With more technical feasibility results known earlier, hard construction costs become more reliable and there would be less likelihood for unexpected reasons for cost changes. Sponsors are better equipped and positioned to deal with potential claims issues. These very reasons explain why the development process in Chapter 2 highlights technical feasibility studies important at the origin phase of projects.
7. A liquidated damage clause in a contract is used as schedule control.

Each of the four projects studied contained a liquidated damage clause in its construction contract to address project delays. Khan and Parra also point out this trend and indicate that these LDs are becoming pre-requisites in EPC contracts. In all four projects, the clause defined a predetermined payment for each day of delay. The Sponsors used this strong incentive to ensure that the project would be delivered by the scheduled completion date. For the THSR and the NLE Projects, the contractors were motivated enough by the prospect of paying liquidated damages to deliver the projects within schedule. Even lenders recommend the use of a liquidated damage clause in contracts to ensure that the Sponsors are well compensated for any effects of project delays. Since the contractors are better positioned to mitigate construction delays, the clause places the most responsibility on the contractor for controlling the schedule.

These conclusions relate to the lessons learned and shared by the parties involved in the studied projects. They are intended to assist managers in of future infrastructure projects in identifying areas which need their close attention for better monitoring of project outcomes.

Recommendations

The private sector involvement in infrastructure development is a continuing trend especially in Asia. To improve future international infrastructure projects, project proponents are advised to focus on identifying the needs of the project at the defined stages of development with the greatest impact. Below are some recommendations that developers should consider for future infrastructure projects:

1. Perform as many preliminary studies as possible prior to construction.

Sponsors are encouraged to learn as much as they can about the macro (political and economic) and micro (site logistics, ground) conditions of the project to support its feasibility and increase the potential for successful
outcome. The effects of the completing the studies in the THSR Project and their absence in the NLE Project confirm their importance in projects.

According to TC Kao, VP of the THSRC Construction Division, one of the best practices in the THSR Project was having a great deal of ground studies conducted before design. The information from these studies assisted in determining the best designs and construction methods for the identified soil conditions. Common issues related to ground conditions were avoided because of this prior knowledge. On the other hand, the inadequate survey of the existing pavement for the NLE Project was the main reason why the crack-and-seat method failed in certain parts during rehabilitation. These resulted in the quality issues which almost prevented the MNTC’s partial acceptance of the NLE Project.

2. *Address technical issues during concession award and financial closure.*

With the projects under PPP, time is limited to the concession period, and the time starts running immediately after contract signing although before completed financing. This leads to a time gap before the project can begin construction. In this period, project participants should focus on getting the design right and work out all technical difficulties to facilitate a faster start of construction when financial closure is finally reached. Although two out of the three projects studied did not let the slow process of financing deter planning works, the NLE Project experienced the effects of under-utilized time between award and financial closure. No activities were performed to better prepare the project for construction, either through design reviews or site surveying, during the four years the project was in the financing process. In the end, the final design underwent continuous revision during construction and the project experienced quality issues. These might have been avoided if the sponsors had attended to technical details of the project before implementation.
3. Contractor experience should not preclude extensive evaluation for selection.

When sponsors select the EPC contractors, the evaluation should consider more than the experience level and financial capability of the contractors. Even at the project origin phase when design or construction methods can not be evaluated yet, the selection criteria should already include review of the firm’s and personnel’s qualifications and the adequacy of quality management systems. Interviewing contractors are also encouraged to validate technical knowledge. Since evaluations should focus on both financial and technical aspects, evaluators should be chosen with expertise from both fields.

The merit of having contractors undergo a rigid selection process is that the Sponsors become aware of the contractor’s actual capacity to perform the work according to expectations. In the case of the THSR Project, the THSRC knew exactly how each contractor was planning to perform its scope of the project. It knew who were the weak or strong contractors and knew how much support it had to provide the contractors. On the other hand, when contractors are selected based only on qualifications namely past experience and financial capacity, Sponsors may form expectations that are not objectively evaluated. In the case of the NLE Project, the MNTC’s expectation of Leighton’s quality management relied greatly on the latter’s ISO certification. This proved ineffectual when the project experienced quality problems resulting from Leighton’s inability to implement quality control.

4. Design-build contracts are not the cure-all for completion risks.

Although design-build is an allocation tool to pass on the design and construction risks to the contractor, Sponsors should not assume that this will be sufficient to cover all construction-related risks. The design-build approach can not be used to diminish risks related to changed ground conditions or excessive weather conditions that are inherent to construction projects. The Sponsors should still have contingency set aside for such cases and should not make the contractors assume the risks for which they do not have better control. Both cases were observed in the studied projects. The THSR Project
had contract clauses letting the contractors assume ground-related risks, and yet, even the THSRC Resident Engineers reported that these were not enforced when the contractors could not handle the impacts of such risks. In the NT2 Project, the NTPC set up contingency funds to address changed ground conditions in tunnels and other impacts from social and environmental activities and did not completely pass on the responsibilities to EDF.

5. **3rd Party technical consultants should be empowered to address quality issues.**

Although sponsors employ technical consultants to assist them in administering the contracts and maintaining project quality, these consultants typically serve as advisers rather than enforcers. In the projects studied that used the design-build approach, the consultants were not authorized to directly address quality issues and could only inform the Sponsors of the non-conformance. If the Sponsor had a highly experienced in-house technical group, these quality issues could be adequately addressed and the consultants’ role could remain advisory. However if the consultants are meant to substitute the sponsor’s technical group, then there is a need to empower, i.e., work stoppage authority, the consultants if quality issues are to be addressed. In the case of the NLE Project, the PB (Owner Representative) could not directly address quality issues because it was not contractually allowed to make decisions which could affect either costs or schedule. As such, when non-conformances were observed, the PB could not force Leighton to stop current activities and perform rectification works without first getting approval from the MNTC.

These recommendations only cover parts of the issues encountered or addressed in the studied projects. They do not address all the types of problems that arise in individual projects. As each project is unique, these recommendations can only address part of the project’s general conditions. Moreover, this research has only provided initial understanding regarding the linkage between front-end factors and project outcomes. The results also suggested related areas of future investigation.


**Related Topics for Future Research**

The four cases used in this research are very limited. Although some general conclusions and recommendations have been made, the study could be further expounded by having more cases and by defining more specific front-end factors. A front-end factor used in this research such as Terms of Reference may be broken down into more specific components, e.g., design review process, site investigations, and could be analyzed further in future research. The project data could be presented differently such that factors are classified according to the development phases and then linked to project outcomes. This could prove useful since the research intent is to identify links between the early parts of development and the actual implementation of the project and select the most important factors which greatly affect outcomes.

The recommendations section mentioned topics that could be further explored in future research, but some ideas were uncovered during the course of this research which have not been included in the study. The following are four areas that could be investigated by future research efforts:

1. **One BOT framework**

   What components should be included in a BOT contract to make it acceptable for global use in future developments of infrastructure projects, i.e., transportation, power, telecommunications? The current trend is for countries to individually create BOT laws which become guidelines for promoting BOT projects. As such, BOT implementation is different in each country. An interesting investigation would be to develop such a BOT framework that could be universally adopted.

2. **Factors for effective design-build**

   Although the use of the EPC contract is becoming a common practice to privately-financed projects, its administration is not uniform and greatly depends on the Sponsors’ familiarity with design-build. Further investigation is needed to identify the institutional factors needed to implement an effective design-build approach on a project. Moreover, design and construction are not
really integrated in these contracts. Design is still separate from construction, even performed offsite, and lack construction input. In addition, there are still some design-build contractors who are unwilling to manage the design process. How could these design-bid-build practices be removed from the current process of design-build to make it more effective?

3. **Standardization of design-build contracts**

   There are current design-build contract forms such as FIDIC available. However, some projects prefer to create contracts from scratch, which was the case in the NLE Project, rather than use these forms. What contracts are currently available for use and what is the extent of their use? How sufficient are these contracts in capturing the interests of involved parties and in facilitating effective design-build? If these contracts are not sufficient, what are the missing components and could one type of contract for design-build be developed for all purposes?

4. **Contractors’ Dual Role**

   The role of the EPC contractor as both sponsor and contractor has been implied as an advantage for the project both technically and financially. The reasons being (1) the contractor is able to make technical inputs at the earliest phase of the development and identifies any difficulties beforehand, and (2) contractors would control construction costs because it would negatively impact their equity as sponsors to exhibit too much conservatism. However, these are just sentiments of the parties interviewed in the projects which had contractors’ playing dual roles. How much of this is assumption and how much is truth? Would contractors having dual roles in the project always bring about a positive outcome? If not, what are factors that would cause the negative impact?
APPENDIX A: TAIWAN HIGH SPEED RAIL PROJECT

I. PROJECT OVERVIEW

The Taiwan High Speed Rail Project runs along the western corridor from Taipei in the north to Kaohsiung in the south and serves eight intermediate stations. The project is comprised of the following main components (Gillam and Townsend 51):

- Core system mainly the catenary, rolling stock, maintenance facilities, signaling
- Electrical and mechanical works such as power supply, telecommunications, and interference prevention
- Track work
- Ten (10) stations and station area developments including terminals in Taipei, Kaohsiung, Taichung
- Civil work such as cut and fill, tunnels, viaducts, bridges, and safety monitoring systems

This case study focuses on the civil work aspect of the project and only makes reference to the other components. The civil component of the project has a total alignment of 345 kilometers made up of 39 kilometers of bored tunnels with cross-sectional area of 90 square meters, 8 kilometers of cut-and-cover tunnels with 2.8 kilometers for the approach to Taoyuan station, 251 kilometers pre-cast, pre-stressed box girder viaducts and steel truss bridges, and 32 kilometers cut-and-fill embankments (Gillam and Townsend 52). The civil work was broken into 12 contracts. These contracts totaled NT$180 Billion (USD15 Billion) and involved the expertise of more than 400 engineers (Lin).
This section will focus on motivations for the THSR project, entities involved in the conceptualization and implementation, and difficulties encountered along the way. The project delivery and procurement process for the civil section will be discussed in the latter sections.

A. Project Goals

The Taiwan High Speed Rail (THSR) project represented a multitude of goals. On the macro level, the project addressed the expected increase in intercity travel demand expected in Taiwan. The existing transportation system consisted of two major freeways which were inadequate to accommodate the forecasted demand for the continuous Taiwanese economic growth. This project intended to serve as a solid underpinning for the future economic growth of the country (Lin).

A study of various alternatives found that adding freeways induced more cars and was not a desirable environmental choice. (Tan) The rail was the most logical of choices, although the feasibility of having a High Speed Rail (HSR) and its type of service were still dependent on factors such as forecasted demand and capacity over the lifespan of the project. Some reasons for the selection were (Lin):

- Lessened pollution due to the use of electrical power instead of fossil fuel
- Alleviation of traffic problems using the approach with the least social and environmental impact
- Reconnecting the cities that freeways divided and forming just one Taiwanese sector

The THSR project was also aimed at providing maximum rider comfort and operational safety, especially safety for the end consumers. The THSR trains were meant to shorten travel time from Taipei to Kaohsiung from four hours to just one and one-half hours. To induce greater ridership, the THSR trains had to be efficient and functional.

On a micro economic level, the project to construct and operate a High Speed Rail (HSR) in Taiwan was granted by the government to the winning bidder in the private sector. This project was offered under the Build-Operate-Transfer (BOT) model of concession (to be discussed in more detail in the latter sections) with the government
encouraging the private sector to take part in providing services that were once reserved for the government. Therefore, the concession had to be financially attractive to appeal to the entrepreneurial spirit of the private sector. Financial profitability meant fast delivery of the project for earlier operation and decreased costs over the span of the project concession. In addition, the government had set criteria for public works in terms of the quality of the finished project to satisfy lenders who expect full quality performance. Many of these goals were reflected on the actual decisions made by the various project proponents over the course of the project implementation.

B. Project Proponents

The government represented by the agency, the Bureau of High Speed Rail (BOHSR), was the spearhead of the project in 1989. The BOHSR provided much of the preparatory work which the private sector utilized in implementing this project. In 1997, the private sector became involved. At this time, the THSR Consortium was selected as the ‘Best Applicant’ for the project (Kao).

The consortium was made up of the following members with the indicated specialization (Lin):

- Continental Engineering Corporation (CEC)– Engineering, Civil Construction, and Project Development
- Evergreen Marine Corporation (Taiwan) Ltd. (EVA) – Transportation, Operations and Maintenance, Civil and Mechanical Construction
- Fubon Insurance Co., Ltd. (FUBON) – Banking & Finance, Securities Insurance, and Property Development
- Pacific Electric Wire & Cable Co., Ltd. (PEWC) – Power, Telecommunications, Information Systems, and Wire & Cable Manufacturing
- Teco Electric & Machinery Co., Ltd. (TECO) – Power, Electrical, & Mechanical Equipment, Air Conditioning, and Information Systems

Changing hands of project execution from the government to the private sector was not only an advantageous decision but also a necessity for this project to come to fruition. The government at that time faced budget cuts and could not afford to build this project on its own. When the THSRC assumed the project, more than 25 banks
became key players in the project financing and a tripartite agreement was signed by the lenders, the THSRC, and the government before funding was finally secured (Tan).

By 1998, the THSR Corporation (THSRC), formerly THSR Consortium, was established and the first Invitations to Bid for the civil contracts went out to the international contracting market. These 12 civil contracts were bid on by Japanese, South Korean, German, Dutch, French, Italian, and Taiwanese contractors. British and American contractors showed initial interest in the project but, due to strict clauses regarding risk allocation in contracts, in the end declined to bid (Rothenburger). International contractors were encouraged to go into joint ventures (JV) with the local Taiwanese contractors. Each winning contractor became a major proponent in the project. These contractors were chosen based on experience and ability to handle the financial magnitude and technical demands of each civil contract (Lin).

C. Challenges

The THSR project was a great undertaking for the Taiwanese community alone to handle. The construction industry in Taiwan had never handled a project of this magnitude before. It was not only a large financial responsibility, but also a substantial technical responsibility because Taiwanese civil contractors had not yet developed sufficient technical experience to construct an HSR project on their own. Furthermore, Taiwan lacked the manpower needed to complete this project within five years from the award of the concession, to maximize the years that the THSRC could operate the railway (Tan). The answer was to go to the design-build (details in Design-Build section) approach with experienced contractors executing civil contracts.

In the beginning, the THSRC faced disinterest from the international contracting community because the THSRC was a newly formed company and unknown in the international construction industry (Kao). Also, the Taipei MRT project, which was completed during the development of the THSR project, had unresolved claim issues which cast doubts on how the mediation process worked in Taiwan (Rothenburger). The industry lacked ‘confidence’ in the THSRC and the project being implemented. This was exacerbated by not having many global contractors familiar with the working
conditions and business environment in Taiwan. This uncertainty created a risk many contractors are unwilling to undertake. Professional dealings and effective bidding conferences assisted the THSRC build the industry’s ‘confidence’ (Kao).

Achieving financial closure was an initial hurdle, but contract administration and quality control became some of the major challenges for the involved parties to overcome during the project.

The succeeding sections will discuss in detail how the BOT contract, design-build delivery method, advance works prior to construction, management of the design and construction phases, and major construction methodologies affected the project in reaching its goals.

II. OWNERSHIP FORM: BUILD-OPERATE-TRANSFER CONTRACT

A. Selection Process

Initially, the Taiwan government conducted implementing the project itself using the conventional government procurement process for infrastructure projects. This would have required extensive government involvement in every step of project implementation. In 1993 that the government decided to change the project’s implementation process for two reasons. First, from the government’s experience with the Taipei MRT system which was eight years behind schedule and over budget, it was not the best entity to implement such a project. The government’s very strict procurement and change management process would have impeded fast implementation of project (Kao). Secondly, the Chen administration had just cancelled the government’s entire budget for implementing projects including the THSR project. For these reasons, the government selected the privatization approach and packaged the project to be economically viable and attractive to prospective applicants. With the government’s lead of enacting the “Statute for Encouragement of Private Participation in Major Transportation Infrastructure Projects,” the Build-Operate-Transfer (BOT) scheme was developed and adopted for the THSR project (Fleming, “Contractual” 233).
B. Build-Operate-Transfer (BOT)

The BOT contract spared the Taiwanese government the financial burden of administering construction and took full advantage of the entrepreneurial spirit of the private sector in improving infrastructure. Under the BOT contractual agreement, a concession was awarded to the THSRC to construct and operate the railway for 35 years, including use of the transportation facility land and use of the enterprise development land for 50 years (Lin). The concession was recorded in the Construction and Operation Agreement (C&OA) between the THSRC and the government starting from the date of signing in 1997. The agreement consisted of a 35 year concession period for the rail project, inclusive of construction time, and 50 year concession for station developments. The 35 year concession meant the THSRC could only operate the railway between the times construction was fully completed to the 35th year after contract signing. A different concession period of 50 years was given for station development because of experience regarding infrastructure development, during Japanese occupation of Taiwan, which took at least 10 years before any advancement occurred in areas surrounding the newly built infrastructure (Lin).

The contract was initially only to implement the THSR project, but the development rights over certain land areas were added to the concession to make the whole package attractive to the private sector (Tan). The concession was arranged to include urban planning and development of new townships. The government found, after four years of study, that the infrastructure itself would not be able to pay back the costs of development. Another type of incentive had to be added to the concession to make it financially appealing to investors. This led to award of additional 50 year land development rights starting from construction completion (Tan).

C. Advantages of the BOT

Through the BOT contract, lenders were fully involved in the drawdown of cash. As such, payments were made directly to contractors and the THSRC had the freedom to implement construction using the approach that provided the ‘best value’ even if not the least cost, such as using design-build instead of design-bid-build for the civil work. Some other advantages of implementing a BOT contract were the extent of
government involvement and contract clauses that safeguarded the interests of the THRSC.

1. **Government Involvement**

The BOT scheme enabled the implementation of the project without undergoing tedious government processes that tended to impede fast project progress. Financing was a very significant issue in the BOT contract arrangement. The debt versus equity (D/E) ratio for the THSR project had 70 percent of the financing coming from loans, making lenders major project proponents (Fleming, “Contractual” 236). This, however, did not signify that the government had no influence in the project. In fact, in the case of the THSR project, the government’s role was very crucial though not as visible as in government-procured projects. The lenders required government backing before closure was granted (Mues). There was initially a great deal of uncertainty in the financial aspect of the project which almost caused the project to fold. This was addressed only in 2000 when the THSRC signed a syndicate loan agreement and a Tripartite Agreement with the 28 banks as lenders and with the government as guarantor. In this agreement, the government offered security to the lenders and had the obligation to buy out, at the price of the loan, the project if the THSRC defaulted (Tan). The government was also directly financially involved through allocation of some of its budget to cover the non-self financing part of the construction costs for underground rail, design and supervision, land acquisition and compensation, and other civil infrastructure costs in the greater Taipei region that completed the THSR project (Chang and Chen 217). Also, the government shared risks in any restoration costs that would be needed after a natural disaster, i.e., 921 earthquake and also gave tax incentives and holidays to the THSRC. The BOT scheme for this project allowed the efforts of both private and government to come together and deliver the project.

2. **Construction and Operation Agreement**

The C&OA had definite terms and conditions that had to be adhered to. Non-compliance to these terms meant termination of the concession which could have proved fatal to the project. The THSRC had the task to either take it upon itself to act
on these terms or try to delegate the responsibility to the contractors through the
Employer Requirements and allocate the risks to those who could best handle them:

- The C&OA required that (1) the promoter, the THSRC, keep its share of not less
  than 25% of the total share and (2) the financial ratio be at least 25% shareholders’
  equity to be reflected in the balance sheet. The THSRC had put up at least 80% of
  the total cost from the start, most of it from loans. This clause only ensured that the
  THSRC would be motivated to keep within the prescribed goals else lose its own
  investment in the venture (Tan).

- The C&OA required transfer of intellectual property rights, including all drawings,
  specifications, information, calculations, materials, know-how, integrated circuit
  layouts, trade secrets and other documents relating to the THSR project to the
government. The THSRC placed “back to back” provisions in all contracts to
comply with this requirement (Fleming, “Contractual” 245-47).

- The C&OA required that the contractor endeavor to construct and operate the HSR
to standards as high as reasonably possible and engage contractors who could
reach ISO 9000 standards. The THSRC required that the civil contracts have
detailed requirements for quality in the form of an established and approved
Quality Plan that the contractor had to strictly comply with, including financial
penalties, e.g., suspension of Price Center 1 (10% of the Contract Price spread over
the Contract duration) to be imposed in the event of continual quality problems
(Fleming, “Contractual” 238-39).

- Under the C&OA, the THSRC had to appoint an Independent Verification and
  Validation Engineer (IV&VE) who would have right of access and inspection to
the project and who would later issue a certificate to the government and the
THSRC stating the soundness of the project. The THSRC not only appointed
Lloyd’s Register as the lead IV&VE but added the IREG as the Independent
Checking and Supervising Engineer (ICE/ISE) as a second layer of checking. This
was fitting to the THSRC’s long term objectives, i.e., having good project quality
and fulfilling the C&OA requirements (Kao; Tan).
According to a written report by Bernard Fleming, Vice President - THSRC Contract Management Division, the agreement also allowed the THSRC to have some flexibility as to how it should administer the project requirements as detailed below:

- The C&OA did not limit the procurement procedure for the civil contracts, therefore leaving the THSRC the decision to employ a design-build approach (“Contractual” 233).
- The C&OA specified only the level of quality that should be achieved for the project. The THSRC had the option of choosing the number and type of project delivery method to employ. The THSRC could have decided to tender out the whole project in one mega-contract or, on the other extreme, break it up into hundreds of small contracts, but the corporation decided to tender out fewer and manageable-sized contracts to minimize the risk of not delivering Civil Works in conformance to the C&OA quality requirements (“Contractual” 235).
- The C&OA did not give exact details of the High Speed Rail (HSR) requirements, but these needed to be clearly defined in the Employer’s Requirements without eliminating the contractor’s opportunity to introduce design or construction methods that could provide potential cost and time savings (“Contractual” 237-238).
- The C&OA gave THSRC some flexibility to checking the design of the final product. The THSRC adopted a ‘hands-off” approach to actual implementation of the civil work design specifications as early as the Request for Proposals. The contractor had to provide the designer, either in-house or external and also hire a CICE to certify the design results (“Contractual” 240-41).

D. Impacts of the BOT on the Project

The BOT scheme was a new concept in Taiwan, and the THSR project was the first its kind built in the country under this contractual agreement. As such, people experienced with the BOT contract, previously involved in similar projects in Hong Kong, were recruited to help develop the contracts (Mues). New knowledge about developing and administering contracts was brought into Taiwan which tremendously impacted the existing contracting industry. The BOT contract also allowed the
avoidance of difficult political issues such as needing to pay off someone since payments were closely administered by the lenders (Mues).

Although the written concession agreement provided major advantages, things stated were sometimes different from what actually occurred. The Resident Engineer of contract D290 noted the following inconsistencies:

- Although a contractor would have on-going quality problems, this did not suspend payments from Price Center 1 as was stipulated in one of the clauses.
- The THSRC’s ‘hands-off’ approach was not really enforced since all the designs had to go through a rigorous design review process. The THSRC actually just withheld any approval until the actual construction was complete.

As the concessionaire, the THSRC decided to set up its organization as an operator instead of a builder (Tan). It recruited people for the core business of the company which was railway operation. Consequently, experienced construction people who knew how to build the HSR and could administer the contracts were hired to manage the construction phase. Getting qualified contractors who could provide manpower, equipment, and proven construction methods, e.g., full span launching, pre-cast, cantilevered, in-situ construction, movable scaffolding, became necessary for constructing the project. These methods will be further discussed in the last section, Construction Techniques. On the other hand, if the THSRC had decided to make construction its core business, 4000 people skilled only in construction would have been laid off before operation of the railway. A massive lay off would have caused a great upheaval in the Taiwanese community (Tan).

At the BOT contract level, the goals of the project were set and recorded in the C&OA and the framework of project execution was defined. The THSRC found ways of fulfilling the C&OA requirements by passing these to the contractors and setting up the right incentives and controls in the design-build of civil contracts. The adequacy of these measures could only be seen from the actual results of the project. As TC Kao said, “Total framework should be right, tender strategy should be right; then all else will follow.”
III. CONSTRUCTION DELIVERY METHOD: DESIGN-BUILD APPROACH

A. Selection Process

The project was broken down into the different sections of Civil Works, Stations, and Depots (Lin). Only the civil works used the design-build (DB) approach. The DB method was selected for civil construction because this work required less permitting and intervention and interaction from government agencies. On the other hand, the Depots and Stations used the conventional design-bid-build approach. Local code governed how these buildings needed to perform. Although stations were special purpose buildings and deviated somewhat from regular building codes, each design of a station had to be defended and the station access had to conform to the urban design or planning in the zone. Coordination with many entities was required before actual construction commenced. The approval process was complicated and not appropriate for the DB approach (Tan).

Technical factors appeared to prompt use of the DB approach to execute the civil contracts, but in reality this was a financial decision. Bob Mues, one of the Resident Engineers, said:

The project is driven by money instead of technology contrary to what (as) people are made to think. The corporation is involved in the project because of a financial point of view. The owner is focused on time and money and how to succeed within the set parameters. To manage the design process in conjunction with (to) construction, DB is a fast track approach to speed things up. The real reason behind why anyone would do the DB approach (DB) is a financial issue.

B. Design – Build Approach

THSR was the first use of the design-build approach for large civil works in Taiwan. Each civil contract was between NT$10 to 20Billion. This was the optimum amount that a single contractor could financially handle, and also what the THSRC’s own personnel could efficiently control (Lin). Through this contract size breakdown, the THSRC was tying the needed C&OA quality requirements to the actual number of contracts tendered out. The technical aspects of the contract were addressed by setting the scope of work to accommodate contractor specialization.
The horizontal alignment was defined by the owner prior to bid. This included tunnels, viaducts, bridges, and embankments alternately cutting through ridges and valleys in the mountainous areas, while in the alluvial plain, only viaducts and bridges were used (Gillam and Townsend 53). The division of the project into contract packages with the different scopes of work, e.g., viaducts, tunnels, bridges, or any of these in combination, was based on the capabilities of the potential contractors who showed interest on the civil projects. The contractors’ capacity for work dictated the scope for each contract (Lin).

The THSRC knew how crucial the civil contractors were in the success of the project. Breach by the contractor meant breach of the C&OA by the THSRC as well; therefore, proper selection of the contractor was important to control this risk of breach (Fleming, “Contractual” 233). The entire tendering phase was very transparent. During tender review, evaluators were restricted from carrying anything out of the evaluation room to prevent any information leakage (Mues). Ricardo Tan said that “the contract might not be fair, but contractors should always be treated fairly.”

The THSRC formed teams to separately evaluate the financial, legal, and technical aspects of the proposals. The final tender was evaluated by members of the procurement department. A group of experienced construction people, who later on became the Resident Engineers of the project, was hired to evaluate each contractor’s technical proposals. According to Bob Mues, these technical evaluators were former project managers or Resident Engineers who had at least 30 years work experience in similar projects and had the appropriate knowledge to assess whether a contractor was capable of doing the job. He stated that they started evaluating the engineering and construction aspects of the proposal using a questionnaire system. Later in the screening process, they asked tenderers pre-screened questions regarding their approach to executing the project. They had to make judgment calls and did not use a point grading system. These were all recorded in reports submitted to the THSRC. Although subjectivity could have been an issue in this type of evaluation, the THSRC was relying on the technical knowledge and the expertise of the people it hired to provide defense to their evaluations. Bob Mues adds that “it was a good system to use
to prevent getting stuck with a system where a guy could fictitiously get points and then end up getting the contract by the technical evaluation.” The approach was adequate to avoid situations in which a bidder was awarded a contract for non-existent qualifications.

Proposal evaluation used the following technical criteria:

- Contractor’s best use of own equipment, e.g., full-span launching method
- Construction methodology for fastest implementation.
- Demonstrate capacity of resource and equipment and know-how in building the work (Lin)
- Contractor’s Construction Quality Control which includes: site supervision, site testing and inspection following the ISO 9001 (Schultz)
- Safety plan as a ‘back to back’ compliance to the C&OA requirement for safety

Technical proposals were evaluated before the financial proposals to pick out the candidates who could actually do the work. Although the bottom line was nearly always what was the most economical for the project, the exception occurred when the technical proposal showed that a bidder could not possibly produce the desired results (Mues). In one instance, the evaluators proved to the Board that the lowest bidder could not possibly finish on time. Since the penalty for delay was so huge, the Board accepted this evaluation and decided on the recommended technical proposal (Mues).

Self-certification for completed work was included in the requirements from the contractors. In the terms and conditions of the civil contracts, the THSRC required the contractors to provide its own in-house or external designer as well as hire a Construction Independent Checking Engineer (CICE) to certify the validity of the designs. During construction, the contractor had to have its own quality team that would validate compliance to the approved Quality Plan. According to Ed Schultz, one of the Resident Engineers, self-checking was considered reasonable before construction started because it was supposed to be more efficient and more economical for fast-track projects. However, the risk involved was the great reliance on the contractors being responsible, experienced, and committed to delivering quality work.
Besides self-certification, the THSRC has other expectations from the contractors as embodied in the General Conditions of contract (GCC) such as (Fleming, “Contractual” 242-255):

- Interface Management, which is to facilitate the integration and co-ordination of the works where a common boundary exists between two parties or where works and responsibilities of any parties overlap or are connected in some way with the works, is in bulk assigned to the civil contract by placing ‘best endeavors’ obligations in the civil contracts. Interviewees commented that this clause was a “hide behind” clause, but the THSRC rationalized that the civil contractors were better situated to deal with any conflicts, and were capable of arriving at a more expeditious solution.

Civil contractors had to sign the Master Interface Agreement so that if one contractor breached the agreement then the affected party, another contractor, could claim damages from that contractor instead of from the THSRC. Roger Rothenburger, another Resident Engineer, commented that “on linear type structures, e.g., viaducts, bridges, tunnels, where the points of contact are only at the ends, then interface management is simple since little interfacing occurs.”

- “Milestones” were defined at a pre-agreed date in the schedule and a price center, or source of cash flow, was associated with each milestone. In the event that a milestone was not achieved, the price center it belonged to would be frozen until the milestone was actually achieved. The payment-for-milestone method was to provide incentive to the contractor to work to the Baseline Schedule and to continue through until substantial completion. If a contractor put a milestone in each price center monthly, then the contractor would not have received any payment if the schedule got delayed.

The contractors had concerns that the THSRC would use the method of freezing price centers to leverage against them and make late or delayed payments. Actually, the THSRC initially tried to use this assumption to add more of its control on the project; in the end, the THSRC still had to adjust the baseline program and price centers to accommodate the contractors (Rothenburger).
Compliance to the Safety Plan was associated to Price Center One and failure to meet requirements meant freezing of this cost center. This contractual ‘stick’ was used by the THRSC to exercise control over the conduct of the contractors. The price center was not specifically divided to safety, quality programming, staffing, etc. and so implementation of the clause was difficult.

Statement of No Objection (SONO) was issued instead of approval or disapproval reiterating the THSRC “hands-off” approach to the project. Even with the IREG and the Construction Independent Checking Engineer (CICE) involved in the project, these groups were only to check and monitor designs. The THSRC relied on the civil contractors to be responsible for the entire scope of the civil work.

The civil contracts had a ‘fit for purpose’ clause stating that the contractor had to exercise all the necessary skills, care, and diligence expected from a well experienced entity to provide Works that would fulfill the intended purpose and would perform reasonably well as implied in the contract. contractors felt that this was an unqualified obligation that the THSRC was imposing, but the THSRC saw this as its way of reiterating the seriousness of the contractors’ obligations to produce Works that ‘fit’ the need.

Risks pertaining to ground conditions were specified as part of the conditions contractors had to shoulder. The THSRC wanted the contractors to assume any ground-related problem that occurred, since contractors were given the opportunity to bid only on items they were ‘experts’ in, e.g., viaducts, tunnels, combination. Also, the tendering period was long (2 years) which would have given the contractor sufficient time to do an extensive study of the ground conditions, since there was vast amount of coring data available for analyses (Kao).

The THSRC had an Owner’s Controlled Insurance Schedule to cover any damages if any unanticipated event, such as tunnels caving in, occurred during construction; although this insurance did not cover events associated to “changed conditions.”

The civil contracts specified who had responsibilities for acquiring permits. The THSRC obtained the necessary permits, but in the event the contractor required
more than the standard permits due to the chosen methodology or surpassed previously set parameters, the contractor then had to take responsibility for producing the needed permits.

- A time extension clause specified that any delay, due to weather issues that were not uncommon, would not result in time extension being granted. This was greatly debated over between the THRSC and the contractors. The THSRC considered this to be a fair sharing of risks with the contractor. The THSRC expected the contractors, experienced as they were, to be able to manage some risks and mitigate some types of delay.

- The civil contract had a latent defect clause which expired either five years from commercial operation or 15 years from issuance of certificate of substantial completion of works (whichever is later). This duration exceeded the existing law in Taiwan but was considered necessary and abated ‘long term consequences’ of having defects.

- The process of conciliation and arbitration during post completion were included in the civil contracts to appease the contractors’ concerns about getting an unbiased decision for any irresolvable issue that could arise regarding contract administration. Sole conciliator or chairman of a panel of three was to come from esteemed organizations such as the Taipei City Engineers and the International Chamber of Commerce, or the President of the Institute of Civil Engineers (UK). This was understandable due to the extent of risk allocation that the THSRC adapted.

C. Advantages of the Design-Build Approach

The THSRC’s major reasons for using the DB approach to implement the civil contracts were:

- The DB approach in civil contracts allowed the contractor to implement the design using means and methods with the best utilization of their equipment.

- Construction time could be controlled or ‘at the hands’ of the contractor (Lin).
o Contractors were more efficient in managing the design, had quicker access to designers, and could assemble a team earlier and as such could start a job faster giving the chance to completing it faster (Rothenburger).

o The project was ultimately the responsibility of the THSRC to the Taiwanese government, but through the DB approach, it was able to pass on the responsibility of producing and managing the designs for the entire 345 kilometer alignment all at once through the 12 civil contracts (Rothenburger).

o Since one-third of the project’s design length (45km) was prone to design changes (Kao), the THSRC felt that these changes would be overwhelming to handle if the conventional contracting approach was used. The risks of designing and constructing the civil work of the project were allocated to the contractor. The DB approach assumed that the contractor would be given control over the design; any delay associated with the design would be anticipated and included in the contractor’s project schedule. The THSRC hoped that by having design and construction become the responsibility of the contractors, change orders related to time extensions would be minimized (Kao).

o Early selection of the THSRC as the operator and awareness of its limited resources for construction of the project highlighted the need for competent and experienced people to do design-build. (Tan)

As Bob Mues said,

Design build is not without its costs. It actually costs more to do DB because the contractor takes more risk and will mitigate this by putting more ‘money’ or contingency inside his bid. [An] Example would be on deciding which wall thickness to use for a segment; he will decide to be conservative and use the higher numbers because of having only the conceptual design to base it on. The contractor will ‘pad’ his bid and then will find ways of ‘shaving it off’ later. For the owner, the real savings will come from having the work finished on time. Looking at the whole picture, DB is actually more expensive in construction but having the revenues come in earlier will make all the difference. The interest not being paid on the loans and the project generating revenues will make project implementation [being] faster, cheaper.
D. Shortcomings of the Design-Build Approach

For this project, letting the contractor do everything including quality assurance might not have been the best decision. Self-certification could have turned out more economical and efficient for a fast-track project due to lessened coordination efforts among different entities, but self-certification translated to complete reliance on the contractor’s ability to self-check. This might have been enforceable if coupled with a very competent and experienced contractor, e.g., German contractors, used to total quality management.

In contracts where contractors were accustomed to self-certification, fewer issues arose regarding the self-checking feature of the contract; but in others not as fortunate, self-checking ultimately failed. The THSRC even had to directly supervise work, which was the contractor's job, just to have the project meet design specifications. The contractor was observed to have underestimated the level of competence that its supervisory people needed to handle the project. Coupled with the time constraints and having lump sum fixed-price contracts, shortcuts were taken and workmanship suffered (Schultz).

A tight schedule and fixed price had a ripple effect of having the contractor, who had a low price, hire personnel who were not well-qualified for the job. These people would then choose subcontractors through competitive bidding with managers who were also ill-qualified. In the end, the tendency was to take shortcuts to get the job done on time and still make a profit. The ultimate burden of ensuring quality fell on the THSRC. Although failure of the system only occurred in remote cases, the responsibilities and involvement of the THSRC personnel become more than anticipated on jobs where these occurred. The THSRC not only had to monitor the progress of the contractor but also had to directly supervise the contractor's and its subcontractors' work. One example was the re-working the embankment when settlement was observed during track work. Due to the lack of adequate inspection during the filling of the embankment in C230, it turned out that there was not enough compaction in the interface layers between two different filling materials. This became evident only after embankment was already completely finished (Schultz).
The remedy to the self-certification issue could have been to obligate the contractor to hire an independent inspector with reporting responsibilities to both the THSRC and the contractor.

Although adequate design criteria were already available in the beginning, the THSRC’s “hands-off” approach made it difficult to demand that contractors conform to specifications. There was even a ‘tug-of-war’ as to how some design specifications were to be interpreted (Kao). The DB method could be used for simple enough projects, e.g., civil work, but even then disagreements arose. An example was the THSRC’s comment on having the slope of an embankment made too steep. The contractor argued that the slope was good enough to conform to the design criteria. The THSRC asked the contractor to put reinforcing blocks to make the slope more durable, but the contractor responded that after hydoseeding, the slope would hold and would perform as designed (Kao). According to Roger Rothenburger, hydoseeding would have been sufficient for erosion control but not slope stability.

If the slope had not eroded due to rains, the contractor would not have repaired the slope and added the necessary reinforcements. The THSRC could not have forced the contractor to follow its directives if the contractor could justify that the design criteria were being followed (Kao).

Due to the THSRC’s lack of expertise to manage the design and construction of a DB project, the THSRC had to hire expensive foreign experts, who were paid 10 to 15 times more than the locals, to provide the technical and construction expertise needed for the project. This was exacerbated by the fact that Taiwan and other developing countries do not have a large pool of people experienced with the type of work involved in the THSR project (Rothenburger).

E. Impacts of Design-Build on the Project

The DB approach worked well with the civil work and, most importantly, allowed finishing the work within the given timeframe. The primary advantage of the DB approach is speed; the THSRC recognized and tried to utilize this advantage. However, occurrence of certain events, e.g., changing design codes by the Taiwanese government after a big earthquake in 1999 (referred to as the “921 earthquake” by
Taiwanese locals) in the middle of project implementation, thwarted taking full advantage of the scheduling benefits. The contractors actually did not lose a great deal of time but they were still allowed to claim time extension because the change was a variation to the works (Rothenburger). Despite this, the THSRC’s ability to promptly define what it wanted built, as specified in the design criteria, and its hiring of people from the BOHSR who had studied this project for years made up for the lost opportunities. The THSRC also did not engage in much debate about the designs, with the exception of design meetings with the contractor to discuss requirements, and encouraged designers and constructors to work immediately on the project.

Roger Rothenburger’s viewpoint about design-build was “time is the objective of the design-build but not the only reality of design-build. It has a lot to do with people, the concept of the work, and how to build the project (it is) just like any other project. If a project starts screwed up, then it stays stayed screwed up, even if it is design-build or design-bid-build.”

IV. PRE-CONSTRUCTION ACTIVITIES

With the privatization of the THSR project the planning, designing, and pre-construction studies made by the government became the preparatory work and knowledge database the THSRC needed for the prompt implementation of work. The government had already identified the horizontal alignment or route of the railway, the feasibility of the project, the civil design, and other details from studies that it had done. Another important decision THSRC made was to select the design-build approach for civil contracts which allowed the THSRC to exert its influence over the construction phase. The project used the ICE Design Build Model Conditions (1st edition), from the United Kingdom, as basis of the civil contracts (Fleming, “Contractual” 237).

Below are other preparatory activities which assisted the THSRC in allocating risks in the civil contracts and in having more influence on the outcome of the project:
A. Coordination Work

One of the greatest challenges of doing infrastructure work is the coordination needed to make sure that the different stakeholders are working towards the common goal of finishing the project on time and with the quality required for operation. For the THSR project, the government assumed coordination efforts for which it could be most effective, as did the THSRC. The following examples illustrate the coordination process in the project:

- The Taiwanese government was to take care of the underground tunneling in Taipei Metropolitan area excluding the core systems and other works. This exclusion was meant to lessen the THSRC’s responsibility for coordination and handling complexities associated with constructing in Taipei, a large metropolitan area.

- The THSRC assumed responsibility for acquiring permits, licenses, and certifications for the contractor, as stated in the civil contracts but with some exclusions. The THSRC knew that administrative tasks involving local agencies could be tedious activities and could impede project progress if not handled fastidiously. Since the government was nevertheless obligated to assist the THSRC in acquiring these obligatory authorizations, the THSRC took the lead in acquiring these permits to ensure project progress. The contractors then had no reason to ask for time extensions (Tan).

B. Utility Relocation

The THSRC awarded a separate advance work contract precedent to all other contracts. This contract’s scope included power, water, sewerage, and other utility relocation that the project needed. The THSRC took care of this portion of the works before having any of the civil contractors move in. Any difficulty related to utility relocation could have resulted to a delay, which the THSRC did not allow. To control the civil work progress, utility relocation works were completed beforehand. The THSRC did not expect the civil contractors to assume the risk of delay associated with relocating existing utilities. Roger Rothenburger claims that as a rule of thumb, it would take at least a year to move and relocate surface utilities for any kind of urban
The THSR project specifically relocated utilities in areas being run along and across the railway.

One hundred lines of high voltage (69KV) overhead cables were raised for the trains to run through because these were initially hanging at very low elevations for the new viaducts to be built. Also, some pylons for power towers were relocated and erected in land that belonged to local farmers. Taipower, the utility company and advance works contractor, worked with the THSRC to negotiate with farmers (landowners) to get the right of way to put pylons in their land or ask them to surrender land for the new pylons (Mues). In other areas such as Cho Yin, some utility lines ran along the centerline of the streets, and these had to be relocated to accommodate the railway.

C. ROW Land Acquisition

Land acquisition for the right of way (ROW) took a long time to complete. The government had to relocate the alignment three times before the final route was chosen. ROW acquisition was very difficult. The government had to forgo two alignments before deciding on a third, since most of the land needed reached exorbitant prices due to opportunistic entities wanting to make a profit. It was only by the third alignment that the government was finally able to acquire the needed ROW without the market taking advantage of the government’s plans (Lin).

All land directly needed for the HSR was acquired by the BOHSR even before privatization. The width of the ROW for the civil work spanned 18 meters which was just enough for the viaduct spans and the piers to be erected. The government also acquired the land needed, including station area development land and station access roads for the five new stations (Tan).

According to Bob Mues, who commented about the government’s measures to acquire the land, “[The] BOHSR didn’t tell the whole story to the landowner to get the land. A farmer would be told that his land will be split in half by the alignment but was never informed that to get to the other half, it would take at least 5km to get to it. People soon discovered that there were some things they didn’t know.” The
government took these steps just to ensure that land was acquired in the most expeditious manner. The contractors were then left to resolve the resulting problems.

D. Studies of Alternatives

Alternatives were studied to decide whether to add more freeways, rehabilitate the old rail, or add a new rail system to address the increasing transportation demand of Taiwan simultaneous with the economic boom. Based on the forecasts of demand and capacity needed, studies revealed that the HSR was the practical choice. Forecasts used to confirm this decision were considered ‘conservative’ and realistic with the current slower economic growth in Taiwan. Other studies focused on selecting the alignment. The studies which lent support to the feasibility of the project and to the decisions made are listed below:

- Ricardo Tan offered the information that before deciding on the HSR, the government initially wanted to rehabilitate the old railway instead of constructing a new one, but studies showed that building a new one would be the more feasible option in terms of cost and social impact. Adjacent and surrounding areas to the old railway were already fully developed. Also, the process of acquisition and demolition would have had tremendous impact on these areas. From an engineering point of view, the existing rail had been in service for one hundred years and had three hundred grade level crossings. These conditions would have required upgrading the existing rail and reducing the number of level crossings to convert to a high speed rail (HSR). The need to stop existing railway service for an extended period would have negatively impacted the existing transportation system of Taiwan. For the mentioned reasons, a new railway had to be built for the HSR project instead of retrofitting the old line.

- The actual horizontal alignment took some time before being set. Studies showed that the first route considered should be changed because of passing through the ‘old cities’ which would not have been efficient for infrastructure management. Land prices also played a part in the final setting of the route. The government decided on a third option which lay between the first two alignment options. (Kao; Lin)
The recent disaster that occurred in South Korea alerted the THSRC of events to be avoided. The fire incident which happened to the Korean HSR cautioned the THSRC from the same event happening in the THSR project. Consequently, when the Taiwan Shinkansen Corporation proposed usage of cables in the core system of the project similar to those of the Korean HSR, the THSRC disallowed their use (Schultz).

E. Design Specifications

The design documents from the BOHSR gave the THSRC a clear view of how the final design should perform. These then translated into the European specifications used to solicit the proposals from civil contractors (Kao):

- The project was to be designed for a 100 year design life (Schultz) to support the idea of having the THSR project as a long term investment which would possibly be the only HSR in Taiwan for a very long time (Tan).

- The THSR Consortium’s tender proposal to the government already identified the most cost effective structures for the horizontal alignment (Lin). The design alternatives were checked during the planning stage with the THSRC’s engineering division working hand-in-hand with the government to identify the locations and lengths for viaducts, tunnels, and earthworks along the alignment (Schultz). Mountainous areas would be traversed with tunnels, viaducts, bridges, and embankments to address gradient limitations. For alluvial plains, only viaducts and bridges were designed (Gillam and Townsend 53).

- The THSRC spent one year to conclude that a 35-meter length was the optimum span length for the viaduct spans. There was no need for each civil contractor to make a study of its own but doing so was not discouraged. This aided expeditious implementation of the civil work (Kao). The THSRC also studied the use of high speed turnouts different than those already existing in the Japanese Shinkansen high speed train system. The standard Shinkansen rail used points that could accommodate 100kph speeds using the Japanese technology of electric multiple unit (EMU) and not the push-pull system. According to Ricardo Tan, the THSRC specified use of a German-technology-based turnout which would accommodate
160kph speeds to maximize the capacity of the line. Having a higher turnout speed lessened the time needed for the train to start deceleration which would affect actual service provided by the railway system. Use of the different turnout would accommodate the long-term service plans anticipated from the THSR project (Tan).

F. Geotechnical Studies

The THSRC provided the contractors with geotechnical information including boring data for every hundred meters of the alignment. This was in conjunction with the government’s detailed design provided as part of the tender documents given to the bidders. According to Kao, “With all of this information already available, the civil contractors knew more of the common unknowns in any construction project and could plan very far ahead.” The following are some of the provided geotechnical information:

- For tunnel construction, some areas had high water table and unstable ground conditions while other areas have medium-hard to medium-soft ground (Hemphill 221).
- The studies predicated the use of ballast instead of the J-slab tracks in three kilometers of the track work due to potential settlement foreseen because the section was at ground level (Tan).

The THSRC provided most of the geotechnical data, utility information, and reference design – the government’s detailed design which were already approved and reliable (Kao).

G. Critical Resources

All resources became critical once the project started. Some resources that were already critical from the beginning were available manpower in Taiwan, concrete and aggregate materials, and piling equipment. However, these were addressed even before the start of construction. Bob Mues commented that the most critical resource of all was money because the willing price to be paid dictated the availability of the resource. He added that the entire contracting and construction industry was waiting
for the project to start where every supplier was ready to ‘rig’ the price. He stated that
the only way to overcome insufficient critical resource supply was to anticipate and
prepare for any price escalations (Mues).

1. **Manpower**

   The decision to offer the project to international bidders was based staffing needed
to finish the THSR project in five years. It turned out that Taiwan only had the
capacity for 1/3 of the project’s needs (Kao). Fortunately, the THSR project was being
bid out at a time when big construction contracts were few and not many were going
online in the international market. There were many contractors willing to provide
technology, manpower, and equipment because of the timing of the project (Tan).

   Subcontractors and general labor resources were limited in Taiwan. The work
force had to be imported from Thailand, but Taiwan had laws limiting the amount of
workers that could be imported to the country. The importation limit was a factor of
the actual contract amount inclusive of all change orders. For the C230 job, the quota
was less than 20% of what was actually needed (Mues). The required labor force had
to be reallocated within the project, which was not optimal, to satisfy the need. This
also had to do with the contractor making the correct application for the appropriate
number of laborers and coordinating with the right person to process the application
(Mues).

   Similar to most government or public projects, preferential advantage was given to
locals and hiring of aboriginal labor was even required. The contractors had no issue
with this requirement with the exception of the unpredictable nature of the local
aboriginal labor reporting to work. This affected productivity which was hard to
tolerate in a fast-track project (Mues). A greater impact on labor productivity was
whether the contractor decided to self-perform the work with own supervision or hired
subcontractors to perform the work (Rothenburger).

2. **Space**

   Another critical resource in this project was the size of the site available for
logistics. The ROW was given by the BOHSR, but the land needed for the contractor’s
camps, offices, and yard setups was not included in the provided ROW. The contractor had little area available to perform construction operations. Of the entire 345-kilometer project alignment, only 1000 hectares of land was used (Kao). The ROW was only 18 meters (59 feet) wide which was all required for construction.

The contractors’ space plan for an office and yard complex exceeded the area available in the ROW for viaduct construction particularly where full-span launching was used (Rothenburger). There were also some inaccessible sites without any access roads provided. Most of the space in the actual project site had to be utilized to erect the piers and columns (Kao).

For the contractors working on the tunnels, there was difficulty in deciding where to locate the main office and site offices to provide optimum coverage. Getting access to some of the portals was the main issue because the locations were in mountainous areas (Schultz). Dependent on the tunnel and the use of its surrounding land, another issue was the limited space that the contractors could use for the access. Although the site had storage areas which were regularly supplied with materials needed for the tunneling operations, resource delivery was strictly scheduled because the site could not accommodate storing bulk materials at once.

3. Materials

Another critical resource was steel. The rail track ballasts had to be imported from Mainland China. In addition, the demand for fabricated steel materials such as structural steel overwhelmed the suppliers (Mues). Prices not only escalated but also the quality of the supplied material initially suffered although eventually recovered. There was a domino effect whenever a standard steel supplier had to use small subcontractors without proper quality control processes or facilities because of the
high demand for fabricated steel. Outsourcing the work to other smaller mills made it difficult to monitor and consequently lowered the quality of steel being supplied.

As early as the tendering stage, the contractors were aware of the insufficient supply of aggregates in Taiwan (Mues). Aggregates were short in supply for this project because aggregates could only be mined from the rivers and not from the mountains, which actually form 70% of Taiwan’s land area. The mountains were off-limits for environmental reasons. Also, there was a monopoly for the supply of aggregates in Taiwan (Rothenburger). Even so, Mainland China was an available market to consider. The contractors anticipated and planned for by adding the hauling price in their bids (Mues).

4. **Equipment**

Taiwan had a shortage in construction equipment especially piling equipment because of the enormous quantity of bored piles needed for the project (Mues). Most of the drilling was actually performed with local subcontractors using imported equipment.

In some cases, the lack of equipment was a result of a company’s economic hardship rather than a local unavailability. For one of the civil contracts, the contractor gave false information to the Resident Engineer in stating that the needed piling equipment was already in transit. However, the equipment never arrived and the contractor’s Joint Venture partner had to procure the equipment itself. It turned out that the contractor was financially constrained and could not afford to procure the needed equipment (Mues).

5. **Social and Environmental Concerns**

For the project’s successful completion, the THSRC had to address the following concerns that affected the local communities:

- The government anticipated the political-social impact of building the HSR. According to SC Lin, even though the original design did not have one station per county to maximize operational efficiency, more stations had to be added to the line to address the needs of the affected counties.
Foreign contractors were encouraged to joint venture with local contractors and have a coordination team take care of local issues, e.g., river permits, labor issues, protests (Tan), because the contractors were in constant interaction with the local community. In addition, the contractors had to compensate the local government for using the local infrastructure to get project resources into the sites by agreeing to maintain the infrastructure (Mues).

H. Impacts on the Project

The results of the Taiwanese government’s studies from 1989 to 1996 guided the execution of the project. These preparatory works were the provision of the geotechnical data upfront and doing advance work such as utility relocation, ROW acquisition, and preliminary designing. These actions proved very important to the next phases of the project as detailed below:

- Acquiring permits and certifications and all other dealings with local agencies can be potential cause for schedule delay. The THSRC assisted in these coordination activities and supported the contractors, consequently influencing how these would affect the project’s master schedule.
- Acquiring the ROW before the start of the project implementation removed any risk of project delay from this key activity.
- By providing advance data that the contractor should further analyze, requests for any time extensions related to ground conditions could be disapproved (Kao). The contractors were responsible for the verification of the validity and usefulness of the given information through their own designers or through investigation bodies.
- The THSRC had an Owner’s Controlled Insurance Schedule that would provide the needed financing to bring back the contractor to full capacity in case of an unforeseen event (Fleming, “Contractual” 254-55).
- The THSRC knew that the scale of the project would have a direct impact on the resources and was able to plan on mitigating the potential impacts on the project. Even with the price escalation of key resources, some allowance in the THSRC’s cash flow enabled it to ‘inject the money’ when needed (Lin).
The THSRC found it a good practice to have as much preliminary study and designing done upfront in Design-Build type of work. Knowing many variables as possible gave confidence to the contractors that they knew on which they were actually bidding (Kao).

V. PROJECT MONITORING SYSTEM

Although the project goal was to perform within a prescribed schedule, THSRC did not want quality compromised. According to Bernard Walsh, Chief Director - THSRC Construction Management Division, “To control the schedule meant being able to control the interface between multiple prime contractors who had control of the site.” For the civil work, the master schedule showed the tunnel completion dictating when the track work could start. The other construction activities were to work around this schedule as well. The THSRC imposed contract clauses about land turnover, i.e., how much time a contractor had ‘prime possession’ of a particular section (Walsh). Each contractor was made aware of how much effect it had over the other contractors, and they were all asked to provide detailed construction schedules to exactly identify key milestone dates (Kao).

Some measures, such as imposing interface management, were defined in the C&OA, while the measures mentioned below were implemented by the THSRC to support the desired sequence:

A. Contractor Selection Process

The THRSC employed experienced technical evaluators who could retain objectivity during the contractor selection process. Each evaluator and/or team had to follow a thorough procedure on how to evaluate bids and each had to send a report to the Board outlining the valid details of the tender. Only questions pre-screened by the THSRC procurement department were allowed in the final discussion with the contractor. These sessions were conducted to clarify issues regarding the tender and to let the contractors explain what they had planned to do. The entire tender was evaluated on the technical and financial aspects before selection was finalized. The
technical proposal had to be deemed workable and acceptable to the THSRC and it also had to meet the time restrictions. The contractors were qualified according to (Tan):

- Evidence that they had competent people available to do the work, e.g., attached resumes of the project manager and team members detailing experience in related works
- Adequate skills (right people and experience) to manage the design part of the contract
- Demonstrated knowledge of construction means and methods feasible for the project
- Presentation of a construction schedule that showed a sequential logic of the work

Some basic items that evaluators looked for in proposals were (Kao):

- Experience of both the design and construction firms and CICE
- Ability of the tenderer to work in Taiwan
- Conduct of RAMS (Reliability, Accessibility, Maintainability study) for components in the civil work, e.g., indicate when and how to replace bearing pads in viaduct sections
- Quality Plan following ISO 9000 standards using the Quality Assurance approach
- Safety Plan
- Design and Shop drawings for all works
- Method Statements (to be reviewed by THSRC)

If the designs of two tenders fulfilled the required function and followed the deformation criteria and earthquake specs, then these two technically suitable bids would be compared based on the financial package (Kao). The financial department would take over the evaluation, check the validity of the financial proposal, and compare tender prices. The contractors, in their financial proposals, had to show that they could support the needed cashflow knowing that there was at least 51 days before payments would be made (Tan).

The lowest bidder was not necessarily chosen for the project, especially when the THSRC did not have complete faith in the bidder’s technical proposal (Tan). In the
civil contract, C250, with five river crossings, the technical evaluation governed the contract award. The Hochtief proposal, although a higher price, was accepted because it was the stronger technically. The proposal showed a better organization of construction methods and plan of action, thus achieving higher points technically compared to the other proposals. Primarily, Hochtief precast all the viaduct sections and guaranteed quality control. On the river crossings, it built the long steel sections on one side and then just rolled them into place on their piers. Other contracts were awarded with ‘acceptable’ technical proposals but better financial terms (Tan).

The station/depot tender evaluations for S280 and S290 were also awarded on the basis of a superior technical proposal but higher tender price as for the C250. Bob Mues reported that for S280 and S290 – where he was a bid evaluator and eventually Resident Engineer (S290):

TECO was the lowest bidder for both station contracts, S280 and S290, but clearly was not capable of finishing the job on time. TECO’s whole construction plan was fictional; and when the Project Manager (foreign) was asked about this, it was obvious that they had no idea how to build the job. [The] Interview revealed that there was no clear logic in the schedule they presented and actually just put the bid items into boxed activities for presentation. [The Resident Engineer] RE had to make presentation to [the] THSRC board that the lowest bidder wasn’t the best choice.

The selection process the THSRC used was comprehensive enough to ‘weed’ out the contractors who could not do the job. This gave the THSRC the chance to get the ‘best value’ for each of the 12 civil contracts, except in cases of political intervention at the THSRC Board level. There had been cases that contracts were awarded based on the Board’s preference rather than the results of extensive evaluation (Mues).

B. 3rd Party Involvement

The C&OA required that the THSRC select a 3rd party to certify that the railway would be satisfactory for operation once completed (Kao). The THSRC decided to provide two levels of assurance. The first tier was represented by the Independent Verification and Validation Engineer (IV&VE), Lloyd’s Register. The next tier was the Independent Checking Engineer (ICE) for the design and the Independent Supervising Engineer (ISE) for construction; each was responsible for double-
checking (Kao; Lin). The lender’s engineer was also involved in the project. The lender’s engineer had to sign-off for all payment requests before payment processing could commence. The lender’s engineer used a checklist, translated from the CO&A, to verify quality, documentation, and signing-off of all the different entities. Before the lender’s engineer signed-off, certification from the THSRC and site verification for actual value were required (Tan).

The lender’s engineer’s involvement will not be discussed in the following sections, which focus on the IV&VE and the ICE/ISE:

1. **Role of the Independent Verification & Validation Engineer (IV&VE)**

   The IV&VE was involved from the very beginning because the government did not have the specialization to check the validity of the HSR. The IV&VE was an independent party who could provide ‘confidence’ to the government, lenders, and even to the THSRC and certify that the rail would perform as expected (Kao). Some functions of the IV&VE included:
   
   - Provision of a systematic process of validating an HSR for safety and readiness of operations through procedures and qualified personnel who could look after the owner’s interests
   - Provision of adequate checks to ensure that the involved project parties were performing and fulfilling their responsibilities (Tan)
   - Auditing and monitoring design and construction, checking the THSRC processes for total quality management, and issuing regular reports to the THSRC and the Ministry of Transportation and Communication (MOTC) (Schultz)
   - Overseeing THSRC’s process of handling design issues and arriving at solutions (Lin)
   - ‘Checker’ to the checkers who were the ICE and the ISE (Kao)

   The IV&VE, being independent, had direct access to all parties and could go directly to the lenders and MOTC if the need arose. It also served as the protection investors sought to ensure that the project was being delivered as needed (Tan). At the last stage of the construction phase, the THSRC would need to present to the IV&VE, proof of the project’s safety and operational readiness. Ricardo Tan, VP of THSRC
Construction Management Division commented that, “Proving to the IV&VE is almost like presenting to the court; (and) proving that you have all the things you said you have.”

2. Role of the Independent Checking Engineer and Independent Supervising Engineer

IREG (Independent Railway Engineering Group) fulfilled the role of the ICE/ISE. IREG was hired almost for the same purpose as that of Llyod’s Register. It was another party that could provide ‘confidence’ to the THSRC (Kao). In addition, it substituted the needed manpower that the THSRC lacked to monitor the project, although the limitation was that the ICE/ISE could only look into quality and design and did not have authority over costs and schedule (Kao). The ICE’s main task was to look after the design process while the ISE’s was to oversee the construction. The ISE was to supervise and check site quality and augment the THSRC’s checking ability (Kao).

C. Design Control

The THSRC had already allocated much of the risks associated with design to the contractors by using the DB approach. But since the DB approach was still a very new concept in Taiwan and people had been accustomed to the traditional project delivery process, checks and control measures were almost redundant in the project. These controls are discussed in further detail:

- Contractors were required to hire the CICE to check and certify the design
- The THSRC hired the ICE to do random checking on the design of the entire project
- The THSRC Engineering Division administered design management using a design review process

The design review process began with the contractor’s designer conducting design and interim checks. The design was then passed to the Construction Independent Checking Engineer (CICE) who conducted an independent check and then issued the certificate to the contractor. Next, the contractor would submit the design together
with the CICE certificate to the Employer’s Representative’s office for approval. The design had to be routed to the THSRC Regional office, the ICE, the THRSC Engineering Division, the THSRC Document Control /System Integration section, and the THSRC Technical Support Section for comments categorized according to a comment grading system. The office of the Employer’s Representative would then issue a ‘Statement of No Objection’ (SONO) or objections with reasons and comments that the contractor would have to handle before design could be implemented. Lastly, the design would be returned to the contractor for implementation or revision. The whole design review process usually took 45 days to complete, excluding any objections that might have happened along the way (Hsieh and Lankaster 162).

1. The CICE

The CICE was hired to assess and evaluate all the contractor’s and designer’s documents which consisted of design reports, calculations, drawings, work specifications, method statements, temporary works, and all as-built documentations. Specifically, the CICE had to (Reinbeck 270):

- Do 100% checking of the design, e.g., detailed design
- Check the design and construction drawings for the permanent work, including conducting structural analyses and calculations
- Provide details needed for construction
- Check the design of the temporary work and inspect it in actual before use
- Check conformance of work specifications to the THSRC’s construction specifications
- ‘Not’ be involved in construction site supervision

Although the CICE had a great deal of influence in the design, it had no obligation over the design and instead had to submit to the THSRC a “notice of no obligation.” The CICE’s main task was to assist the contractor in achieving its target to finish within time and budget by making sure that the design conformed to contract requirements. In some cases, the CICE had to act as the interfacing body between the
designer and contractor if both were not used to directly working with each other (Reinbeck 271).

2. **The ICE**

   It was not the ICE’s role to duplicate the CICE’s activities or functions (Davis 260). A major role of the ICE was to ensure that all parties, including the CICE, were carrying out their functions properly. In making detailed design checks on the contractor’s design, the ICE only took a sampling of around 5% of the overall design, unlike the CICE, who had to check 100% of the design and construction drawings. Most of the works of the ICE and ISE were very interrelated in order to fulfill the contract clauses that encompassed both parties’ scope of work. Some activities the ICE fulfilled were (Davis 261-62):

   - Reviewed the contractor’s, including the designer’s and the CICE’s, quality plans
   - Thoroughly reviewed all design submissions and made the necessary comments that were categorized using the comment grading system to distinguish which were ‘preferences’ and which were ‘non-compliances’
   - Did detailed design checks focusing on the critical elements and areas where design errors might have been overlooked
   - Carried out audits of designers and the CICEs, with focus on the processes and quality assurance at the early stage but subsequently focusing more on the technical issues and interfacing

   The ICE was meant to place more emphasis on the Process of the design rather than the Product of the design, but the resource demands for the product were so great that little else was left available to focus on the process. The ICE felt that more Audits and fewer Reviews could have been beneficial and would have better served the interest of the project (Davis 266).

3. **Engineering Division – Design Management**

   The main function of the Engineering Division was to administer the design review process and ensure that the design criteria were being followed. It was
important that the THSRC had some degree of control over the design process. Some cases are illustrated below:

- Some of the international designers involved in the viaduct work voiced their skepticism over the use of a novel rebar configuration to confine steel reinforcement for earthquake loading that was going to be implemented in the project (Schultz). This was a new structural design and there was no knowledge of prior use. The configuration was based on an empirical study made by a Taiwanese professor on how to curtail rebars and tie hooks using a wrap-around type of reinforcement thus preventing rebars from bursting from the concrete in case of an earthquake. The THSRC insisted on its use in the project and reiterated its relevance to fulfilling the prescribed design criteria. The contractors had no choice but to comply with this design requirement.

- The THSRC had to take the lead in sending queries and getting answers to the question of fitting an elastomeric bearing pad vertically to the shear key. EuroCode EN3037 did not cover this use of the bearing pad, and clarification was needed. The contractors could not have been expected to take this added task, thus the responsibility fell to the THSRC (Schultz).

- The THSRC’s involvement in the design process made sure that if any unanticipated event was to happen, it would still have the necessary influence to make sure that the four year schedule would still be attained. This actually became important when after the 921 earthquake, the government ‘beefed’ up the codes and the THSRC had to ask the designers to revise the design.

Almost simultaneous to having the contracts awarded, Variation Order No. 1 (VO1) was issued due to the 921 earthquake which resulted to a revised national earthquake code with higher resistance to earthquake forces (Schultz). This caused some delay in the design phase because of changes in decisions that were made. After some analyses, VO1A was issued to withdraw this revision on the THSR design criteria. Since the THSRC specifications were based on the European and the Japanese systems for rail and the American system for construction specifications, e.g., the ACI code, the structures were already designed to be very robust. The prescribed
specifications already fulfilled the newly revised earthquake requirements. The requirements only nominally affected the structural sections but due to the additional reinforcements needed, analyses were still run to reassure adequacy of sections. Also, the THSRC had to check constructability of the design, i.e., changing the type of concrete, to be able to penetrate tightly reinforced sections. The change in the code delayed the schedule by a total of eight months (Schultz). As a result, contractors had to submit acceleration plans even before construction began (Tan).

Having the THSRC focus on the design also assured that the contractors’ design management teams were working to have the design ready as soon as possible. Bob Mues commented,

> Designers would design forever and continue to work with the design until it was perfect; but for DB projects, designs have to be quick and adequate. The final designs might not be the best design but time was such an issue that wise design decisions had to be made early on. In some instances, it was not the designer that was the problem in having a project [get] going. [The] contractors lacking experience in the DB approach had a different thinking regarding design management. There was an unwillingness of the contractor to recognize that in entering the DB contract it was also contracted to take care of the design [as well]. The concept of design-build wasn’t there and the contractor thought to just hire a designer but let the owner manage the designer and build whatever design the owner came up with.

Ed Schultz adds to this,

> The contractor unnecessarily spent so much time trying to optimize the design. Economy was the issue and the contractor lost focus on what was important trying to minimize sections. The THSRC design manager had to push the design process and get the construction started on time. [The] Supervising RE had to urge the contractor to start with a more conservative initial structure, then try to optimize along the way so that construction could start. [The] contractor should have understood that the designer wasn’t doing anything strategic to cheapen the design because they needed to comply with existing codes.

Designs were made on computers with built-in codes, so even if the contractor (Hyundai) was pushing for a cheaper design, the designer had limitations and would balk at the idea of having to put their reputation on the line just to satisfy the contractor (Mues).
D. Construction Control

The contractor had the most influence over the project once design had been approved and construction work was already on-going. The contractor had the responsibility for quality through self-certification which was specified in the DB contracts. The THSRC’s role was extended to contract administration and making sure that contractors complied with specifications.

The THSRC’s role was important especially when a contractor was intent on not following the THSRC prescribed specifications. There was a case when the TSC, the contractor for the Shinkansen trains, disregarded the owner’s specifications and submitted items that were not approved and completely rejected by the THSRC. The THSRC’s specifications were more stringent than the current design of existing Shinkansen trains running in Japan, but the contractor wanted to retain the existing train design. It shipped equipment, such as cables not meeting the fire code, which were not approved. The equipment contested were the same materials used in the Korean HSE which experienced a fire incident. The contractor persisted and shipped the questioned materials expecting the THSRC to accept them once they arrived on port; however, the THSRC did not capitulate and even disallowed unloading of the questioned materials in Taiwan (Mues). With instances such as these, the ISE’s and Resident Engineers’ (RE) presence during the construction phase became evidently important.

1. The ISE

The ISE team reviewed the method statements and work specifications submitted by the contractors. It also performed site visits and surveillance and planned for Site Inspections and Technical Audits. During these Inspections and Audits, the ISE verified the contractor’s work against the Method Statements, Work Specifications, and Drawings. Formal reports were issued to capture non-conformance and potential issues. The ISE also conducted reviews of As-Built Drawings and Operations and Maintenance Manuals based on 10% to 20% of the Design Units. The ISE provided the added layer of checking that complemented the routine surveillance of construction that the THSRC representatives did (Davis 263).
2. **Resident Engineer (RE)**

The Resident Engineer was the employer’s representative at the construction site who had both technical expertise and knowledge in project execution. In the hierarchy, the RE reported to the Vice Presidents (VPs) and the VPs reported to the Employer’s Representative (ER). The ER assigned VPs specified scope of works, e.g., civil work, stations and depots, while the appointed VP would delegate contract clauses of general conditions to the RE who administered these on site. The RE had ultimate authority on the site to decide on issues relating to contract administration, except for those that would affect schedule, design, quality, or had any commercial implications. Technical decisions were made only if there were no commercial impacts. (Rothenburger; Mues)

Change in the contract was only allowed if it had an isolated effect and would not affect other contracts. Even so, the RE did not have the power to change any contract but could only administer it to the “T” (Kao).

Any decision that would affect cost, time, quality or design needed to be referred to the VP or even to the Chairman of the THSRC depending on the magnitude of the effects (Kao). Only top management could approve any change order. It was commented that the RE was given maximum power on one hand and none in the other, because the RE could not disapprove any design but could only give a Statement of No Objection (SONO), which did not really constitute an approval (Rothenburger). The RE’s ultimate role in the contract was to facilitate work on site and could only monitor and advise the contractors on how to proceed with the work. (Rothenburger; Mues)

The RE’s technical expertise was very essential, especially to the contract with a contractor who could not perform the required work and was also failing in administering proper quality control. It became the RE’s assumed role to directly supervise the contractor and control how the project performed in the end. The RE was very effective in influencing construction progress because of the following (Mues; Schultz):

- The RE understood the requirements of the contract and knew how to build the job. He knew what available resources the contractor had and what was actually
needed to meet the schedule. As a result, he could make constructive comments and observations and advise the contractor regarding adequacy of resources and optimal construction methods to maintain the schedule. Although the RE could not impose on the contractor and only give advice, e.g., add additional equipment, the contractor usually cooperated and acquiesced to the RE’s requests; this kept the contractor focused on the job.

- The RE had the authority to stop work, especially for issues regarding safety. The RE could threaten to stop work when non-conformance was obvious, but issuing a work stoppage was difficult because all parties involved in the project wanted work to progress. Project progress and quality had to be balanced, and the RE usually had to reach a compromise with the contractor to achieve this balance.

- When the contractor’s quality team was not implementing proper quality control, the RE could oblige the team to raise non-conformance reports (NCR). The difficulty in the situation was that this team reported to the contractor and was intimidated by having the contractor as its employer. Closing out an NCR became a more involved process for the RE and his staff. The RE couldn’t directly close out an NCR, but the process of closing out took more than expected because of the need to monitor the contractor and advise or instruct how to close out an NCR.

- The RE understood the contractor’s financial situation and could push for payments to be made on change orders. The RE was in charge of assembling the documentation and sent it to the VP with recommendations. Generally, Requests for Payments got approved, but in some cases, the VP’s staff members, who were semi-empowered to review claims, would veto these payment requests. The RE then needed to defend these and explain to the VP that contractor needed to be paid to continue working.

- The different REs of the contracts interacted and passed experiences, such as what had been good design items, problems that came up, to each other. An RE could not impose a design feature on the contractor, but he could make recommendations about items that would potentially work in the project based on another RE’s experience on another project.
3. **Contractor Self-Certification**

Construction quality was self-certified by the contractor using quality control backed by quality assurance systems. The contractor was required to establish its own quality assurance and checking (QA&QC) team to perform self-certifying duties and to administer the approved quality plan. This team reported to the contractor’s quality department and construction division. It was required to produce quality control documentation manifesting that self-checking was being carried out. Documentation was always produced, but records did not always reflect what actually happened (Schultz). In some cases, the NCRs would only be raised when the THSRC’s staff had pointed problem areas out instead of the contractor’s QA&QC team directly discovering the non-conformance and making the appropriate reports (Schultz).

The THSRC originally allocated small site teams to monitor the contractor’s work, but the size doubled as the need for monitoring increased and as doubts about the efficacy of self-certification developed (Nichols 299).

The project was on a fast-track schedule, and the premise was that by making the quality checking system the contractor’s responsibility, there would be time savings. With self-certification, the contractor was not held back by the need to wait for 3rd party inspections to finish before moving on with the work. Inspections and testing needed less coordination and planning compared to the conventional approach. Instead of having to devote resources to planning and coordination, the contractor could divert all his efforts to making progress in the project. Unfortunately, this approach had its advantages and disadvantages. Self-certification did not fulfill the THSRC’s long term interests. According to Ed Schultz, the C230 Resident Engineer:

> The THSRC should have hired an independent inspectorate and gone through the conventional route. The system was made to work in the end, but it would have been more efficient and there would have been less gray areas and arguments and fewer repeats of the same non-conformance, such as concreting mistakes reflecting the efficiency of the contractor’s QA/QC, if the THSRC had implemented the conventional process of 3rd party quality inspection.

**E. Impacts on the Project**

The THSRC had a pro-active approach to the influencing the outcome of the project. It did not only rely on contract clauses or other parties to resolve issues. The
THSRC took the lead to resolve issues or at least ensured that it could lend support to the party and drive faster resolution of problems as discussed below:

- The THSRC cooperated with the contractor because the schedule was a priority. It assisted the contractor in the financial aspect and “injected money” to the contract when needed to keep the project on track (Lin).
- Change orders were allowed but only in rare cases and usually to expedite the schedule of the project and about specific issues, e.g., political issues, which the THSRC handled (Lin).
- The REs were very essential to controlling the project progress. In most cases, the RE ensured that the contractor was on the right track to finish the work as fast as it could. The RE knew that the schedule was driven by construction and knew that the design for the pieces that had to be built first had to be finished first, i.e., cast-in-place portions of the viaduct that needed to be built earlier had to be designed first to carry 30-meter pre-cast spans (Mues).
- Self-certification is still an approach ahead of its time (Nichols 299). The experience of all the parties associated with self-certification still had to be developed before the full benefits could be reaped. Although for some contracts self-certification was moderately successful with only a learning curve to overcome, having ‘weaker’ contractors defeated the system (Kao). The THSRC was unable to anticipate this and assigned the same number of personnel to assist all the contractors. The THSRC lacked the resources to completely monitor a weaker contractor and did not immediately notice an earthwork issue consisting of slope failure and embankment settlement, which occurred in one contract. There was less priority on earthworks and more priority on tunnels and viaducts which exacerbated the issue (Kao). Even if self-certification was employed, a dedicated parallel QC team should have been on site to implement 100% monitoring of the works (Schultz).

The THSRC considered not having enough bidders to choose from at the tendering stage to be the main cause of not achieving the best quality. Even though
the ‘best value’ was selected for contract awards, the ‘best’ contractors were not always chosen (Kao).

VI. CONSTRUCTION MEANS AND METHODS

A. Selection Process

As mentioned in earlier sections, the THSRC did not specify construction methodologies for completion of the civil contracts. The THSRC awarded to contractors who could best utilize their equipment using the most suitable construction means and methods (Kao). Each contractor was given the flexibility to best manage and control its part of the project. As a result, the selected contractors did not necessarily employ the same designs and methodologies in constructing the different sections of viaducts, tunnels, and embankments. Although some contractors had initial learning curve issues with their labor force, this was anticipated and accounted for in the schedule submitted to the THSRC (Tan).

The contractors had their own strategic plans for complying with the limitations set by the THSRC with regard to site constraints, fast delivery of works, and cash flow. Since the project was being delivered using design-build, contractors not only had the option of choosing the construction methodology but could also fully optimize the designs. Some contractors were successful in being able to manage both design and construction. In the civil contracts C260 and C270, the Joint Venture of Bilfinger Berger and Continental Engineering Corporation was able to utilize the advantage of the DB approach by introducing value engineering before actual construction. The design of piers for the viaducts was changed from using four piers to just one pier to reduce the number of non-standard viaduct spans (Mo 130). This affected the way construction commenced in this part of the project. By having more standard spans, the contractor was able to optimize use of the Full Span Launching Method (FSPLM) equipment. Looking at the schedule utilizing the FSPLM, the critical path lay in the fabrication of the spans instead of their erection. The FSPLM became the contractor’s method of choice because the contractor had greater control over the quality of the
viaduct spans fabricated in the pre-cast yards thus, minimized any likelihood of rework.

For tunnel excavation and support, the Sequential Excavation and Support (SES) method, the New Austrian Tunnel Method (NATM) or the Shotcrete method became the project’s method of choice since there were many short tunnels and was advantageous to use for ground conditions that needed constant monitoring (Hemphill 228).

Although the contractor made the ultimate decision as to what construction method to use, the decisions made were really based on such factors as number of contractors the THSRC could choose from, process of selecting the contractor, varied soil conditions, and time allocated to finish the work. These factors contributed to selecting the type of construction methodologies used in the project and will be discussed below:

- **Limited number of interested contractors**

  The THSRC initially faced commercial issues because it was an unknown entity in the construction industry. It received only a limited number of interested participants when the civil part of the project went out to bid. Only 28 contractors submitted their intent to participate for 12 contracts and only 22 bidders pre-qualified. Actual contracting practice recommends having at least 3 bids for evaluation for each contract (Lee and Orange 24).

- **Thoroughness of contractor selection process**

  The project was broken into several contracts and all were offered under the Design-Build delivery method, and so these methodologies had to be evaluated as early as the tendering phase. Different technologies and methods were introduced by the contractors as each one had its own specialization. The THSRC decided to involve highly experienced construction people very early in the project to perform the appropriate evaluation. Each contractor’s proposal needed to show the logic and sequence of work. Appropriate cash flow and resource scheduling had to support the flow of construction work the contractor was planning. The diligence exercised in the contractor selection kept only qualified contractors and their
proposed construction methods available for project execution. Although other methods could have been proposed, disqualifying a contractor inadvertently removed an alternative construction methodology that could have been used in the project.

- Geotechnical variability

The selection of the tunnel construction method depended on providing the flexibility to adjust to changing ground conditions (Gillam and Townsend 55). The changing condition of the existing soil dictated the use of the Sequential Excavation and Support method or New Austrian Tunneling Method as most efficient. Geotechnical data also affected construction of both bridge and viaduct piers.

- Fast-tracking of works

From the beginning, the contractors were made aware of the THSRC’s emphasis on delivery time. The THSRC wanted to take advantage of the fast-tracking capability of the DB method. Consequently, the contractor’s proposal had to indicate that the project could be delivered within the targeted four-year timeframe through means that could be implemented under time-constrained conditions.

B. Types of Construction Methodologies

The following section focuses on the methods used in the civil contracts especially types of viaduct construction and tunneling methods seen in the THSR project:

1. Viaduct Construction Method

The variable terrain and wide river plains in the area influenced the structure type and viaduct erection method to be used. 50% to 60% of the viaducts were designed to span lengths of 30 meters to 35 meters. These spans were actually shorter compared to those in equivalent road structures but were necessary to support the higher loads to be carried. The viaducts relied on bored or cast-in-place pile foundations and spread footings supporting single columns of reinforced concrete while piles, pile caps, and columns were constructed in-situ. Selected construction methods were based on the
contractor’s prerogative thus resulting to the use of various techniques such as free cantilever, balanced-cantilever, full-span precast launching, movable scaffolding and advanced shoring, and full-support (Gillam and Townsend 54).

- Free-Cantilever Method (FCM)

  With the use of a form traveler, segments were cast to form the longer spans reaching maximum spans of 80 meters. This system was used when intermediate supports were considered obstructing and not allowed for railway crossings and highways (Barsby 60).

- Full Span Launching Method (FSPLM) or Pre-cast Span Method (PSM)

  Viaducts were designed as simply supported single-cell box girders of pre-cast, pre-stressed reinforced concrete. Site access was through very minor roads thus prompting the use of a precast span-by-span erection method. This erection method has been termed as the ‘Full Span Launching Method’ or the ‘Pre-cast Span Method’ depending on the contractor using it. Using the FSPLM or PSM in Taiwan on this scale, e.g., 563 30-meter spans for C215, was seen for the first time (Tan). In this method, a launcher and a dedicated girder transporter made use of the substructure and deck sections that were already completed to advance the deck erection. Guideway beams were pre-cast and weighed 600 tons each. (Gillam and Townsend 54) The other systems resulted in greater progress at the beginning, but after a year, the FSPLM or PSM allowed launching three spans per day, which surpassed the rates of other methods (Tan). This not only provided some time advantage in the erection phase but also
produced a better quality product compared to in-situ construction. Although the system was effective, a length of work that made economic sense was needed to consider use of this method.

- Movable Scaffolding System and Fixed Scaffolding System (MSS & FSS)

Contracts C291 and 295 used movable scaffolding. With these systems, progress was seen as early as day one, and a span would usually be finished in a week’s time (Tan). Some factors which dictated what type of scaffolding system to use were the height of the viaduct from the ground and actual costs. Producing spans using the moving scaffold was faster but more expensive than the fixed scaffolding system. The contractors who had already invested in the movable scaffold therefore tried to maximize its use as much as possible. Similar to the FSPLM, the decision to use the MSS system depended on whether it made economic sense to use it for the project considering the total length of the viaduct (Schultz).

2. Tunneling Construction Method

The master schedule reflected the tunnels as the critical path of the project and basis of effective interface management. The master schedule indicated the locations where the tunnel segment had to be finished and the expected time of its completion (Kao). As such, selecting a tunnel method that would allow completion on time was necessary.

The tunnels in the project were confined to the northern half of Taiwan located along the lower lying western strip of the country. The soil was typically composed of silts and clays, through sands and gravels, to boulder conglomerates. The soil manifested the characteristics of being variably compacted and slightly cemented.
ranging from dense or stiff soils to being ‘soft’ rocks (“Taiwan’s” 24). The tunnels were generally shallow especially in areas with low groundwater levels identified during the intensive soil investigations. Dewatering work, using face probes, was necessary on occasion because groundwater was affecting the behavior of the excavation. Tunnels had cross-sectional areas ranging from 135 to 155 square meters to house the double-track main line. The design included provision of emergency egress for tunnels with greater than or equal to 3000-meter portal-to-portal lengths (“Taiwan’s” 22). Portals were enlarged to act as pressure relief structures, 20 meters long with cross-sectional areas equivalent to 150% that of tunnel to account for sound wave dissipation (“Full” 39).

The Tunnel Boring Method (TBM), which was contractually allowed, was used in some areas but was considered impractical and uneconomical (“Lining” 51). Out of 42 tunnels, only five used TBM excavation while the remaining tunnels were excavated using the Sequential Excavation and Support (SES) method. In the project, the SES method, the New Austrian Tunnel Method (NATM), or the Shotcrete method was considered one type of tunneling method. This was also the preferred method for tunneling. The SES method was selected because of its flexibility to changing geological conditions (Gillam and Townsend 55), its ability to provide emergency exits in the tunnels (“Full” 39), and the “soft-ground” consistency of the ground mass allowed used of conventional equipment, e.g., hydraulic excavators (“Lining” 51). The SES method advanced in three stages, which were heading, bench, and invert, thus restricted the open surface of
each face and reduced the potential of collapse. The project also utilized an “outer lining” as the immediate support system for the tunnel. This “outer lining” was a combination of shotcrete with layers of welded wire mesh, lattice girders, and untensioned grouted bolts. Every tunnel was also designed with a final, inner lining system. The tunnel was drained or undrained depending on the design. The THSRC’s only requirement was that tunnels be completely dry. Implementation of this requirement depended on a contractor’s interpretation. Most of the contractors designed drained tunnels with internal drainage systems. The majority of the contractors’ designers used the German code DS853 Class 3 as the criteria to fulfill for keeping the tunnel dry while the standards of the ACI318, Eurocode EC2, and British Standard BS8110 were followed for the structural design (“Taiwan’s” 25). The constructors had the option of providing the lining using cast-in-place concrete or segmental lining. Most of the contractors selected the cast-in-place concrete for economic reasons.

Preliminary exploration probes were performed ahead of excavation to detect problem zones in advance (“Full” 39). By using the NATM, tunneling was not dependent only on existing geotechnical data. The NATM facilitated monitoring and predicting movement of the soil of the next tunnel section to see what support was needed to restrict the movement of the tunnel. This method checked the performance of the tunnel and predicted the succeeding support system for the next segment. Using the NATM meant that the final design was not completed until the actual tunnel was finished. Although not a practice that was usually acknowledged, the THSRC accepted the methodology but made sure that only well-qualified personnel were executing the methodology (Kao).

The risky nature of tunneling works prompted the formulation of recovery methods (“Taiwan’s” 24). These were needed when the tunnels experienced instability and sometimes collapsed. The designer, contractor, and RE worked together and cooperated in formulating the methods for safe resumption of work. Designing the recovery method was usually ‘fast-tracked’ and utilized the existing resources already
available on site to limit delays (‘Taiwan’s’ 24). Once the recovery methods were in place, the work usually commenced without any further incidents.

C. Impacts on the Project

The introduction of different construction methods had the following effects to the project as well as Taiwan in general:

- Given the contractors’ ability to implement their methodology of choice, the Taiwanese construction industry were introduced to the new systems through ‘baptism by fire,’ but nevertheless was able to develop its construction talent over the life of this project (Mues). Transfer of technology occurred in this project and the recipients were the local Taiwanese who were able to work hand-in-hand with the international contractors.

- Contractors had different approaches to fulfilling the required components of the project. The interpretation and use of codes varied among the contractors’ designers, e.g., use of three different codes for the design of the tunnels’ inner lining (‘Taiwan’s’ 25). The freedom to choose the design and construction methods affected the specifics of the final product delivered to the THSRC. The shortcoming of employing different designs and methodologies is that different approaches will be needed to maintain the project’s structures, e.g., cleaning tunnel drainages, replacing wear-and-tear parts of the structures over the project’s life cycle. The THSRC will bear this burden since maintaining these structures over almost 30 years is its responsibility as the railway operator.
APPENDIX B: NORTH LUZON EXPRESSWAY PROJECT

I. PROJECT OVERVIEW

The North Luzon Expressway (NLE) is an existing highway that serves as the major transportation link between the Metro Manila region to the towns, cities, and provinces of the Philippines’ Northern Luzon region. The poor service provided by the NLE due to its deteriorated condition prompted the need for its rehabilitation (“Philippines”). The scope of the project included the rehabilitation and expansion of:

1. the existing 83.7 kilometer NLE, connecting Metro Manila to the Sta. Ines town which is close to the Clark’s Special Economic Zone (SEZ),
2. the segment connecting the NLE to the Subic SEZ,
3. two greenfield segments of Circumferential Road 5 (C-5) to the NLE and MacArthur Highway to Letre Road.

The actual works included rehabilitation and expansion of existing facilities and the construction of new interchanges, toll platforms, operations and maintenance facilities, and the design installation of certain fixed operating equipment. The project scope consisted of 14 interchanges, 24 bridges, and 31 overpasses between Manila and the Clark SEZ (“Philippines”).

The NLE Project was the flagship project under the “Philippines 2000” program which supported the government’s thrust to develop the national road network with private sector participation. The project formed part of an integrated road development plan that included construction of the northern extension of the C-5 in Metro Manila and expansion of the NLE to the Subic SEZ. The development plan was split into three phases: Phase 1, the aforementioned scope and the existing Segment 7; Phase 2,
northern section of the C-5 currently ‘in the drawing board’; and Phase 3, connection between Segment 7 and the NLE from San Simon to Subic SEZ (Bautista).

Implementing the NLE Project needed involvement of various project proponents who would have agreed upon the purpose of the project and looked at the possible challenges inherent in the NLE Project. These will be detailed in the following sections.

A. Project Goals

To decentralize economic activities in Metro Manila, the Philippine government had to develop a transportation infrastructure to support it. The NLE, one of the Philippines’ major road arteries, was seen as an effective link to local economies and a means to assist industrial development outside the Metro Manila corridor. Unfortunately, the NLE was then in a state of disrepair. The NLE was narrow, constantly congested, and poorly maintained. By rehabilitating the NLE, the traffic could be decongested and this would facilitate the envisioned decentralization. The project’s operational goals also included reducing pollution from vehicular traffic especially in the areas traversed by the NLE. Other goals associated with this project were construction operations with the least environmental impacts and compliance to stringent World Bank (WB) and Asian Development Bank (ADB) guidelines such as noise and dust mitigation measures.

B. Project Proponents

The NLE was first developed in 1977 by the Philippine National Construction Corporation (PNCC), a state-owned construction company, through a 30-year concession agreement with the Philippine government. For the initial offering of a new Rehabilitate-Operate-Transfer contract for the NLE, the PNCC looked for companies it could venture to serve as technical partners. The respondents were First Philippine Infrastructure Development Corporation or FPIDC, a Lopez Group of Company, and Egis Projects S.A., one of the world’s largest toll operators.

The FPIDC was already a private sector participant in infrastructure development through its development of the Segment 7, a roadway system amounting to PHP650
Million (USD2 Million) of civil contracts composed of roads, bridges, and overbridges. The Segment 7 was built and solely financed by the FPIDC (Bautista) as a concession from the Government. Consequently, when the Philippine Government started solicitation for concession of the NLE Project, the FPIDC was the likely candidate for the project because of investments made in the Segment 7 project. Other parties involved in this project were:

- Toll Regulatory Board, representing the Philippine government
- Manila North Tollways Corporation or MNTC, formalized consortium of the FPIDC (67.1%), PNCC (2.5%), Egis Projects S.A (13.9%), and Leighton Contractors Asia Limited (16.5%)
- Leighton Contractors Asia Limited, major design-build (DB) contractor for the civil works
- Egis Projects SA, Fixed Operating Equipment (FOE) supply contractor
- Lenders and technical advisers
- 3rd Party Consultants
  - Parsons Brinckerhoff, Employer’s (MNTC) Representative, administering the design-construct contract and fixed operating equipment (FOE) supply contract
  - Norconsult, Independent Design Checker and Checking Engineer advising TRB
- Tollways Management Corporation, operations and maintenance (O&M) group for Phase 1

The MNTC was awarded a 30 year concession period including the design and construction schedule. This concession was taken over from the PNCC, who had the rights up to 2007, leading to an amendment of the Supplemental Toll Operation Agreement (STOA) in 1998.

C. Challenges

One of the major hurdles was achieving financial closure. The project was almost aborted because of the questionable financial viability but this would have meant losing PHP 1 billion (USD20,000,000) worth of investments by the Lopez Group made to the Segment 7 project that would not have been recoverable if the NLE
Project did not push through (Bautista). Complete acquisition of the Right-of-Way (ROW) was also a major hindrance to achieving financial closure. The ROW acquisition was just one of the numerous conditions that the lenders required before closure. Fulfilling the pre-closure conditions took three to four years of the 30-year concession period (Bautista).

This long wait reflected the uncertainty in actually developing the project. As a consequence, the DB contractor was not able to take advantage of the four-year wait period to streamline its delivery process and address design issues. The project was at risk of not pushing through and the contractor had to consider demobilizing its resources from the project (Killick). Resolution of construction-related issues with the design was not fully implemented because the contractor was not willing to invest more on a project that would not possibly pay back (Killick). When financial closure was reached, the project needed to be completed within 24 months or by February 2005 which was a very tight schedule.

The design-build concept posed another challenge for the Philippine construction industry since the design-build is relatively new and only a handful of people had experience in administering contracts using this project delivery approach.

II. OWNERSHIP FORM: REHABILITATE-OPERATE-TRANSFER CONTRACT

A. Selection Process

The private public partnership (PPP) is not a new project delivery method in the Philippines. Power projects have already been implemented in the country with the participation of the private sector. Even the initial development of the NLE was under a franchise agreement between the Philippine government and the PNCC.

The Rehabilitate-Operate-Transfer agreement was chosen as a supplement to the ongoing franchise of the PNCC. As mentioned in the earlier section, the PNCC was already looking for a partner to form a joint venture with for the continued
maintenance and upkeeping of the current NLE. With the involvement of FPIDC in the development of Segment 7, it was the likely candidate for the next concession.

B. Rehabilitate-Operate-Transfer (ROT)

The ROT agreement for the NLE Project was for 30 years starting from the signing day of the agreement or up to December 31, 2030, or whichever was earlier. This concession period included the time needed to design and construct the project. The project requirements were embodied in the STOA that the MNTC signed with the Toll Regulatory Board.

Initially the project was intended to be funded by equity from the Lopez Group of Companies, but due to the large scale of the project this would not have been sufficient. International financing was sought to augment the lack of funds, but at that time the climate for financing only catered to “limited recourse” projects (Bautista). Therefore, the project had to be structured such that international financing could be secured subject to the following requirements:

- Allocation of the design and construction risks to another entity other than the sponsor company, the MNTC
- Substantial completion of Right-of-Way acquisition before financial closure
- Fixed price and date-certain delivery of the project
- Use of the French-based toll operating system for the FOE

The involvement of the international financing community in the project resulted in the long project development phase of eight years. Prior to achieving financial closure, the Independent Design Checker had to confirm that the engineering design was compliant with the Performance Standards and Basic Design, the Lenders’ technical advisers had to confirm that construction schedule of 24 months was feasible, and that the construction cost was certain. The lenders had a great influence on how the project would be constructed. The Design-Build contractor, Leighton Contractors, had to be approved by the lenders. In addition, due to the lenders’ preference for a single Design-Build contract, the MNTC was not allowed to directly contract with Egis Projects S.A., which was also the FOE supplier. Egis Projects S.A.
had to be nominated to Leighton Contractors as the preferred subcontractor for the toll operating system (Bautista).

Egis Projects S.A. was already a sponsor and the established FOE supplier for the project even before Leighton became involved in the project. Leighton had to be evaluated as a qualified Design-Build contractor before it became involved as both sponsor and contractor in the project.

C. Advantages of the ROT

Government agencies prefer to involve the private sector in the development of infrastructure projects for several reasons. For the NLE Project, financing was the greatest hurdle to overcome. This project was proposed at the time of the Asian financial crisis which also struck the Philippines (Bautista).

The existing franchise agreement for the NLE was with a government-financed enterprise, the PNCC, who lacked the capability to facilitate the rehabilitation on its own. By involving the private sector, the project was offered under limited recourse financing and the government did not have to take on the burden of financing the project. There was even an absence of an offtake agreement or government guarantees to back up the financing. The government’s share came in the form of the PNCC as a sponsor of the MNTC.

Only through ROT could the NLE Project have proceeded due to poor economic conditions. The financial closure for the NLE Project brought about by the ROT also opened the doors to easier financing for future toll operations in the Philippines. This project became the benchmark for future transportation infrastructure deals in Asia (‘Asia’ 39).

D. Impacts on the Project

Some of the impacts of the ROT on the project were due to the decisions made during its negotiation and are detailed below:

- The financing structure of the project affected the decisions and outcomes on both design and construction, as well as timing of the project’s implementation. Having the design ready before financial closure did not make it error-free for
implementation because of the under-utilization of time between design completion and implementation. Instead of using the time before financial closure to address issues in design, administer pre-construction activities such as permitting, get material approvals, and try out construction methods, doubts about reaching financial closure caused the contractor to start demobilizing its resources from the project and time was not used to advantage (Killick).

- The involvement of various proponents in this project provided a great deal of oversight to the project from the lenders, the MNTC, and the TRB and from their consultants. The monitoring responsibilities overlapped but each had discreet accountabilities, e.g., Norconsult, IDC/ICE, would have reporting responsibilities to TRB (Punzalan).

- Since the MNTC had to guarantee a fixed-price to the lenders, the driving factor for implementing the project was for the most economical means of project delivery.

- The involvement of Egis Projects S.A. in project development determined the type of FOE system without going through a process of competitive evaluation.

III. CONSTRUCTION DELIVERY METHOD: DESIGN-BUILD APPROACH

The following section will discuss how the construction phase was implemented in the NLE Project. The section will detail the decision to adopt the design-build approach, advantages as well as shortcomings experienced with this method, and impacts of the design-build approach on the project.

A. Selection Process

Although new to the Philippine contracting industry, the financing structure of the NLE Project promoted the use of the design-build approach for the construction phase. For the lenders to approve project financing, the MNTC was advised to transfer all construction risks to another entity to manage the construction process and to consolidate responsibility for FOE supply and civil works under one contract for easier administration. Initial negotiations between the MNTC and Egis Projects S.A.
for the FOE had to be folded and placed as a subcontract into the civil works contract of Leighton to result in a single design-build contract.

The contract was negotiated as lump sum, fixed price with liquidated damage clauses and bonuses for early completion. The construction schedule was fixed to be completed in 24 months after the Construction Notice to Proceed or February 2005. The contractor had to pay at least USD$225,000 for each day of delay (Bautista). This large sum for liquidated damages prompted the offering of the civil works contract to the international contracting industry. The local contractors did not have the capacity to shoulder the costs of potential construction delay.

Since the request for qualifications (RFQs) were sent out before financial closure was achieved, the MNTC initially asked potential tenderers to develop only the design of the project but with the intent of following through with a construction contract once the financing became more feasible. All of this was happening during the development phase and before contracts were formalized. Leighton was selected as the contractor and began with the design, but without any official Notice to Proceed (NTP). This was a necessary first step because financing required identification of project costs and schedule before any loans could be considered. Having the contractor involved very early in the development phase and using its technical expertise made it possible to develop a more realistic cost estimate and schedule.

B. Design-Build Approach

The NLE Project was a ‘brownfield’ project and was the first design-build project in the Philippines to use private financing (Bautista). The actual contract took years to develop and was not a version of any standard form such as the FIDIC, the British standard form of contract (Killick). To select the design-build contractor, the MNTC
evaluated bidders by checking their track or performance records, financial capability through financial statements and bank certificates, and company profile. A Prequalification, Bidding, and Awards Committee composed of the MNTC’s financial, commercial, and senior technical personnel evaluated the qualifications of the bidders and selected the preferred contractor for further negotiations. However, this evaluation process did not look into the detailed design, quality plans, construction methods, and other details showing the contractor’s plans for building the project. These mentioned items became the contractor’s deliverables once the contract was awarded (Bautista). According to Luigi Bautista, Vice president of the MNTC’s Contracts Management Group, “[Once selected,] [i]t is done. Because when you get big contractors such as Leighton, it is almost sure that they will finish the job. They are not ‘fly-by-night’ contractors and they are sure to have their own quality control systems and other systems in place.”

The performance criteria and Employer’s Technical Requirements (ETR) specified AUSTROAD as the design guidelines for the pavement while the bridge designs would relate to the AASHTO. The contractor made use of these documents in developing the Detailed Engineering Design (DED). The DED were then subject to design reviews and had to be approved by the TRB through the IDC, Norconsult, and the MNTC’s own consultants, Parsons Brinckerhoff, before it was implemented. The TRB and the MNTC’s major roles focused on the commercial aspect of the project, such as checking the shortlist of subcontractors and their quality systems and commenting, to ensure that the end product would comply with the requirements of the ETR.

C. Advantage of the Design-Build Approach

From the MNTC’s point of view, the major advantages in using design-build were with risk allocation and flexibility to address unplanned events during the construction phase.

The greatest advantage of using the design-build approach was the ability to pass on the risks of both design and construction to just one entity, which is the design-build contractor. The contractor assumed full responsibility from design to
construction until the project is handed over to the client. Because of this setup, the client and contractor were able to develop a working relationship with the common goal of reaching the best design at the most economical way.

Also, during the project implementation, the design-build approach allowed the contractor to propose design changes because of differing site conditions and if approved, implement them immediately. Maunsell, who was Leighton’s design partner, would only need to issue field notes and gain approval from the consultants and implement the design expeditiously (Punzalan).

Actually, even before the start of implementation, the original design was already changed because of monetary constraints. Since implementation took three to four years after financial closure, the price of the works had already escalated beyond the initial budget. The design had to be value engineered to stay within the budget. This resulted to some changes such as redesigns for ancillary works such as overbridges – from total rehabilitation to just retrofitting (Killick).

Through the design-build setup, the contractor was able to have more control over the coordination between the design and construction phases which resulted to less coordination complications for the MNTC. There was always just one point of contact because the contractor was responsible for every step of the way.

By using the design-build approach, the MNTC was able to use a much simpler and more economical approach for the construction phase. The MNTC considered this economical advantage for the cost of rework in the project, which was the full responsibility of the contractor during the warranty period (Punzalan). In addition, the MNTC was able to negotiate with the contractor to increase the warranty period for latent defects of one to two years.

Compared to the conventional approach of project delivery which is the design-bid-build, the MNTC believed that the design-build required less client involvement in the project execution and less claim issues (Punzalan). Although there were some variation orders due adjustments in the ETR and concession agreement specifications caused by differing site conditions, these did not affect the original costs of the project (Bautista). As for project quality, it remained comparable with that of the design-bid-
build approach because of the testing procedures that were the same for both (Punzalan).

D. Shortcomings of the Design-Build Approach

There was some difficulty for the locals to accept the design-build due to the design-bid-build orientation of the engineers in the Philippines. These translated to some issues which highlighted the inadequacies of implementing the design-build approach for the project.

According to Graham Killick, a PB representative, “The contract could have been more comprehensive and ironclad. Although the design-build approach placed overall responsibility on the contractor, the quality assurance and approvals should be acquired first before implementation.” This comment relates to the contractor carrying out construction activities before changes have been formalized in design drawings. The MNTC could also only make limited comments on the design since the contractor was assuming all the risks (Bautista).

A certain expectation with the design-build approach was being able to consider construction inputs to the design. Renato Punzalan, Project Controls Team leader, made the comment that unfortunately for the NLE Project “input from the construction for the design was not evident. Design was only a ‘table’ design. Without actually going out to the site, the design would not be sufficient for site implementation.”

E. Impacts on the Project

The design-build approach enabled delivery of the project within the allotted time frame. Since the construction risks were passed on to the contractor as the design-build entity, the MNTC did not prevent the contractor from implementing the works according to its preference. An ideal partnership existed in the beginning but became strained especially during the construction phase. Luigi Bautista commented that “a contractor is a contractor. The requirements have to be fulfilled such that they (Leighton) would still make a profit. The contractor will look at the way that is most economical for them.” In the end, the MNTC and Leighton looked after their own interests which brought about the strain in their relationship. It came to a point where
the MNTC fired Leighton’s project manager for ignoring instructions from PB and for testing without informing parties from the owner’s side.

In addition, the MNTC evolved from not having direct technical involvement in the construction phase to having a formal monitoring body, the Project Management Team, to oversee compliance to the ETR. Together with this body, the PB managed the contract. Graham Killick commented that “design-build is fairly new in the country. The contract could have been set up to be more manageable and leaning towards a more traditional type contract with a bulk of the testing being handled by a third party instead of the contractor being responsible for it.” The PB had difficulty imposing its authority to stop work when issues arose because the contract lacked provisions to allow this.

IV. PRE-CONSTRUCTION ACTIVITIES

The preparation works for the NLE Project came in the form of the lender’s requirements. As mentioned in the previous section, the advance works directly related to the construction phase were not addressed due to the volatility of achieving financial closure. The following section will cover some of the necessary groundwork that had to be in place before the project could be implemented, as well as the lack of advance works which had significant impacts on the outcome of the project.

A. Traffic Management Plan

An aspect of this project that was very important to the MNTC was keeping the NLE open to traffic even during the construction phase. To address this, the MNTC required Leighton through terms in the ETR to submit a traffic management plan that the MNTC and the PNCC, current NLE operator, approved. Leighton had to define the methodology and traffic management measures that maintained a level of service and safety satisfactory to the approving parties. It was required that there would be lanes always available to allow traffic flow. Some provisions that needed to be addressed in this plan during construction were (MNTC “Employer’s” 18):

- Lanes reduced to 3.2 meters width between obstacles
- No counter flow traffic allowed unless safety boundaries set
- Advance warning and information signs
- Sufficient lighting provisions for night work
- No sharp turns allowed for ingress and egress to work site from or to traveled lane

This plan was also related to when the contractor would turnover parts of the toll road upon completion. Although this was the agreement between the MNTC and Leighton, Leighton did not follow it. Leighton had control of the entire construction site all at once and turned over completed project in one piece.

B. Utility Relocation

For the NLE Project, any type of utility that would be impacted by the project was handled by Leighton as detailed in the ETR (MNTC “Employer’s” 18-19). Leighton’s responsibilities ran the gamut of utility relocation requirements including surveying, coordinating, financing, designing, and constructing. Leighton was also held responsible for any impact that utility relocation would have on the schedule. The MNTC passed on all responsibility to Leighton. Fortunately, this did not seem to have any major impact on the progress of the project.

C. ROW Land Acquisition

One of the conditions the lenders placed on the terms of financial closure was to have the ROW land acquisition complete. The ROW land acquisition phase had to be concurrent with the design phase, cost estimating, and scheduling of the construction phase to achieve final financial closure. Although the project was for an existing toll road, ROW was still needed for planned areas of expansion. To implement the trumpet style of interchanges, a bigger area of land would have been required for the ROW. Instead, the design was revised to keep the existing interchanges and implement the trumpet style only in the new interchanges.

Some initial problems with the ROW acquisition involved the government’s lack of money to finance the land acquisition. The MNTC helped the government acquire sufficient funds to pay the affected landowners. It was the government’s responsibility to provide ROW, but the ROW purchase was delegated to the MNTC with terms
agreed upon by both parties, i.e., the government pay back the ROW expenses through yearly allocation at the same time grant the MNTC rights to increase toll rates as the MNTC deems necessary. This was stipulated in the signed STOA. Also, the policies for expropriation in the Philippines were not as developed and were subject to debate. To augment this, the MNTC created a team to negotiate and facilitate expropriation procedures to acquire the ROW (Bautista). For landowners who resisted the expropriation, the government still claimed their land, set aside payments in respective accounts, and decided to let the landowners take the action of suing the government if they so decide. The government did not allow the issue of ROW acquisition to hinder the implementation of the project (Punzalan).

D. Studies of Alternatives

This section will discuss how the MNTC decided which particular features of the project were selected. This included design for the toll system, pavement, and interchanges.

- Open and close system

Traffic forecasts were conducted by Halcrow Fox and reviewed by PB (MNTC Information 13). The forecasts were deemed reasonable and consistent with historical trends of having strong traffic growth in the NLE. The study validated the volume of ongoing traffic in the NLE and laid the groundwork for selecting the toll system to ease the increasing traffic congestion in the existing NLE. Studies measuring peak vehicle rates and traffic analyses were conducted to assess which of the open or close system would be most effective. Operational input was considered in the
system selection (Punzalan). The decision was to use both open and close systems for the NLE with certain boundaries as to which sections would be included in each system. Using the combined system supported operational efficiency and economy because of lower number of workforce for operations (Punzalan). Also, the selected system was the basis for selection of toll equipment and technology for the NLE Project.

- Asphalt Concrete and PC Concrete Pavement

The MNTC looked into the life cycle costing to determine the most cost effective treatment for the existing pavement, considering both initial costs and longer term costs. It took into consideration the construction costs, maintenance and rehabilitation costs, salvage value, real discount rate, and the analysis period. If the pavement was asphalt concrete the design would be for 10 years, but the next overlay would be in the next five years. The concrete pavement, on the other hand, would have a design life of 20 years but would prove more costly. Compared to concrete, flexible asphalt was cheaper, provided a better ride, and exhibited less life cycle costs, although concrete had less maintenance and rehabilitation costs (Maunsell 30). Although concrete indeed had a longer lifespan and could be subjected to heavier loading, the more economical method was to crack and seat the existing pavements and recycle existing asphalt to use as overlay for the rehabilitation process. On the other hand, on certain areas in the project where the crack and seat method could not be applied, it was more economical to consider a full deck reconstruction rather than do an overlay to rehabilitate (Killick).

- Existing and Trumpet-Shaped Interchanges

As for the interchanges, the design was to implement a trumpet style. This was best for operational purposes since this type would only need one point of collection, unlike the other types such as the diamond shape. This had to be foregone to allow the budget to be kept intact and was only implemented on two newly built interchanges (Punzalan).
E. Design Specifications

The local codes in the Philippines mostly follow the US standards of the ACI and the AASHTO; but in the NLE Project, the AUSTROAD was adopted as the guide to structural design of road pavements. The reasoning was that AASHTO was empirically-based which was considered unsuitable to the Philippines given the dissimilar climatic conditions. The AUSTROAD could better represent the Philippine environment and was the more objective approach through the use of the mechanistic approach, which analyzed pavement responses to traffic loadings and how composition, materials, load types, and the environment affected the pavement. Other advantages of using the AUSTROAD were (1) improved reliability in the design, (2) predictable types of distress in the pavement, and (3) ability to extrapolate from limited field and lab results (Maunsell 9). The third benefit is actually in contradiction to Killick’s comment about the adequacy of the initial surveys conducted by the contractor before starting the construction work because of the end result of the final pavements.

The minimum requirements the project had to follow were the Department of Public Works and Highways (DPWH) standards, but provisions were set such that other standards could be used as long as these were above the minimum required. Since the construction methodology adopted for the project was completely new to the Philippines, all items related to pavement followed the AUSTROAD. An example of a pavement item that was not even available in the DPWH standards was the lean mix base instead of base course (Punzalan).

The standards and tolerances used in the design process indicated more of an ‘end-result’ rather than ‘performance-based’ type of specifications.

F. Critical Resources

This section will define the atypical materials used in the project, as well as detail how the contractor managed to implement a construction method in terms of manpower and equipment that had not been implemented in the Philippines before. None of the resources actually became critical, although comments have been made
about how the lack of skill in implementing the new technology and operating new equipment were the causes of some deficiencies in the process and the product.

1. **Manpower**

   The Philippines had a workforce that was adequate to address the needs of the project. The only deficiency was with the expertise needed to handle the new equipment Leighton had brought in for the project. Ex-patriots had to teach the local people how to manage the equipment such as the guillotine or hammering machine for the cracking treatment.

2. **Space**

   Since Leighton had full control over the site, it had the opportunity of strategically locating its facilities such as an office and a batch plant in the middle of the project and staging areas around the site. The contractor also had site offices within the same areas with the consultants and the MNTC for easier coordination among the parties (Punzalan).

3. **Materials**

   One of the factors looked into during method selection was the type of available materials. Because of the existing pavement, recycling the asphalt to use as overlay was a major consideration. The asphalt was sent to the plant to be recycled and batched out to be used as overlay. All the materials used in the civil works were available locally. Lahar sand was used as a substitute material of the subbase because of its abundance and its competence as a subbase material (Punzalan). For the concrete needed, the contractor decided to set up a batching plant in the middle of the project. This provided the contractor more control on concrete production not only in terms of having the concrete when it was needed but also the quality of concrete. The only potential issue associated with the concrete was delivery especially during the peak traffic hours which later on turned out not to be a real concern.
4. **Equipment**

The FOE and all related ancillary items were imported from France and Australia (Killick). It was a contractual requirement that almost all the parts be imported from the mentioned countries with the exception of the television screens in the control room (Campos). For the civil works, Leighton had to import the equipment such as the cracking machine, 50-ton pneumatic compactors, testing apparatus such as the Falling Weight Deflectometer (FWD), paver with laser capability, and slip-forming equipment for the median barriers (Punzalan).

**G. Social and Environmental Concerns**

This project was partially funded by the World Bank and the Asian Development Bank. As such, these lenders had special provisions for environmental compliance in funded projects. The MNTC took a great deal of effort to comply with the requirements as well as ensuring that the contractor had environmental plans in place for areas affected by construction activities. These plans were to address the negative impacts such as (1) noise generation, (2) land disturbance and dust generation, (3) solid and liquid waste generation and spills on pavement, (4) gaseous emissions from construction equipment, (5) surface runoff, (6) construction hazards to workers, (7) traffic congestion in construction areas, and (8) soil erosion. The MNTC created an Environmental Unit team to oversee that all environmental issues were addressed and to coordinate with the respective agencies.

**H. Impacts on the Project**

Although the previously mentioned preparatory works had been essential to the project’s implementation and success, there were still some key items that had been overlooked and had impacts on the completed project.

- There were some issues with the asphalt design mix. The aggregates used in the mix had a very narrow grading which didn’t allow enough bitumen in the mix to maintain the void ratio and reach the maximum density line. This meant rutting and cracking resulting to earlier deterioration of the pavement (Killick).
Site inspections were not administered as detailed as possible which caused some issues with drainage alignments. These issues had to be corrected even after the project had been turned over to the MNCT (Punzalan).

V. PROJECT MONITORING SYSTEM

Using the design-build approach had impacts on how the MNCT monitored and influenced the progress of the project in terms of cost, quality, and schedule. The MNCT’s initial efforts consisted of selecting the best contractor and making sure that technical specifications corresponded to project goals. Standards were also set in the STOA governing the design and construction processes (MNCT Information 7). The following section provides details of the monitoring activities that were present in the project.

A. Contractor Selection

The design-build contractor was selected among three foreign firms who expressed interest in the project. The contract was only for the civil works because the FOE was already being provided by Egis Projects S.A. The project was open to any company who could qualify but with the set criteria, only international contractors could have pre-qualified. Bautista commented that the local contractors were incapable of shouldering the USD$225,000 liquidated damage that was imposed in the contract. The MNCT’s contract department took the lead in evaluating the contractor’s qualifications mostly based on the capability to deliver the project. Some technical factors were also considered but mostly as a part of considering the costs. Selection of the contractor was based on firm’s experience and financial capability. Experience was considered synonymous to contractor capability; as such, the MNCT expected that the selected contractor would also have quality control systems in place (Bautista). Leighton, with Maunsell as its design partner, was selected as the design-build contractor based on its experience on civil works. Egis Projects, subsidiary of the FOE supplier, was chosen as the subcontractor for the design, installation, and commissioning of the FOE as per the MNCT’s recommendation.
B. 3rd Party Involvement

Norconsult represented the Philippine government’s interests in the project by being the Independent Design Checker (IDC) who reported to the Toll Regulatory Board. Its contributions came in the form of design reviews and approval. As a contractual requirement, the IDC had to review the Detailed Engineering Design (DED) and find it sufficient for the project before the Construction Notice to Proceed (CNTP) could be issued to the contractor.

Before Parsons Brinckerhoff (PB) became the official Employer’s Representative (ER) for the MNTC, it was already involved in contributing to the civil work requirements in the ETR. As the MNTC’s ER, the PB was to maintain quality, administer the contract, and issue instructions and change orders when the project went underway. The PB was also in charge of filing claims against the Philippine government when the ROW was not handed over to the MNTC for timely execution of the project (Killick). The PB was the technical expert the MNTC depended upon to make sure that the ETR was being adhered to by the contractor. The PB had control over all technical aspects except for issues that affected construction cost or schedule. To this, the PB’s comments would only be recommendatory and the MNTC’s senior personnel would make the decisions. Norconsult and the PB would review designs and design changes to check contractor’s conformance to the ETR. Initially, there was a great deal of non-conformance cited and so the contractor had to adjust the design and make sure that it complied (Bautista). The PB’s main role of monitoring project quality was important in looking after the MNTC’s interests. The impact of achieving quality expectations was long term due to the 25 years the MNTC could operate the tollways. If quality was not up to standards, the serviceable life of the project would be shorter than expected and corrective work would need to be implemented more frequently, i.e., overlay needed every two years instead of every five years due to poor quality.

The PB’s scope of work depended on the contractor’s inability to perform its function. If the contractor’s quality system failed, then the PB would have more difficulty managing the project. From the consultant’s point of view, the PB was
supposedly a nominal team for checking the contractor’s compliance to its approved quality systems. Unfortunately, the contractor was constantly delayed in its submissions. The PB had to be more involved to track post-testing (Killick). From the MNTC’s point of view, the PB was not manned sufficiently to oversee the works-in-progress (Punzalan).

C. Design Control

Financial closure for the project was parallel to the design phase (Punzalan). As such, major design decisions such as construction method for the pavement were based on the most economical approach to rehabilitation. Changes to design were based on financial and not technical reasons. Improvement to the design were for items missed out in the original design, i.e., rehabilitation of overbridges with just basic design and expanded and replaced pedestrian ways (Killick). The design-build contractor provided the DED attachment for the financial proposal. The contractor also provided the other design documents such as construction design with some minor revisions and after the financial closure, construction drawings used in actual construction. Punzalan commented that “the design was a design-in-progress which was normal. Depending on the site conditions, the design would be revised and major revisions would need approval from Norconsult, PB, and the lender’s technical advisers.” The consultants reviewed the contractor’s proposal and negotiated the technical aspects. Any revision in the design needed to comply with the specifications and were verified if the revisions would result in cost changes. Since the design submitted for financial closure was fixed, any changes to it needed to go through variation orders that were either positive, if costs increased, or negative, if costs decreased. The consultants made the reviews and recommendations to the MNTC, but final decision depended on the MNTC for acceptance. Before construction commenced, the contractor had to get approval from both the MNTC and the consultants. During construction the contractor had to arrange a meeting with them if changes in the design were made (Punzalan). The decisions needed to come from the MNTC’s top management, but according to Punzalan, this was a formality since the technical people really decided the technical issues.
Some design issues that were brought up and resolved included deciding on one-meter outer shoulders instead of three meters due to the 60-meter wide ROW bounded by the service roads. Another design revision that included the ROW issue was changing all interchanges to trumpet-style for better operability, but this would have entailed huge ROW acquisition which meant added costs and time. In the end, the decision was to just improve the existing interchanges and forgo the trumpet-style (Punzalan).

D. Construction Control

The section is broken down into the systems in place to maintain cost, quality, and schedule in the project. The systems detailed out do not necessarily belong to the MNTC alone:

1. Cost Control

By having a fixed price lump sum contract, the MNTC controlled cost changes from the owner’s perspective. Within the life of the project, there were negative variation orders but no positive variation orders. The liquidated damage clause in the contract allowed the MNTC to strike a deal with the contractor to increase the warranty period to two years. At the time the contractor was handing over the project, there were some sections that the MNTC was not willing to accept. Instead, the contractor agreed to a longer warranty period and committed to rectifying any problematic areas. Any maintenance or rectification works within the two year timeframe would be shouldered by the contractor (Bautista). The MNTC technical group was in charge of looking after the payment requirements. Progress payments for milestones were based on per kilometer completed.

For the contractor, one way that it expedited the payment process was to slow down the work process when payments were not being processed fast enough. Especially when the MNTC commented that there was not enough manpower on site to speed up the construction works, the contractor was not willing to add more manpower until the MNTC paid them expeditiously to cover its expenses to hasten the work and increase the work force (Punzalan).
2. **Schedule Control**

The MNTC prescribed the use of Primavera Suretrack. The contractor followed a schedule which was reported to the TRB with specific turnover dates of traffic lanes. Any changes had to be approved and reported to the TRB. Killick commented that planning was more of an exercise because as early as day one, the contractor was not following the schedule. The schedule indicated that the work would start with outer widening with traffic being shifted to that section once completed. Only after completing work in the outer widening would work on the inner widening begin, but in reality the contractor started work on the inner widening on day one. The contractor prevailed over how it completed the project. This worked well because the project was able to finish on time, but as a consequence, the finished quality was questioned (Punzalan). The project turnover only included items that made the project serviceable and operational. Pending items did not affect the operations of the actual tollways and so liquidated damages did not need to be paid (Killick).

To begin with, the project was on a very optimistic schedule. According to Killick, if the schedule had been held back, this would have resulted to claims. This made it difficult to enforce work stoppages because not only did the contractor have full liability for the project, but also work stoppages meant cost implications which no one was willing to shoulder.

3. **Quality Control**

The quality assurance and control of this project was handed to the contractor, as opposed to having a third party be responsible for it. Even during contractor selection, the MNTC considered quality assurance and control systems key for selecting the contractor. The MNTC expected the contractor to implement its quality systems (Bautista). The contractor submitted a quality plan that the PB used to check against its performance during the project. Leighton was an ISO certified contractor, but according to Killick, the quality system applied more to its accounting procedures than to the way it conducted. Leighton was able to pass its audits, but audits were based on operating system rather than the construction processes. In addition, Killick comments that “quality assurance (QA) is an attitude. A lot of the contractor’s staff members
were not familiar to quality assurance. They did not have enough training and those
given the responsibility to maintain QA were supervisors on site. I don’t think they
appreciated being in control of quality either.”

One way the MNTC was able to influence the outcome of quality issues was its
ability to issue threats to the contractor of contacting the bank and cashing in the
bonds amounting to USD18 Million if the contractor did not “get its act together”
(Bautista). All in all, the contractor had full responsibility for the quality. Already
mentioned is the problem the PB had of not being able to stop work when it felt it
needed to because to do so was not contractually allowed. The PB had to get approval
from the MNTC and the lenders. The difficulty was that each had different viewpoints
for allowing work stoppages with the exception of safety issues.

The PB checked quality through testing documents Leighton submitted. Since
submissions were always late, the PB had no way of checking the adequacy of test
results. By doing so, Leighton was assuming full risks if the completed work was
eventually rejected (Killick).

E. Impacts on Project

The deficiencies in the monitoring systems manifested in the end results especially
in the quality. In hindsight, the MNTC could have imposed more requirements in the
contractor selection process which would have addressed some issues that arose later
in the construction phase. The procedural system worked but it depended a great deal
on the contractor. Administering the contract with Leighton was very contentious,
although it still worked because the contractor assumed most of the risks. Bautista said
that “a contractor is a contractor and will go to claims to try to protect its profit.
Leighton did not make money in this project because of the amount of rework it did in
this project. At the end of the day, the contractor has to shoulder the risks and answer
for the design and quality of its work.” In addition, Killick commented that the
contractor was getting away with using revised design that was not reviewed by the
PB and the PB could not stop the work. There were cost implications associated with
working without approval and by doing so the contractor was assuming risks for work
that might get rejected.
The project resulted in an acceptable product but some portions did not meet the specified standards. According to Bautista and Killick, the following could have been done to improve the outcome of the project:

- The MNTC could have conducted a background check of the contractor’s project manager and of the critical people involved in the project.
- The MNTC could have scrutinized how the contractor would administer the subcontracts since the projects required involvement of a great deal of them. The success of the project depended on how well the contractor managed and monitored its subcontracts.
- The MNTC could have required that the contractor only subcontract with firms with approved quality systems. Most of the subcontractors were local who were not used to implementing quality systems.
- Quality control could have followed the traditional approach of third party testing and been removed from the contractor’s responsibility.

As a result of these deficiencies, quality assurance issues arose in this project, especially in the crack and seat process and the asphalt design mix.

- Crack and seat was a special process and good quality assurance work had to be implemented for the pavement to perform. The pavement moved a few millimeters and there was seepage under the pavement where a barrier should have been (Killick).
- Problems with the asphalt included cracks forming which may have been from the concrete moving beneath the asphalt or the design mix of the asphalt (Punzalan). Transverse cracks appeared just six months after handover of the project and these should have been manifesting 15 years into the pavements lifespan. The latent defect clause covers the design for 10 years although the MNTC does not really expect the asphalt to last 10 years due to the wear and tear of the road. However, the pavement is deteriorating at a higher than expected rate for which Leighton should be responsible (Killick). Leighton hired third party experts to check the cause of the quality issue and had the responsibility for rework since still within warranty period (Punzalan).
Due to these quality issues, the MNTC will potentially experience problems in maintaining the roadway especially after 10 years.

VI. CONSTRUCTION MEANS AND METHODS

The NLE Project’s major component was the rehabilitation of the road pavement. This section will focus on the factors considered for selecting the crack and seat method, details of using the method, and impacts of the selected method on the overall outcome of the project and the lifespan of the facility.

A. Selection Process

The construction method selected for pavement rehabilitation was the crack and seat approach. Some reasons that the MNTC considered before selecting the approach are detailed as follows:

- Most economical choice
  
  Since the NLE was an existing toll road, reusing the materials from the existing pavement was a big consideration. The cost of reconstructing the entire road system with a new concrete pavement would have been prohibitive. The crack and seat approach recycled the asphalt material and the existing concrete pavements were cracked and seated.

- Part of the design criteria approved during financial closure
  
  The design criteria for the NLE Project specified the use of the crack and seat method for pavement rehabilitation. Besides the requirement of using the AUSTROAD as a basis for pavement design, the design criteria specified that “existing concrete pavement, wherever required, will be cracked and seated, a technique that allows it to be used as an integral part of the improved pavement structure. The pavement so treated will then be overlaid with the specified thicknesses of asphalt pavement in accordance with projected traffic loading” (ETR).

- Contractor knowledge or expertise
Leighton was selected very early and had an input on the design and construction criteria for this project. Its input came in correlating the similarities of the transportation systems, traffic conditions, climatic conditions, and temperature seasonal variations between the two countries and making design and construction assumptions based on those. Also, having implemented the crack and seat approach in a project in China, Leighton had proven experience for the aforementioned rehabilitation approach.

- Limited techniques for rehabilitation of existing pavements

For already existing pavements, Killick commented that there was a very limited number of methods or means that could be implemented besides the crack and seat approach. It was also considered that Leighton, being the proponent for the crack and seat method, had great flexibility over choosing a construction method since the contract was design-build as long as the MNTC would be in agreement with the selected approach.

As for the method used in drainage construction and the use of material for subbase of the pavement, the reason for their selection was more what was locally available. Lahar sand was a product from the eruption of the Mount Pinatubo more than a decade ago but was still very abundant where the NLE Project was being constructed. Leighton developed and designed the use of lahar sand with cement to form the subbase layer of the pavements. Using local testing and experimentation, a density requirement was established for its use and this led to considerable cost savings for the contractor (Killick). Drainage works utilized the local method of banding abutting culverts together but the contractor experienced some difficulties with differential movements at the joints which caused rectification works. The contractor utilized this process because of labor cost advantages and lessened control measures needed for in-situ placing of manholes rather than pre-casting.

**B. Type of Construction Method**

This section will describe the crack and seat approach, its intended purpose, and how it was actually implemented in the NLE Project:
1. Crack and Seat Approach

To implement the crack and seat approach for the NLE Project, the contractor had to import the needed equipment such as a guillotine or hammering equipment to create the cracks in the existing concrete (Maunsell 40), advanced survey control equipment, testing equipment such as the Falling Weight Deflectometer (FWD) to detect the deflection of the pavement and specify pavement thickness, and self-leveling pavers. The equipment needed special handling and foreign experts were hired to operate it and train the locals.

The cracking treatment transformed the Portland Cement Concrete (PCC) pavements into fragments the size of large crushed stone base. The term break-and-seat indicates use of a crack and seat method for reinforced concrete, including debonding the steel from the concrete. Crack-and-seat applies to unreinforced concrete. The intended use of the crack and seat method was for all areas with rocking or moving slabs in the NLE (Maunsell 40). According to Killick, the crack and seat approach was only a remedy. The original plan was to identify areas that needed to be cracked and seated. Areas which were not appropriate for the crack and seat approach needed to be rectified. The contractor, on the other hand, planned to crack and seat the pavement for the entire project. The process was quick and the costs were low in comparison to having to spend money and time on identifying areas that needed to be cracked and seated. The contractor used the crack and seat approach to resolve all the problems of the existing pavement other than the isolated areas which were beyond repair.

The cracking treatment provided the preliminary step to asphalt overlaying of badly deteriorated concrete. The thickness of the asphalt overlay depended a great deal on the traffic loading the pavement was designed for. The current design of pavements accommodated to a limit of 13 tons, but for the NLE Project, a traffic loading factor...
for a maximum of 20 tons was considered. According to Killick, this was pushing beyond current experience and cast doubts on the actual performance of the finished pavement. When the FWD is dropped from a known height, the signals received from the rebounds indicate the deflection from which the required pavement thickness can be calculated.

The asphalt overlay was 50% recycled from the existing asphalt pavement after hot asphalt recycling. Hot asphalt recycling was the only recycling process considered because of its fit with established practices. The plant recycling process was considered over the in-place recycling because of the better consistency and separation of recycled asphalt since there were separate crushing operations for the old and new materials.

Paving operations were accomplished using a computerized paving device, imported by the contractor, which automatically leveled its screed to the required thickness from the design criteria and survey data.

The results of post-construction tests, also using the FWD, of the finished pavement were somewhat inconclusive as to whether the actual pavement thickness was reached. Killick commented that there was a lack of expertise in interpreting the results such that the MNTC and Leighton had difficulty reaching an agreement because results were dependent on non-standardized methods of calculations. The methods of calculations were dependent on the specifics of the testing machine, testing procedures, and even the calculation method used.

C. Impacts on the Project

Implementation of new construction methods and importation of state-of-the-art equipment allowed the Philippine construction industry to learn from this project through an informal transfer of technology. Local people were trained to use the FWD for testing, although the training was somewhat insufficient to develop the skill needed to go hand in hand with the pace of the project (Killick). Through the NLE Project, new methods were introduced to the Philippine construction industry such as the crack and seat approach and the hot recycling of asphalt.
These methods have never been used in the Philippines before and consequently, there is a great deal of doubt as to whether appropriate quality control measures were implemented in the project. According to Killick, “Validity of testing results was a bit gray because the pavement has been cracked. We basically don’t know whether [the pavement is] going to perform or not.” Other factors that could be associated to the untimely deterioration of the pavement are the contractor’s decision to bypass the preliminary survey to identify problem areas and the lack of quality control for the asphalt mix which resulted to mixtures lacking in bituminous content for the gradation of the aggregates used. Killick further commented that, “The contractor finished on time but the quality is questionable and not up to international standards.”
APPENDIX C: SOBRR CHAO PHRAYA RIVER BRIDGE PROJECT

I. PROJECT OVERVIEW

The SOBRR Chao Phraya River Bridge is part of the larger South Outer Bangkok Ring Road (SOBRR) Project, 22.5 kilometers, which is the last leg of the major expressway to complete the connection around the city. The bridge is designed with eight lanes, four in each direction, 36.5 meters total width with a main span of 500 meters, and side spans of 220.5 meters each. The bridge will be the longest cable-stayed bridge in Thailand after completion. Construction of the bridge started in 2004 and is expected to be completed by 2007.

The following discussion of the project includes the purpose, the major parties involved, and the major challenges in the project.

A. Project Goals

Three segments of the Outer Bangkok Ring Road (OBRR) have been completed. The Eastern OBRR consists of 64 kilometers from Bang Pa-In to Bang Na. The 70-kilometer Western OBRR extends from Bang Pa-In to Bang Khun Tien. The partial construction of Southern OBRR from Bang Khun Tien to Suksawat totals 13.27 kilometers. Construction of the remaining 22.49-kilometer Bang Phli-Suksawat Expressway which including the SOBRR Bridge will complete the road network. The Thai government has the following goals for the project:
- Link roads in the Bangkok metropolis and surrounding vicinities to the completed highway network for fast and convenient travel
o Decongest traffic in Bangkok to promote effective operations in the business sector
o Provide an additional access to the Suvarnabhumi Airport

Overall, the Thai government aims to foster economic prosperity by improving the transportation system in Bangkok.

B. Project Proponents

The Outer Bangkok Ring Road was first identified through the Inter-city Motorways Network Study by the Japan International Cooperation Agency and the Department of Highways in 1975. This feasibility study was conducted to determine how the transportation system of Thailand could be improved and to reach the traffic goals of the country. In 1997, the Government approved the Inter-City Motorways Master Plan (DOH; TAP).

For the implementation of the SOBRR Bridge, the following parties were key to the project:

o Department of Highways (DOH): key project proponent during the feasibility phase and supervising agency for the design and construction phases
o Expressway and Transit Authority of Thailand (ETA): manage and maintain the SOBRR Bridge after construction completion; chosen for experience in handling financial aspects of operations
o Krung Thai Bank: lending bank for the project through contractor financing
o Siam General Engineering Consultants, Asian Engineering Consultants (AEC), Thai Engineering Consultants (TEC), PB Asia, and Oriental Consultants: design team involved in the feasibility study and design phase of the SOBRR project; PB Asia was responsible for the Chao Phraya River Crossing
o Ch KarnChang Public Company Ltd of Thailand: main bridge contractor
o TAP (TEC, AEC, PB Asia) Consultants: provide construction supervision together with the DOH
C. Challenges

This project was a stop-and-start endeavor since it was conceived in 1996 (“Chao”). As for most projects, the financial ability is a critical consideration for a project. In addition, some of the initial and current issues are:

- The DOH preferred a tunnel in the beginning.
- The bridge designer addressed ROW issues by modifying the design including realignment of the bridge to avoid an existing steel mill and relocation of the west tower due to ROW issues (Hsu). Nonetheless, the contractor faced issues related to ROW because of the tightness of the site due to the constraints of the location as well as design of the foundation for the towers (Ch KarnChang).
- Although PB Asia, the bridge design firm, is retained as part of the TAP Consortium to review construction engineering documents, locating the actual designer offsite is not ideal for fast resolution of design issues (Ch KarnChang).

II. OWNERSHIP FORM: 100% PUBLIC OR GOVERNMENT OWNERSHIP

A. Government Ownership with Private Funding

For this project, both the DOH and the ETA are involved. The DOH was involved as early as the feasibility stage and in the supervision of the design and construction of the project. The ETA was appointed as the owner agency in 2003 to take over the operations and maintenance of the project when completed. The reason for the transfer of this project to the ETA was to integrate the highway system under one government agency (“Expressway”) as well as to take advantage of the ETA’s broader experience with financial aspects of projects (Hsu). Both the ETA and the DOH had past experiences with the BOT contracts particularly with the Second Stage Expressway System (SES) and the Don Muang Tollway. Although this project is not specifically under a BOT contract, the funding plan for this project is similar to that of the BOT because the contractor implementing the project had to look for a lending institution to finance the project. Part of the construction contract included an approved loan from Krung Thai Bank which the ETA will start to repay beginning February 2007. To
acquire the construction loan, the contractor was pre-qualified by the bank; in addition, the Thai Government through the ETA issued bonds to guarantee future payment. Included in the financing terms were (1) Minimum Loan Rate (MLR) of 2% to 2.5% and (2) penalty of 0.1% of loan per day of delay of construction payable by whoever is liable, either the contractor or the ETA. A Thai newspaper in year 2003 (“Southern”) quoted the Minister of Transportation and Communication claiming that the public-private joint venture process was better to speed up the delivery process of the project. He was also quoted as stating that using Japan Bank for International Cooperation (JBIC) loans and government bonds required Japanese involvement and would increase government debts which were not attractive measures to take.

Most of the upcoming transportation projects in Thailand are leaning towards formalized privatization with specific terms listed in the invitations for proposals.

B. Impacts on the Project

As noted above, the reason for the type of funding plan was to expedite the project delivery process and have the project on-line at the same time as the new international airport. Although the government agencies have great influence on the outcome of the project, the type of financing scheme used in this project builds partnership between the contractor and the government agency. One example was the owner’s acceptance of a revised foundation design submitted by the contractor for easier construction and lower construction costs.

III. CONSTRUCTION DELIVERY METHOD: DESIGN-BID-BUILD APPROACH

A. Selection Process

In 1996, a group of consultants led by Siam General Engineering Consultant was awarded the contract to conduct a feasibility study comparing a tunnel and a bridge to cross the Chao Phraya River, as well as to develop a design. The design for a cable-stayed bridge started three years after the results of the feasibility study favored
building a bridge. By 1999 before the design was finalized for the bridge, the Thai government solicited a design-build proposal. Bilfinger Berger was chosen for the contract; but in 2003, the design-build concept was scrapped and according to the Transportation Secretary (“Matichon”), the deal was cancelled because the design-build (turnkey) contract would have incurred more costs, and foreign contractors would mean increased external debts. New bidding, on the other hand, would mean faster implementation for the project because the need for further negotiation would be eliminated. In addition, a Ch KarnChang representative commented that a design-build process for the bridge project required financial capacity from Thai contractors that was not available.

According to some representatives from the DOH, some reasons for preferring the design-bid-build approach (traditional) were as follows:

- A pure construction contract would provide loan advantage due to the bank’s assessment of the main contractor for creditworthiness.
- The preference for local contractors requires that foreign designers be involved in the design phase due to the lack of bridge design expertise in Thailand.
- The total costs of the project would be lower than turnkey as experienced from past projects. With the traditional approach, the government has more control over costs and schedule.
- Construction claims were already expected because of missing as-built drawings for existing utilities in the project location.

B. Design-Bid-Build

The first step in the designer selection process was inviting qualified consultants, who were already in the existing DOH priority list, to submit technical proposals. Each proposal was evaluated based on (1) previous and related experience, (2) working plan and concept, and (3) key staff. In 1996, the feasibility and design contract was awarded to Siam General Engineering Consultant teamed with PB Asia, Oriental, and local firms AEC and TEC. The preliminary design took the lead designer, Ruchu Hsu, two months to complete. Only minimal changes were made from the preliminary design to the final design. It was not until 2003 that bidding
documents for the construction phase were made available and contractors were called to bid. Due to some pre-qualification requirements, only two bidders showed initial interest in the project although by bid opening there were at least four bids to be considered for the project. Some restrictions in the pre-qualification stage were (“Matichon”):

- No joint ventures allowed especially with foreign firms
- Bidder must have completed works amounting to Seven Billion Baht and completed one project of 1.5 Million Baht (USD 40,000)
- Bidder to complete the project in 30 months
- Company should be eligible for a loan from a bank without any initial guarantee from the government

The bid evaluation consisted of a two-step evaluation process: technical and financial. For the technical evaluation, the contractor’s technical experience, personnel, construction methodology, and environmental plans were scrutinized. The contractor had to describe their planned process of building and finishing the project. This included method statements and the kind and capacity of equipment to be used. For the cable system of the bridge, the top three potential suppliers had to be identified in the documents presented (Ch Karnchang). After deciding on the qualified contractors based on the technical evaluation, the financial evaluation, which is actually more important, followed. The financial evaluation checked the capability of the contractor to acquire a loan based on its creditworthiness and at the same time check the financial package that indicated the minimum loan rate and payment structure. The winning contractor was Ch KarnChang with the lowest responsible bid while the three other bidders could subcontract from Ch KarnChang.

C. Impacts on Project

The designer and contractor had different interpretations of the design drawings. The designer considered design drawings to only specify the end product and expected the contractor to undertake significant construction engineering works – as usual for cable-stayed bridge construction – to account for the preferred construction method and equipment. As for the contractor, it expected the design drawings to be 100%
correct and completed before construction. According to a Ch KarnChang representative, the construction drawings were not complete. In addition, having the designer off-site was causing delay in implementing the project. Some design requirements were difficult to implement on-site. Examples were specifications for steel not locally available in Thailand and constructability problems for the tower footing located in an area constrained by the available ROW. However, the contractor was aware of the difficult details, working space constraints, and foreign materials before bidding and should have accounted for all these existing conditions (Hsu).

Although the designer, Ruchu Hsu, himself, had thought of constructability and maintainability of the structure during the design phase, the problems faced on-site were different. An example was the issue of the ROW being too narrow to build the designed footing. The original design was based on the ROW at the tower section being 100 meters wide and a construction schedule of 42 months. Upon construction commencement, the ROW was narrowed to 80 meters at the towers and 40 meters beyond and the schedule was shortened to 30 months. This resulted in a change order altering the original design and decreasing the amount of concrete and piles to accommodate the limited space. Even when the designer was made aware of these changes, he was unwilling to compromise with the contractor and maintained his position of adhering to the original design (Ch KarnChang). Since the change was not the designer’s fault, the designer refused to redesign without compensation (Hsu). As a final resolution, the contractor hired JMI Pacific of France to redesign the footing and assumed full responsibility over the tower foundation to allow construction within the limited area. This is a case of the contractor adopting a design-build practice to meet the construction deadline of 30 months.

IV. PRE-CONSTRUCTION ACTIVITIES

A. Study of Alternatives

The feasibility study of constructing a tunnel or a bridge to span the Chao Phraya River considered (1) existing soil conditions, (2) marine navigation, (3) cost of
construction, and (4) ROW needs. From the study, the tunnel option necessitated a deep tunnel to prevent great impact on marine traffic. The entrance of the tunnel was too far from any major thoroughfare near the river to construct an interchange. The Bangkok Port was part of the site and the docking area should be clear and accessible at all times. The bridge option did not have the same issues and had lower construction costs (Hsu).

Public participation confirmed the choice for the bridge option. The DOH and the group of consultants worked together and collected data from the public to account for environmental and engineering factors, i.e., tunnel or bridge, viaduct or underground, and alignment considerations. (DOH; TAP) Hsu looked into a suspension or cable-stayed bridge to span the width of the river. A suspension bridge was not feasible because of the existing soil condition which required a large anchorage and massive foundation. On the other hand, the cable-stayed bridge could be self-anchored and erected from land without interrupting on-going marine traffic.

B. ROW Acquisition

The project’s ROW was acquired during the design phase. The designer was asked to make necessary changes in the design to accommodate the available ROW. The bridge alignment was supposed to cut across an existing steel mill but due to political issues the alignment was moved by 50 meters instead. The designer was able to accommodate this due to uniform soil formation; the design was not impacted by the change. The tower at the west side of wharf was also moved by 20 meters because of difficulty in ROW acquisition. Although the designer considered the impact of ROW in the design, the contractor also considered the impact especially with regards to the available site space. A change order resulted from having to redesign the footing to fit within the existing ROW. The original design required relocating an existing factory and steel furnace. Since this would have caused further delay in the schedule, the DOH decided that a redesign was more appropriate to address the issue of lack of ROW.
C. Design Specifications

Since the project was design-bid-build, the contractor was fully aware of the requirements for this project. On the other hand, the designer had to set up his own design goals for the project. Three of these goals were: (1) design a long lasting and user friendly bridge, (2) design a signature bridge for the capital city of Bangkok, and (3) design a very economical bridge using local materials as much as possible. A standard code for cable-stayed bridge does not exist. As such, bridge designers must prepare the design criteria and construction specifications for each specific project. For this project, the designer prepared the design criteria and acquired the DOH approval before design commencement (Hsu).

D. Critical Resources

For a design-bid-build process, the availability of construction drawings allows the contractor to plan for the needed resources in the project. Although this bridge was the fourth cable-stayed bridge in Thailand with two others being constructed during the same timeframe, the challenges that each project faced were not exactly the same. In addition, construction of another project of equal magnitude at the same time made resources a challenge. Resource management plays a major role in the success of the project. The contractor’s approach was to foresee problems and solve them at once. It could not afford even one day of delay in resolving issues due to the tight schedule and liquidated damages (Ch KarnChang). The following sections will discuss how the contractor managed existing resources, what resources were considered critical in the beginning, and how the criticality was addressed:

1. Manpower

The project was not labor-intensive but the use of new equipment meant people needing to be trained for proper operations and handling. An example was training labor to use automatic steel cutting and bending machines instead of having more labor to cut and bend bars on site. Manpower was allocated according to the activity schedule. Allocation was based on the project manager’s extensive experience of knowing how many people were needed to finish a job.
2. **Material**

Even before the project was awarded, the contractor consulted with local material suppliers regarding requirements. This was critical to this project as the specified steel grade for the bridge was not available in Thailand or Asia and had to be imported from the United States. Through consultations with the local steel mills, the contractor received a recommendation to import the raw materials from the United Kingdom and allow the local mills to produce the type of steel needed. The contractor not only had to make sure that the local mills could produce the amount of steel needed, but as well as to take the lead in making sure that the quality of the locally produced steel would be up to specifications.

3. **Equipment**

Specialized equipment was needed for this project such as the biggest bored piling equipment in Thailand capable of drilling 2-meter diameter holes. From the onset, the contractor was aware that there was only one set available in the country and it would not be enough to drill the required number of holes. As a result, the design was changed from 200 piles to 148 piles. Other types of equipment used were the automatic self-climbing PERI formwork and scaffolding from France and a 500-ton crane for the superstructure. Equipment such as the crane and guideway was expected to be transferred from the Industrial Ring Road Project because of the limited resources available in the market (Ch KarnChang). Some equipment that was initially planned for had to be changed because of spatial restrictions. Instead of using a 3000-ton crane for facilitate the heavy lifting on site, the limited available space prompted the use of smaller cranes being that were relocated to different stations every six months.
4. **Space**

Available ROW limited the space for construction on the project. The designer was asked to move the bridge whenever ROW was difficult to acquire. During construction, the contractor had to use alternate equipment because the designed footing covered most of the available space and could not accommodate the contractor’s initial equipment preference. As mentioned earlier, the crane’s capacity was supposed to be 3000 tons. Since the remaining space could not accommodate anchorage needed for this crane, smaller 250-ton cranes were brought in and had to be relocated every six months. This meant changing the crane location three to four times instead of just one time for the 3000-ton crane.

**E. Impacts to the Project**

By studying the merits of both the bridge and tunnel options, the DOH was able to use objective criteria to select the final design. The selection process showed that the bridge option could better fulfill the interests of keeping the waterways open and lessened impact on its surrounding areas.

The difficulties in ROW acquisition required the designer and contractor to accommodate the impacts on their respective processes. Fortunately, the designer was able to move the design alignment without issue because of the uniform soil conditions. Similarly, the contractor had to rethink its options regarding the type and size of equipment to use because of the site constraints brought about by the limited ROW. As a consequence, the contractor had to use smaller equipment and this meant increasing the amount of equipment to meet the schedule or be subject to delays. In addition, some equipment needed for this project was dependent on the schedule of other projects. The limited number of specialty equipment items in Thailand forced the contractors to share the available equipment. Although this project’s contractor has planned on acquiring the equipment on a “just in time” schedule, delay in the transfer of equipment from other projects were difficult to mitigate. The contractor relied greatly on this transfer scheme and had not planned to acquire equipment from another source.
Material and equipment are critical resources for this project. The contractor’s immediate recognition of these critical resources has given them the ability to plan ahead and mitigate impacts as much as possible.

V. PROJECT MONITORING SYSTEM

The DOH, as the initiator of the project, was responsible for overall monitoring. Even if it was privately-financed, no other agency represented the lenders except for the DOH. This section will discuss what systems were in place to oversee the achievement of the project goals from design to construction of the project.

A. Design Control

The lead design firm for the project is the PB Asia, a subsidiary of US-based firm Parsons Brinckerhoff. The lead designer was responsible for the design as a product while the design manager was in charge of design as a process such as controlling the costs and schedule of the design phase and communicating with the client.

The DOH had a very hands-off approach to monitoring the design phase. The DOH did not have a defined review system similar to the US review system of 30%-60%-100%-completed designs which are reviewed by client (Hsu). As a result, the designer had to unofficially get the client’s comment on the design. The designer became responsible for setting up the design goals, design criteria, and the final design. Some design criteria that the designer set up were:

- 500 meter single span of the bridge
- 55 meter undercarriage clearance for navigational purpose
- 3% maximum slope of bridge deck
- 100 year design life for the bridge

According to Ruchu Hsu, he personally addressed the issue of constructability in the design especially in the details of the system to provide easy equipment and manpower access during construction.

The designer had a role that extended beyond the design phase. He was responsible for reviewing construction methods and plans for erection, reviewing shop drawings,
addressing design questions, and making recommendations to the contractor during construction. During the coordination meeting, the owner stated that any change in the design would require approval from the designer (Hsu). Rules were also set regarding the responsibility of the construction engineer, although no rules were set regarding the communication process, particularly timeframe for RFI (Requests for Information) response and commenting on plans, between the designer, consultants, and the contractor. The designer, who was in the United States, communicated via email and usually responded within a day (Hsu).

Although the PB could accept or reject any request for change, the final decision was made by the DOH. Changing the footing design into a smaller dumbbell shape was approved by the owner but the designer had to relinquish its responsibility over the footing design to the contractor. The contractor accepted the responsibility to expedite the work and meet the schedule.

B. Construction Control

The project’s success depended on the DOH’s ability to achieve a balance between cost, quality, and schedule. To help the DOH, the TAP Consortium was selected as the construction manager. TAP is responsible for enforcing the design shown in the contract drawings and specifications and for making recommendations to the DOH regarding technical issues, but only the DOH can make final decisions affecting costs and schedule. In addition, other cost, schedule, and quality control measures are present in the project as will be detailed below.

1. Cost Control

Initial costs for this project were controlled by using a lump sum, fixed price contract with a liquidated damages clause in case of delayed delivery by the contractor. To address potential costs related to the project after construction completion, the DOH required the contractor to issue a 24-month guarantee for works completed. This took effect after acceptance of the project. Although the financing was provided by the contractor through bank loans, the DOH influences the disbursement of cash. Payments are based on the amount of progress actually reached.
The DOH and ETA representatives, specifically the Acceptance Committee, certify that the work has been satisfactorily completed before the contractor could apply for payment to the bank. If changes have to be made, changes costing less than 50 Million Baht are approved by the DOH Project Director but anything above 50 Million Baht must receive approval from the ETA Board (DOH; TAP). The contractor submitted an initial payment schedule to the bank before construction but the schedule can be revised to show changes in disbursement as long as the bank is informed of the needed changes to allocate funds (Ch KarnChang).

2. **Schedule Control**

   Ch KarnChang is an ISO-certified company with its own company policy of not being more than 5% behind schedule. Since the contractor has the ultimate control over schedule, the DOH relies on the contractor being bound by its own mission statement. In addition, the existence of a liquidated damages clause in the USD 50 Million construction contract of 0.1% per day of delay (payable to the bank either by the contractor or the owner depending on the reason of delay) motivates both the contractor and the owner to complete the project on time. The construction schedule is submitted at the beginning of the project but adjusted as required (DOH; TAP). When TAP was asked how the schedule is maintained, the representative replied that only the end completion date is fixed but the interim schedule is dependent on the contractor.

3. **Quality Control**

   The DOH and TAP work together to make sure that the design specifications are followed. TAP provides construction supervision as well as the appropriate quality assurance. A common industry practice is to include the design company as part of the consortium of consultants. This allows easier access to the designer for response to questions about the design.

   The contractor is responsible for quality control while the consultants check the quality assurance system of the contractor. Both parties are involved in witnessing the needed testing. Since representatives from the DOH and TAP are on site, any observed
non-conformance is immediately addressed by stopping work. The work continues only when the contractor had corrected the cited quality issues (DOH; TAP).

A material checking system for ordered materials such as steel includes certification by a third party specialist in addition to the quality check administered by the DOH and TAP. Since the contractor partnered with the steel suppliers to produce the steel, the third party expert provides the unbiased review conformance to design requirements.

For the cable system in the project, the DOH asked for a shortlist of potential supplier during bidding. The contractor subcontracted the cable system to Freysinnet (France) based on their reputation as well their willingness to provide a fixed price contract for the cost, material, service, and installation of the cable system. To check the quality of the cable system, bi-directional testing is required by the designer and witnessed by both the DOH and TAP.

C. Social and Environmental Considerations

This was one of the first infrastructure projects to implement noise and dust measurements on site. This was required by a new environmental law for Thailand. Tied with this legal compliance is the existence of a liquidated damages clause in the contract regarding safety and environmental considerations.

D. Impacts on Project

Involving the designer in the checking and approval of construction plans and design changes preserved the intent of the design. Despite direct and immediate communication between the designer and contractor with the awareness of the DOH and TAP, the effectiveness of the process still had some exceptions. The contractor expressed concern over not having the designer within easy access. This hindered fast implementation of design changes and construction innovations which have to be approved by the designer. Examples included changing the box-shaped edge girder to an open section and redesigning of the tower foundation.

The focus of the DOH and TAP is on the quality of the project. Being able to stop work for quality non-conformances sends a clear signal of how important quality is to
this project. On the other hand, schedule control is entirely shouldered by the contractor. When delay occurs, the DOH and TAP can ask the contractor to submit a revised schedule but no formal intervention measures are in place. Although the contractor is sometimes behind schedule (20% completed work over 40% of schedule), the DOH and TAP expect the high liquidated damage rate to prompt the contractor to keep the construction on schedule. Acceleration plans have already been started, i.e., work in the river using barges to expedite the schedule (TAP). The schedule is connected to the project costs such that it will be affected as well because of the penalties that will be charged by the lenders to the project in case of delays. In this regard, Schedule control translates to the needed cost control for this project because of the penalties that could be avoided if the project finishes within schedule.

VI. CONSTRUCTION MEANS AND METHODS

The project was to construct a cable-stayed bridge over the Chao Phraya River. This section will focus on the selection process for the construction methods and mentions some techniques that the contractor could use for constructing the bridge superstructure:

A. Selection Process

According to the Ch KarnChang, the major activities to constructing the bridge were foundation, piling work, tower construction, superstructure erection, and cable installation. These activities were sequential and could not be constructed in parallel. Some of the contractor’s reasons for choosing the construction methods were:

- Erection method is governed by the design.
  
  The bridge design was based on a balanced cantilever method to erect the superstructure. A detailed construction sequence was included in the contract documents but the contractor had the make the decision of following it or not. The design already considered the erection aspects such as the layout of the structure and external anchoring system.
- Fulfill the project goal of keeping the waterways open for navigation
Although two options exist for erection scheme, using temporary support or balanced or free cantilever method, the intent of keeping the river open for marine navigation is a key project goal. The balanced or free cantilever method would be the only option to fulfill the goal.

- Tight construction schedule

The contractor had to find ways and means to increase the rate of production. Although labor in Thailand is relatively inexpensive, the use of machinery to cut and bend bars was relatively faster and more productive. The contractor was very schedule-oriented because costs associated to a project delay were very prohibitive.

B. Types of Construction Methods

1. Pylon Construction

In constructing the pylon (tower), the contractor employed self-climbing scaffold which is a normal practice in Thailand. This method shortened the construction period due to the continuous casting of concrete. To place the concrete in these pylons, the contractor used a bucket system with a braced 200-meter high tower crane installed outside the actual structure (Ch KarnChang). These cranes are normally installed inside a structure such as those seen in building construction.

2. Superstructure Erection

The contractor used the balanced cantilever method to install the actual bridge deck spanning the Chao Phraya River. The deck was temporarily fixed at the towers.
during the erection. Superstructure segments were then lifted on both sides of the tower to keep the balanced cantilevering. After each steel segment was bolted to the previous segment, cable installation followed and then the precast deck panels were installed. After finishing half the span from one side, the other half was finished coming from the other side to meet at the center.

The cables used in this project were parallel-strand stay cable. Seven wires made up one strand and each cable consisted of several strands depending on the demands on the cable. The strands were then installed using the isotension method – inserting and stressing 7-wire strand one by one that need to be bundled at intervals with a binder to ensure integrity and avoid individual oscillation of wires – and enclosed by a HDPE pipe for protection and to achieve an aerodynamic shape. This method is popular due to low cost and easy handling. The entire cable system was subcontracted to Freyssinet (France). The cables will be jacked at the tower ends where working spaces have been reserved.

Fig. C-4 Cable to Tower Frame Connection, from Ruchu Hsu

C. Impacts on the Project

With the implementation of new systems in this project, Thailand is experiencing a great deal of technology transfer. An example would be the introduction of the bi-directional testing for the cable system. As mentioned earlier, this is the fourth cable-stayed bridge being constructed in Thailand but each bridge project is unique in its own way especially on the exogenous factors by which each is affected. Although the selected construction method expedites the construction of each component, the sequential nature of each activity makes it difficult to develop a recovery plan when one of the activities is delayed.
APPENDIX D: NAM THEUN 2 HYDROPOWER PROJECT

I. PROJECT OVERVIEW

The Nam Theun 2 Hydropower (NT2) Project is located 250 kilometers east of the Lao PDR capital, Vientiane. The main features of the project include a 48-meter high Roller Compacted Concrete (RCC) gravity dam on the Nam Theun river, a 450-square-kilometer reservoir, a powerhouse, a 130-kilometer long double-circuit 599kV transmission line to provide electricity to Thailand, and a 70-kilometer long simple circuit 115kV transmission line for domestic use of electricity (“Decision” 1). The project has been in development for the last 10 years and is currently under construction.

The vision for the project, the entities involved in planning, implementation, and some of the major challenges are discussed in the following sections:

A. Project Goals

Lao PDR is currently the poorest country in Asia. Implementing the NT2 Project is seen as the start of the country’s economic growth pattern. This project will be the benchmark for future growth in Lao PDR because of the country’s potential to be the supplier of electricity for other countries in Asia. As a development project, the NT2 Project aims to be operational after the 54-month construction period and, more importantly, address the social and environmental issues that affect every activity in the project. Some key social and environmental goals of this project are: 1) to relocate almost 1500 villagers who will be affected by the development 2) provide affected Laotians with new homes and 3) provide Laotians a sustainable way of life through...
assisted livelihood programs, e.g., fishing, producing organic fertilizers, agriculture. Lastly, achieving these goals is tightly bound to the fact that, first and foremost, the project has to be financially viable.

B. Project Proponents

In 1970, the Mekong Secretariat identified the Nam Theun River as a potential source of hydropower. Through a feasibility study that spanned from 1989 to 1991, the World Bank, through Snowy Mountain Engineering Corporation (SMEC), was able to determine that a hydropower project in the Nam Theun River was the most economically viable hydroelectric project in Lao PDR (Project History). As a result, the Government of Lao PDR started the solicitation process for a hydropower project and Nam Theun Electricity Company (NTEC), the foreign consortium comprised of the sponsors – EDF of France and Montgomery Watson Harza (MWH) of US, responded to this invitation (“Decision” 1). Both companies were highly rated in their respective fields with EDF being involved in developing thermal power projects under the Build-Operate-Transer contracts while MWH had extensive experience in building power projects. In 1993, by joining with Electricite du Laos (EDL), the NTECO was formed and was granted a concession period of 25 years for the project. The NTECO, which is now formally the Nam Theun 2 Power Company Limited, has the following as sponsors: EDF with a 35% share, EGCO with a 25% share, LHSE with a 25% share, and ITD with a 15% share (“Decision” 1). The concession agreement is between the Government of Lao PDR and NTPC. Through the World Bank’s endorsement, the project became more financially attractive and this was the key to financial closure. To achieve financial closure, 19 lenders, including the World Bank and the Asian Development Bank, were involved in negotiations. The focus on the social and environmental aspects of the project was driven by the World Bank and the ADB. These banks are known to have strict policies with regards to the environment. Hydropower projects have developed an infamous reputation regarding relocation of people and other social and environmental impacts and have left a black mark in terms of development. Since the NT2 Project is the first hydropower project endorsed by the World Bank in a decade, it has to follow stricter compliance measures.
than previously endorsed projects. By having the World Bank as a partner in financing of this project, the NT2 Project must comply with the World Bank standards, which are higher than any previous standards (Harrison).

To ensure that the technical, environmental, and social aspects of the project are being addressed, a Panel of Experts (POE) and Dam Safety Review Panel (DSRP) are providing oversight to this project. These groups are directly reporting to the lenders and the Government of Lao PDR. They publish reports about the project that are publicly available. The Government of Lao PDR and the lenders have their own technical advisers who monitor the project on their behalf. The NTPC has a Director of Social and Environmental Safeguard Division to focus on achieving social and environmental goals. It also has a Director of Construction who facilitates construction from the NTPC side and coordinates with the Head Construction Contractor for overall project management. In addition, the NTPC also hired an Owner’s Engineer to provide technical support and advice. Besides these formalized proponents in the project, it has attracted the attention of various non-government organizations (NGOs) who are concerned about the outcome. The NTPC has adopted an ‘open door’ policy and allows oversight from all interested parties (Harrison). Roles and contributions of some of the project proponents such as the POE and DSRP will be elaborated in the latter sections.

C. Challenges

John Harrison, the NTPC’s Director of Construction said, “There are always problems in a project but the responsibility of the managers is to resolve these to both the owner’s and contractors’ benefit.” For this project, the key challenge could be in facilitating construction and development while achieving the socio-environmental goals. Some design features were yet to be decided because of the desire to tie these in with socio-environmental goals. An example was the design of the downstream channel for which the plan to divert outflow from the powerhouse to provide irrigation water to the nearby villages was not yet finalized. There are as yet no perceived impacts on project progress but similar situations at the latter part of the project will likely create impacts. Also, some socio-environmental factors in this project are not
easily controllable but have a great impact on the progress of the work, e.g., the evacuation of the villagers from an area needed for constructing the downstream channel. If evacuation is not finished by the time the contractor is ready to perform the work, the contractor will delay project progress. With regards to the technical aspect of the project, the work poses no challenge except for the sensitivity of the assumptions made regarding the hydraulics of the downstream channel and its confluence with the Xe Bang Fai River. The NTPC is responding to the challenges by adding the Director of the Social and Environmental Safeguard Division whose focus is on socio-environmental issues and the Director of Construction who focuses on the technical aspects of the project but is also involved in addressing socio-environmental issues. The owner also created a contingency fund to mitigate risks (Harrison).

II. OWNERSHIP FORM: BUILD-OWN-OPERATE-TRANSFER CONTRACT

A. Selection Process

As mentioned in the earlier section, Lao PDR is the most economically-marginalized country in Asia. As such, its government did not have adequate capital to fund a project such as the NT2 Project without external parties getting involved in the financing and developing stages. The involvement of private entities and international financing institutions, such as the World Bank, to help financially-constrained countries in the pursuit of economic development became necessary, and this translated to a Build-Own-Operate-Transfer scheme that actually fit the needs of Lao PDR. The NTPC was awarded the concession for 25 years and the concession agreement between the Government of Lao PDR and the NTPC covered the entire obligations in the contract (“Decision” 1). In the selection process for the concessionaire, it should be noted that the World Bank has strict procurement procedures and social and environmental compliance measures that are usually mandated for the projects it finances. The World Bank requires that all procurement for these projects undergo a competitive bidding process before any award is made. In the NT2 Project, the World Bank’s endorsement of the project created more financing
opportunities. The World Bank selection process was not fully enforced in this project as indicated by the negotiated process of selecting the concessionaire and even in that of the Head Construction Contractor, which will be discussed in the latter sections. The reasoning could be that even before financial closure, the Sponsor was already involved in the development and was the logical choice to implement the project. Another reason could also be that the World Bank provided only a small fraction of the financing that was needed for project; therefore, the NTPC did not consider it an obligation to follow the World Bank’s competitive bidding procedures (Delplanque).

In some other aspects of the project such as the environmental and social aspects, the NTPC has acquiesced to World Bank standards and is fully committed to fulfilling terms and conditions in the concession agreement as will be detailed in the following section (Harrison).

B. Build-Own-Operate-Transfer

The key to making the NT2 Project financially viable was signing the 25-year “take-or-pay” Power Purchase Agreement (PPA) with the Electricity Generating Authority of Thailand. The duration of the PPA was consistent with the concession period that was recorded in the CA. The CA covered all the conditions the NTPC and the GOL agreed upon getting into a BOOT contract. This included all environmental, social, and technical aspects of the project. More specifically, the CA delineated: 1) representations by the involved parties, i.e., the NTPC and the GOL, 2) warranties, 3) 25-year concession period, 4) needed changes in the Laotian laws to support the project, 5) required project documentation including drawings and monthly reports that the NTPC needed to submit to GOL, 6) financing terms, 7) obligation of GOL to provide land for the Right-of-Way and to turn over specific corridors to the NTPC, 8) the NTPC’s obligation to achieve specified socio-environmental goals, such as relocation of 6,200 villagers, 9) the POE’s and DSRP’s role in the project, 10) lenders’ role and jurisdiction, 11) selection process for the ‘Laotian preference,’ and 12) use of specific products in the project (Harrison). Some of these points are further addressed below:

- The POE’s and DSRP’s role in the project
The POE and DSRP are made up of three members each. The POE looks into the environmental and social issues focusing on how power plants affect the existing ecosystem. The concern is righting social implications and fulfilling environmental obligations. On the other hand, the DSRP concentrates on the technical aspects of the project including constructing the dam, addressing hydrology issues, ensuring that contingency plans are set in the event of dam failure, and considering any factor that would affect the downstream people. Based on the CA, any ‘recommendation’ made by either the POE or the DSRP should be considered a directive and the NTPC must comply unless the NTPC vetoes it. The NTPC can make an appeal and ask for a review (Harrison).

Lenders’ role and jurisdiction

Lenders have the approval right to subcontracts of a certain value. Variation orders involving cost changes also require approval from the lenders. With regards to subcontracts, the NTPC has first approval but as mentioned the lenders have final approval. The lenders usually rely on their technical adviser, PB Power, to review the documents provided by the NTPC, ask the questions regarding the technical and commercial issues, and then make the recommendations to the lenders. The processing time for getting worldwide approval varies and depends on the 19 lenders but does not pose as a major hurdle for the project.

Selection process for the ‘Laotian preference’

The NTPC is obligated to employ as many Laotians as possible. The CA defined which levels in the NTPC organization must have a percentage of qualified Laotians. Positions excluded from the “Laotian preference” were the CEO, CFO, and Director positions in the NTPC. Levels involving junior engineers and less qualified personnel were required to be filled by a percentage of Laotians.

At the same time of the CA’s finalization, other project documentation was also completed. The reference design was developed in cooperation with the HCC, which was EDF, and the NTPC. The EDF was working on 'both sides of the fence' during this time because it was both a sponsor and a contractor who had a stake in the project but also had tremendous experience in building power projects in Europe. The
reference design and design criteria were the basis for the HCC’s detailed design. These documents had to be consistent with the terms specified with the CA and had to complement the CA for implementation (Harrison).

C. Advantages of the BOOT

Using the BOOT scheme to develop projects is fairly common in Asia. The developing country does not have to carry the burden of financing a project that would bolster its economic growth. In the case of the NT2 Project, the BOOT contract agreement allowed the NTPC to develop the project with full cooperation of the government through the CA, which sealed the partnership between the GOL and the NTPC.

1. Government Involvement

GOL is a partner – sponsor offtaker – and supporter of the NT2 Project. As such, there was no hostility or difference in opinion that hindered the progress of the project. Examples where government involvement or cooperation had beneficial were: 1) faster importation of materials and equipment through the GOL facilitation and 2) permitting and local community relations through oversight and support of the local district authorities. There was no actual interference on the project from the GOL. Through the partnership, the NTPC gained the Laotian people’s confidence that the project would be built and would perform according to the criteria.

2. Concession Agreement

Under the usual concession agreement for power projects, the country’s obligation comes in the form of an offtake agreement for the electricity produced. This project is similar except that another offtake agreement exists with EGAT, electricity agency of the Government of Thailand. Through the BOOT scheme, Lao PDR benefits not only by buying only a fraction of the produced electricity but also having a revenue generating facility at the end of the concession period. Furthermore, upon turnover of the facility to the GOL after 25 years, Laotians will have benefited from transfer of technology and learned how to operate the facility themselves.
D. Impacts on the Project

The BOOT had some major benefits for the parties involved. To the project itself, the impacts on completion projects are still to be assessed. Some requirements imposed in the concession agreement have resulted in the following impacts:

- Local authorities have started to become involved in the activities of the project especially in providing oversight. Examples include the Department of Transportation inquiring about the construction of the roads in the site (Harrison).

- The NTPC favors the ‘Laotian preference’ and is willing to employ local Laotians because of economy and convenience as well as a great opportunity to help raise skill levels. A disadvantage is lower productivity levels during construction and increased supervision. An example was the construction manager ‘tutoring’ Laotian engineers to prepare reports and fulfill other engineering activities. On the other hand, Laotian engineers are intelligent and willing to learn and the only deterrent to their achieving the level of other experienced engineers is the lack of experience specifically on this type of project (Harrison).

- The process of getting approval from the lenders is time-consuming and not conducive for fast implementation of work without having to forgo contracting standards. An example was to have a subcontractor start work without a signed or approved contract. A well qualified and experienced civil subcontractor was chosen to work on the roadwork. The firm received preliminary approval from the Head Construction Contractor (HCC) and the NTPC but had to wait for the lenders approval before a formal contract could be issued. It took at least three weeks for the 19 lenders to reach a consensus and give their approval for the contract. In that timeframe, the subcontractor was already working under ITD, the Civil Work Contractor and initially had to take the risk of being rejected or as they say ‘placed in the frying pan’ while awaiting formal approval from the lenders.

The BOOT scheme if paired with the design-build method was able to unify all parties involved by making all parties in a project participate in the obligations of the concession agreement. The concession agreement was the key document that directly linked all the design-build contracts in this project.
III. CONSTRUCTION DELIVERY METHOD: DESIGN-BUILD APPROACH

This section describes how the project will be delivered, including reasons to design-build approach was selected, major elements of the design-build approach, and advantages and shortcomings for this project. The potential impacts of the design-build approach will conclude the section.

A. Selection Process

One major construction contract exists between the NTPC and the Head Construction Contractor, EDF. This is a negotiated, lump sum contract. Several reasons prompted the use of a negotiated, lump sum, design-build contract.

- EDF is one of the longest-involved developers of this project. The negotiated procurement method was not contested by the World Bank since almost all the design had been partially created by EDF. The EDF’s experience in the field of power project development is well-known and warranted their qualification as the Head Construction Contractor. Also, the knowledge EDF had about this project would have created advantages over any other tenderer.

- The NTPC had a reference design and some design criteria but it needed another entity to take on the obligation of finalizing the design. The NTPC’s role is a developer and not a contractor. As such, the NTPC is not capable of taking on the role of the HCC. If NTPC had wanted to be the HCC for the project, it would have needed to hire its own engineering people to supervise and implement the project. Currently, the NTPC’s responsibility is for the resettlement and social issues, which make up a big facet of the NT2 Project, and also managing the contract with the HCC. The NTPC’s responsibility extends only to the mentioned issues, otherwise it would lose the ability to pass on the risk to the HCC; and this would not have gone well with lenders.

- The NT2 Project is financed by at least 19 lenders around the world, these lenders needed to be satisfied that the risks were well-defined and those responsible were well-qualified to manage these risks. Lenders agreed to the design-build because the responsible entity for the risk was defined. If risks were passed on to different people, the project could end up with responsibility gaps. Also, splitting the work
into different contracts would have made cooperation difficult. Choosing a project delivery method was synonymous to preferring a particular contract type. According to the Director of Construction, John Harrison:

Where you place risk, who is responsible, who carries the liquidated damages (LD) matters because if the NTPC and the offtakers are stuck carrying the liquidated damages then no lender would be willing to finance the deal. [The] NTPC would need to put in 85% as equity and maybe 15% would be from the lenders; so it's about placing the risk. The contractor is willing to take it and of course there is a fee for it.

B. Design – Build Approach

The contractual arrangement between Head Construction Contractor and the NTPC is a very detailed document with a great deal of reference material covering the technical aspects. In this contract, there is even an obligation for the HCC to conform to the concession agreement. Every essential requirement in the concession agreement are included in the HCC contract or specifically spelled out in the reference design furnished to the HCC. The Head Construction Contract was then split into five major subcontracts: three (3) civil work packages and two (2) electrical and mechanical packages. These major subcontractors share all the risks and responsibilities of the contract with the HCC. The NT2 Project has a very stringent project schedule and contractual agreements existing among the parties cover all risk aspects of the project.

A major portion of the design-build approach for the NT2 Project is based on subcontracting under the design-build approach with the HCC providing the design and construction management support to the project.

1. Subcontracting

No criteria were set on how the HCC evaluated the subcontractors, although the NTPC reviewed the subcontractor’s proposals before sending it to the lenders for final approval. As John Harrison commented about putting such clauses in the contract, “When you start putting clauses in the contract on how to procure subcontracts, you are actually managing [the HCC’s] work and [the NTPC] do[es]n't want to do that.” The NTPC was concerned only about its contract with the HCC. Since the HCC was fixed price, the HCC had the flexibility with its selection of suitable subcontractors as
long as it obtained approval from the lenders. In some instances such as for the civil work packages, the lenders disallowed contract award due to limited capabilities of a contractor. The ITD, although being involved in the latter part of the project development and also a project sponsor, was not allowed to have the entire civil works package because of its limited experience in tunneling. Only after it formed a joint venture with Nishimatsu was it approved by the lenders for all the civil work packages. The HCC selected the best subcontractor for the work who may not be the lowest bidder.

Each subcontract covered a particular area in the project. Detailed design and construction were assigned to the subcontractors but the HCC worked closely with them. Specifically, the EM1 contract with General Electric included responsibilities for the design and installation of the turbine generator package inclusive of all ancillary equipment, such as transformers, breakers, switchgear, needed to generate the electricity. Another contract was for constructing the transmission lines namely the 500kV line and towers and 115kV line and towers. Some design items were not finalized in the reference design and only the design criteria for this contract were set. For example, the subcontractor needed to finalize the cabling to be used, height of the towers, distance between towers, and foundations of the towers. With the civil work packages, the ITD was not doing the design. The engineering work involved in the cofferdam and dam design by the contractor was further subcontracted out. The ITD worked very closely with this engineering firm, finalized the design, and then submitted final design to the HCC.

2. Design and Construction Management

Major parts of the design were passed down to the subcontractors, but the HCC retained responsibility for some items. The HCC was still responsible for the impacts of the dam. The subcontractor had the responsibility for excavation, structural work, and the cofferdam, but the HCC could not hold the subcontractor responsible for the hydrological impact. The hydrological analysis involved in this assessment was the responsibility of the HCC. The subcontractor could not be responsible for the backup effect of building the dam. The subcontractor received directions from the HCC
defining what was to be built, produced method statements describing how the structures would be built, and provided a design memorandum describing the performance of the structure. The subcontractor was responsible for the scope of work detailed in his contract but not for effects of factors such as rainfall and the impact of rising water on the surroundings. The HCC had to assume the responsibility for checking the hydrology and informing the NTPC regarding the water level net effect on the villages. A civil contractor like ITD, although very experienced, did not have expertise regarding hydrological issues. The EDF has a worldwide reputation and experience for being involved with hydrology to handle these issues. Passing off this responsibility to another entity would increase costs and lower profits.

The design management role of the HCC was especially important because the engineering was being done offsite. The design groups were not familiar with the specifics of local conditions and the input from the contractor was significant. The manager of engineering for the EDF came to site frequently and relayed information to the design engineers. The remaining part of design management was coordinating the design with the NTPC and subcontractors to produce a well-integrated final design. The subcontractors submitted the detailed design to the HCC who provided them to the NTPC. The HCC was responsible for submitting the design criteria, basic design memorandum, and drawings to support the final design of the structures such as the dam. The contract between the HCC and the NTPC required that all documents be submitted to the NTPC before any actual work commenced. The NTPC reviewed the design and raised questions when the design did not fulfill the criteria, sent back a query to the contractor, and waited for a response. The contractor resolved the design issue by proposing a technical solution acceptable to the NTPC and completing the approval process. An example of this was one of the hydrological structures that had a test model built in Singapore. Model testing indicated that the design was inadequate. The proposed gates for the structure had to be enlarged to handle the required flow. The NTPC was not at first willing to accept the design but later on reached a compromise with the contractor if further testing on the model showed that the structure would pass. The contractor had to run more tests through the model and had
to provide the NTPC with the data to support the results. So even if a design was provided by the subcontractor, the HCC was responsible for its performance.

The HCC was contractually required to provide the construction schedule using the Primavera program and meeting specific requirements concerning level of detail and presentation. The schedule showed up to a Level 3 work breakdown structure and anything more detailed was provided in specific Method Statements. The design-build contract between the NTPC and the HCC required a date-certain completion date therefore the overall responsibility of planning fell solely on the HCC. The contract placed great emphasis on the schedule because of the NTPC’s obligations to EGAT, EDL, and the lenders. The NTPC is subject to liquidated damages if milestones are not met and in turn these liquidated damages are imposed on the HCC. The HCC passed on the same clauses to the subcontracts and set milestones in conjunction with the project master schedule. The HCC was also expected to provide acceleration plans when progress was falling behind schedule. When projections based on productivity rates over several weeks showed that work was falling behind, acceleration plans were required based on the criticality of the work and the degree of negative float.

C. Advantages of the Design-Build

Since the HCC was involved in the project during the development phase, the design-build approach was chosen to give the HCC flexibility and to assign the risks were to those who could best manage them. The HCC ultimately handled construction-related risks with highly experienced subcontractors sharing the risks with the HCC through back-to-back contracts. The HCC managed the construction phase more easily if it had sole responsibility for the work. In a design-build approach, less coordination efforts were needed from the NTPC. Also, the lenders would not agree to have the NTPC assume responsibilities and preferred to have an experienced construction company take on the risk.

As to the design-build approach adding value to the project, the specifications, owner's requirements, and reference design were been clearly defined and the contractor had to comply to these. Having these documents clearly detailed lessened the NTPC’s risk of not getting what it anticipated as the final product. Also, if the
contractor suggested some design changes as was the case for the re-alignment of the downstream channel that had a cost savings of US$300,000 for the project, the NTPC could take part in the cost savings. The HCC in this project is a sponsor with the largest share. It is not interested in constructing a less than desirable project because the stream of cash flows that this project creates will directly affect the HCC. If they produced a project made up of inferior or low quality material and equipment and the overall quality of the project was less than desirable, then there would be an increase in the operations and maintenance costs which would affect the end profits of the facility. Also, every breakdown or shortfall this project encounters over the 25 year concession period will ultimately fall into the hands of the sponsors. This is not a scenario the HCC would want to be in.

D. Shortcomings of the Design-Build

For the NT2 Project, the use of the design-build approach did not completely eliminate the coordination issues that occurred between design and construction. Engineering work was being performed by companies in New Zealand and Canada, and even the HCC’s own engineering group was coming from France while construction work was being done in Lao PDR. Having the engineering work off-site slowed down the design process. The problem was logistic in nature especially for the HCC in coordinating the drawings. The HCC's engineering manager conducted his coordinating efforts from France and visited Lao to assess the site every six weeks. A solution should have been to have a design group on site but neither the NTPC nor the HCC or the subcontractors were willing to shoulder the cost of having the design team on site. Bringing in the design team into the site was not an easy since senior engineers had to be relocated to the site. The design team had to be composed of at least 42 people to support the subcontractors in their work. When asked about the design coordination issues, Harrison noted, “We've had to deal with it. We've been able to keep our heads above the water, but it hasn't been the smoothest as we would have liked.”
E. Impacts of Design-Build on the Project

The design-build approach was not meant to remove all project risks from the NTPC and let the HCC assume all the responsibilities. Similar to the BOOT contract, the contract between the NTPC and HCC is a partnership with each party having their responsibilities defined in the contract. Through the design-build approach, risks related to the project construction phase were passed on to the HCC and the subcontractors. The NTPC was relieved from coordinating actual construction works; nonetheless, the NTPC still needed to constantly monitor and support the activities especially in areas where environmental and social issues existed. The HCC was given flexibility to implement the project but always with the consent of the NTPC. That being said, a proposed change in the contract should be considered fairly and reasonably as the contractor might in fact be correct and have the right to implement the proposed change.

As to the impact of the current setup of the design group, it was acceptable and functional, but inefficiencies were already been cited and could pose problems during critical times. A likely scenario that could be crucial would be when a design had to be revised and was not ready by the time construction work had to commence. The NTPC insists on reviewing the finalized design documentation before construction work is allowed to start. With this being the case, the inefficiency in the design process would lead to impacts in the actual project progress.

IV. PRE-CONSTRUCTION ACTIVITIES

Preparatory works are essential to the success of any project. With sufficient planning, many variables affecting a project may be anticipated and mitigating plans formed before any activity took place. In the NT2 Project, the preparatory works that had potential impact on construction were the coordinating efforts, relocation of existing utilities, land acquisition for the project’s Right-Of-Way (ROW), preliminary geotechnical and environmental studies, approach to risk management, management of the design process, identification of critical resources, preliminary construction
activities such as Unexploded Ordinance or UXO clearance and equipment mobilization, and allocation for season changes.

A. Coordination Works

The concession agreement between the GOL and the NTPC was signed in Vientiane but the actual project was built on the Nakai Plateau. The government at the district level in Nakai was not initially privy to the terms and conditions of the concession agreement. The key to getting any cooperation from the local agencies was to have them become a partner in the project. For the NT2 Project, the NTPC had to take the initiative of informing the district concerning the concession agreement. This only came to light after the NTPC’s confusion regarding the uncooperative nature of the district agencies and the non-performance of the GOL’s responsibilities for the project. The NTPC had the concession agreement translated to Laotian language so that the people in the district level people could understand the contract and could provide the support the NTPC needed. Although the responsibility of information dissemination lay with the GOL, in reality it was easier for the NTPC to assume the responsibility and assist the people at the district level to perform their tasks.

While coordination activities are the responsibility of whoever could best manage it or has the clause specific in its contract, the NTPC usually assumed the coordinating efforts with the local agencies in cases such as the importation of materials and equipment. Since the GOL was a partner in the project, government agencies from the district level to the ministerial level supported the NTPC’s efforts to get importation documents approved. The limitation to this was if the contractor did not submit the proper documentation and set itself up to be refused by the government. In reality, the contractor was at fault and should facilitate its own coordination activities with the local agencies, but still the NTPC provided assistance because it was more beneficial for the project as a whole to have the NTPC facilitating coordination activities with the government.

The key coordination activity that solely fell on the HCC’s realm of responsibilities was the project schedule or programme. Although a milestone program was set up by both the NTPC and the HCC, the preliminary schedule prepared from
this had to be more detailed. Once the contract was formally awarded to the HCC, it automatically took full responsibility for schedule. The contract between the NTPC and the HCC included specific requirements for the schedule and the HCC had to demonstrate that the schedule could meet these requirements. The contract required identification of key milestones and the critical path. The schedule needed to be developed using the Primavera program fully integrated with all engineering, manufacturing, and subcontractor activities. In addition, the HCC was responsible for submitting an updated schedule every month to the NTPC. The HCC and subcontractors identified key elements that had to be finished on predetermined dates to prevent liquidated damages.

A key milestone that the NTPC identified was filling the hydrocircuit with water all the way from the intake area, the intake and pressure tunnel, then to the powerhouse. Completing and testing the circuit was a key activity in this milestone because until the hydrocircuit was completed, the powerhouse could not admit water and the turbines could not be run and tested.

B. Utility Relocation

All through the areas where roads were widened or relocated or where the downstream channel, regulating dam, regulating pond were constructed, electrical poles and lines were relocated. The utility relocation was handled by the EDL, who is also a sponsor of the project, and the NTPC told the EDL where lines had to be moved. Work was done promptly and the EDL was agreeable completing the work and later sending an invoice for payment to the NTPC. The NTPC was fortunate to have the trust and cooperation of the local utility company because very few utility companies would invest time and equipment to move power lines and poles without a solid contract. The EDL was very supportive and cooperative with the NTPC which allowed a good working relationship.

C. ROW Land Acquisition

A very wide section of property was allocated for the downstream channel because the final design was completed when the major subcontract was awarded. From the
original channel location, the tunneling for the channel was realigned through a limestone caste. The area of the downstream channel was never fully surveyed until the contract award. The original alignment followed the meandering of the existing river. The realignment was a good engineering decision but would not have allowed if the ROW was not sufficient. This realignment was able to save time and money for the project. Unfortunately, not all ROW for this project has reached conclusion. Acquiring the other pieces land needed by the project is a continuing process until all the villagers that would be impacted by the project have been relocated and compensated. The NTPC is aware of its risks especially regarding the social and environmental aspects. The NTPC has a very big exposure because it has to turnover lands to the contractor at predetermined times. When it can not do so, the NTPC can potentially delay the contractor. Associated with this was the risk of stalling river diversion because of non-resettlement of reservoir residents. The NTPC would have to delay the HCC’s activity of filling the reservoir if the resettlement is not complete. The project is situated near a Nationally Protected Area (NPA) and Biodiversity area such that the NTPC’s risks are far greater than for most projects. Relocating a thousand families is the greatest factor for turning over land to the contractor.

D. Geotechnical and Environmental Studies

1. Geotechnical Studies affecting Design

A great deal of geological borings had been conducted over the 10-year development phase for the project. Based on the results of these investigations, some features of the project have already been changed or could be affected. These are detailed below:

- As a result of site investigations, the dam had to be relocated at least 100 meters from the previous location because of poor substructure. The decision was finalized in 2003 after extensive explorations and investigations.
- Borings done by the EDL determined the best locations for transmission line towers.
Due to geological uncertainties, the design for the powerhouse had already been changed to be above ground rather than underground. Also, the contracts included provisions for design changes regarding the vertical conduits between the powerhouse and reservoir and target pricing to shift risks to project sponsor from the contractor in case of geological problems.

The reference design and design criteria were predicated on these investigations. The HCC held responsibility for confirming the results of the investigations but since it had been involved in most of the studies anyway, it felt no need to reconfirm. The HCC assumed the risk regarding existing site conditions and relinquished the ability to go back to the NTPC and ask for compensation for any changed conditions except for those that were explicitly defined in the contract.

2. Geotechnical Studies affecting Environment

To comply with environmental regulations that did not allow significant contamination of the river flow, the contractor was required to implement a system to contain the sediment released into the waterway. A sedimentation basin intended to address excessive soil transportation, but after the NTPC took water samples, it found out that the amount of sedimentation exceeded the maximum allowable. The sedimentation basin was undersized and could not handle the volume and flow of excavated material. Closer inspection revealed that the reason for the problem was that soil was not settling as anticipated. The soil excavated from the tunnels and at the powerhouse contained red iron oxide, termed as “mudstone,” and could not be controlled using the sedimentation basins because of the long settling time needed. The material was clayey in nature and could be used as backfill and foundation material. But once exposed to the open and dried out, it crumbled and became difficult to control. The HCC did not anticipate the characteristics of this soil, its existence in different areas in the project, and especially needing to control its entrance into the waterway. This type of soil was not present in the plateau where sandy loam soil existed. Although borings were performed in the area up to six meters in depth and samples were taken, this only gave a general picture of the soil. Soil characteristics
were not consistent over the entire project. A thorough analysis of the soil’s characteristics was required to determine the best recourse for containment.

3. **Environmental Studies**

   The areas for spoil storage were identified during the project development phase. Locations were identified by construction people based on ease of access. The initial selection did not consider how these areas would impact the villagers, rice paddies, etc. An example was selecting spoil areas every two to four kilometers for constructing the downstream channel which only considered the traveling distance that vehicles have to make between hauling trips. The NTPC reviewed the proposed areas and identified those which could not work due to social reasons, e.g., area where a school is situated. These did not show up in drawings or aerial photographs but could only be known through surveying. The location of spoil areas were then changed to provide the least impact on the villagers and their way of living, e.g., access to rice fields. Land meetings were conducted and issues sorted out before construction commenced. This is a continuing process until all social and environmental issues are addressed.

**E. Critical Resources**

   The critical resource for the NT2 Project was the lack of skilled labor in Lao PDR. This was not unexpected especially in the remote areas of third-world countries. Because of the “Laotian preference” clause in the contract, Laotians formed a greater part of the labor force. Some qualified Lao people were able to operate excavators and drive trucks to haul soil. But there were some basic construction works, e.g., concreting, that the labor force in Lao were not even familiar with. Concreting works on the powerhouse involved a great deal of heavy construction especially with the rebar requirements which were unfamiliar in Lao PDR. According to Harrison, “Preparatory work for concreting is not purely technical but is a matter of skill and skills are developed over a long period of time.” Consequently, most of the Lao workers were inexperienced in the erection of forms, tying of rebar, and placing and vibrating of concrete. The contractors did not anticipate this and ended up increasing
the number of supervisors to train the labor force and bring them up to speed. Construction was already falling behind schedule and the work had to get done. The contractors spent time to train people on the job and this placed a bigger burden on the contractor to have more supervision in the field to compensate for a less skilled labor force. The contractor had to increase its level of supervision to maintain a Lao preference level and had to implement this throughout the job. Because of the lack of skilled labor in Lao PDR, the subcontractors will need to import electricians, instrumentation people, and qualified welders to do the penstock welding in the latter part of the project. Instrumentation, electrical works, and terminations are very specialized for the skill level of the local people in Lao. The higher the skill level needed to perform the work, the more the subcontractors will have to look outside Lao PDR. The electrical and mechanical subcontractors will feel most of the impact of the lack of skilled people because of the specialized work involved in their contracts. Even in the stringing of the transmission lines, the people to be hired should have experience in putting up 500kV transmission lines and this would mean importing quite a number of people from Thailand to have the work done.

F. Preliminary Construction Activities

Pre-construction work that was advanced under a Pre-Construction Agreement (PCA) between the EDF and NTPC was to take advantage of time before financial closure. Rather than waiting for actual financial closure before commencing with construction works, the HCC started with “raw” civil works and proceeded to perform preparatory works for tunneling and powerhouse excavation, work in the dam site, and also UXO clearance works. The contractors did limit the amount of equipment and
manpower mobilized in this phase because of the cost and risks of the resources sitting idle if the project did not reach financial closure.

The PCA included mobilization of manpower and equipment for the tunneling subcontractor, work on the access adit leading to the pressure tunnel, bridging work on the dam site location, UXO clearance, excavation and cutting back of hills, clearance of vegetation and area for the switchyard, build accommodations for the construction staff, and repair works done at the dam site. Pre-construction activities also included setting up of an office facility in the dam site area and in the powerhouse area and excavation of the diversion tunnel, which was needed to block off the river and force the water into the dam site location.

UXO clearance was an important pre-construction activity because it was not only a contractual requirement but more importantly was a safety issue that involved everyone. The whole area of Lao PDR was previously bombed and mined especially between areas of Maxai and Savakhet. The NTPC knew that there were UXO (bombs) but did not anticipate the actual site of the mine field. Actual UXO clearance was undertaken by both the contractor, as clearly defined in its contracts, and the NTPC. UXO clearance was divided according to what areas would be used for construction and which areas were populated with local people. The NTPC had responsibility over areas of relocation and resettlement and also construction sites with local people living close to them. An example was a saddle dam area in Oudomsouk that was adjacent to a local settlement which fell under the responsibility of NTPC because local people were involved in it. Saddle dam clearance for this area was done by NTPC while the rest was of saddle
dam areas where handled by the contractor. The contractor was responsible for areas where construction work would commence. In some areas, both the NTPC and HCC clearing groups checked the site for UXO. Both parties were interested to make sure that the UXO clearance was performed thoroughly.

G. Seasonal Changes

Lao PDR has a dry season and a wet season. During the wet season, only certain work can be accomplished while others will have lower productivity or no productivity at all. These were anticipated and incorporated in the schedule. Anticipated effects of the change in seasons are detailed as follows:

- Road works were greatly affected. After the roads from Thakkek to Yamalat were elevated to keep it from being flooded during the wet season and culverts were installed to allow water to pass from one side of the road to the other without flooding the road, these needed to be maintained during the wet season to keep them passable. Actual progress on roadwork commenced during the return of the dry season.

- For work in the powerhouse, the contractor prepared for activities that would be affected by the wet season. Concreting works needed protection such as large plastic tarps or a roof to keep the water off areas where concrete would be placed. Concrete could be placed in wet season but this would be slower depending on the amount of rain. The schedule captured the productivity drop during the wet season and the contractors had to plan accordingly.

- At the dam site, the NTPC already projected that work could only be performed during the dry season. During the wet season, even though the cofferdams were already in place, they were expected to be overtopped. Foundation work on the dam could only be performed during the dry season.

- Tunneling works would not be affected during the wet season.

- All excavation works for the downstream channel, regulating dam, and regulating pond and all activities exposed to the elements were anticipated to have lower productivity.
Seasonal change referred greatly to the amount of rainfall experienced by the project. The NTPC was at risk for any rainfall that exceeded a 1/100 year rainfall event and if this caused damage to the project in any way, e.g., the contractor suffered loss from a force majeure event, the NTPC had to provide relief to the contractor.

H. Impacts on the Project

By doing preparatory work for the project, the NTPC and the contractors could better anticipate activities required further planning. After having identified that the NTPC has risks regarding rainfall events, handover of land to the contractor, and possible non-performance of the project due to geologic uncertainties; it created a contingency fund to deal with the unknowns in the project. The NTPC assumed risks even if the Head Construction Contract was fixed price. Even if the NTPC carries insurance, some exclusions exist especially force majeure.

The preparatory works were very beneficial to the community especially the UXO clearance which helped protect the people’s welfare. With the performance of the pre-construction activities, the sponsors made the lenders aware that they were very committed to the project. Also, it was advantageous for the contractor to do the advance work for the project and by getting into the PCA, the contractor was able to gain more time to accomplish the rest of the construction work.

V. PROJECT MONITORING SYSTEM

The project control section details measures put in place in the NT2 Project to support the project delivery method and influence the outcome. Some key topics discussed in this section are subcontractor selection process, oversight provided by 3rd party checking parties, design control processes in place, and construction monitoring measures for schedule, costs, and quality. Discussion of perceived impacts monitoring measures concludes the section.
A. Contractor Selection Process

As mentioned in the earlier sections, the Head Construction Contract was split into three civil work packages and two electrical and mechanical work packages. These major subcontractors were ITD and Nishimatsu for the civil work and GE and Mitsubishi for the electrical and mechanical work. The work in these subcontracts was further subcontracted to smaller scopes of work. In the selection process for these smaller subcontractors, the HCC and the NTPC underwent the same exercise in pre-qualifying subcontractors but since the NTPC had approval rights for major items or equipment supplied to the project, it could evaluate and check the qualifications of the potential subcontractor or supplier on its own. The NTPC looked into the experience, qualifications, and past performance records of the company. If convinced, approval was sought from the lenders and the contract was awarded. But on the other hand, if the NTPC was not convinced, then the subcontractor had to present more documentation, specifically contact information of past clients who had made use of their service or materials. The NTPC went through the whole process of verifying authenticity of information and checking the company’s credentials. The NTPC’s main purpose was to reach a level of comfort that the subcontractor could actually perform the work and prove that it had a history of providing the offered service or materials. An example was the case when GE wanted to subcontract some of its work such as a large casting for a spherical valve. It submitted the potential supplier's criteria to the HCC then to the NTPC for approval of the subcontractor. The NTPC then conducted its due diligence and looked for the experience level of the proposed supplier and samples of past projects where it had supplied the same services or materials being proposed and evaluated the qualifications of the subcontractor. The NTPC’s evaluation process was a double check since it knew that the GE was not interested in selecting a firm which was not able to perform the job. At the end of the day, the GE is ultimately responsible for delivering the work.

The selection process was designed to cull out subcontractors who were unfit to perform the task. There was an instance in the NT2 Project that a contract was very close to awarding to a subcontractor whose intention was to subcontract the work into
yet smaller scopes and retain a percentage of the contract price while passing on the responsibility of actually providing the work to others. According to Harrison, this was a common practice in Asia. The major issue with this practice was that the NTPC would end up with a subcontractor with inadequate resources or capability of finishing the work. A rigorous selection process should discourage unscrupulous subcontractors.

B. 3rd Party Involvement

The NTPC was committed to following the WB and ADB guidelines regarding social and environmental concerns. The POE and DSRP represented the mentioned banks and formally reported to the GOL in providing oversight to the NT2 Project. These groups were already familiar with the key components in the project because of their involvement and knowledge of the Owner’s Requirements and reference design. Even before the HCC was given the responsibility for the final design, the POE’s and the DSRP’s primary concerns were identified in the Owner’s Requirements and reference design. The NTPC acknowledged the importance of the oversight and made sure to meet its commitments. As detailed in the concession agreement, these groups were authorized to make recommendations that the NTPC were required to follow unless objections were made. In the event that a comment necessitated a major variation in the project and incurred costs, a contingency fund already existed to address these costs.

1. Role of the Panel of Experts

The POE was involved in the project during contract formation. It was the social and environmental advisor that the World Bank required for this project. Its main concern then was whether the social and environmental goals set for this project were achievable. The group’s focus was on the project’s impact on the social and environmental aspects especially the relocation of villagers and sustainability of programs. The POE was involved in the construction phase of the project since 2003 and provided the oversight for the banks, lenders, and other different organizations. Currently, the POE’s purpose when visiting the project is to look into all resettlement areas, check the status of the resettlement, see how people are being relocated and if
they are suitably compensated and inquired about the sustainability of programs for the villagers. For example, relocating to new pieces of land with irrigation would also require that people could provide for themselves in the future and maintain their status of living. The POE makes recommendations during the process and the NTPC considers them as necessary items to be implemented. An example was the case of a constructed road that the POE deemed too wide and was considered excessive for its purpose. Although the road was built according to approved design documents, the NTPC had to rectify the road according to the POE’s recommendations.

2. Role of the Dam Safety Review Panel

In the Dam Safety Review Panel is a group of three technical experts. Two members are involved in the hydrology and downstream channel while the third member is focused on the electrical and mechanical part of the project, such as installations within the powerhouse, and also focuses on the safe and long term operations of the facility situated on the dam site. The DSRP checked on the technical soundness of the project, especially the dam. Although it had the right to recommend the use of a different component in the project, it also had to provide reasonable responses to the contractor’s requests if the item under consideration was not crucial. An example was using a ball valve instead of a butterfly valve which had cost implications. Although the DSRP recommended the use of a ball valve, the NTPC’s suggestion that the butterfly valve would work as well was accepted and agreed upon by the DSRP (Harrison).

C. Design Control

1. Design Revision Process

Variation orders whether having cost or schedule impacts or no impacts were documented to provide the records of design changes in the project. In the NT2 Project, the design changes that incurred negative or positive costs and affected the schedule were carefully reviewed. Although the Head Construction Contract was design-build, any deviation from the reference design had to undergo a variation order
process. The review and approval process for a variation order started with the HCC submitting a request for variation order. The NTPC Director of Construction then made a recommendation to the NTPC CEO whether to reject or approve the variation order. Final approval was required from the lenders especially for variation orders with cost implications. In certain instances, the cost implications were not to add costs but to subtract costs. Contractually, these types of variation orders termed as “negative VO” were not required to be reported to the lenders, but nonetheless, the NTPC still informed them of the variation order out of courtesy.

In fact, the NT2 Project had a case of a ‘negative VO.’ This meant that the contractor’s proposed change accrued some time and cost savings and the NTPC negotiated with the contractor to have part of the savings as well. The variation order was due to an alignment change to a portion of the downstream channel at the contractor's request. There was no technical issue involved in the change and would delete a great deal of unnecessary civil work for the project. The contractor was able to find a better route for the downstream channel. The original route had been the basis of the costs for the contract but the new alignment created a cost savings of USD 300,000.

2. Design Review Process

The NTPC’s influence on the design was through the design criteria and OR, which were basis of the engineering work performed by the HCC. Also, the OR listed the approval rights of the NTPC with regards to design. The NTPC expected all drawings to be controlled in a register from which it selected drawings to review. It had the right to review every drawing and document produced in this project although out of the 10,000 drawings only those which the NTPC considered critical were checked. The NTPC was not well-staffed to review the engineering designs but a 3rd party Owner's Engineer assisted in the review. Electronic files were sent to the Owner’s Engineer for review in their offices while the NTPC formally reviewed 35 percent of the documents for the key items in the project. Furthermore, the GOL’s engineer, Scott Wilson of UK, reviewed the drawings but also focused only on the critical drawings.
D. Construction Control

1. Owner Representative

The NTPC had representatives on site to oversee and supervise the physical work. The NTPC engineers on site were required to ensure that work was performed in compliance to the drawings. When on site, the NTPC engineer worked for the HCC but had defined reporting duties to the NTPC. Although the contractors were not bound to follow comments from the NTPC engineer, they usually acknowledged the comments and allowed the NTPC to provide oversight. When the NTPC engineer found faults in the practice or workmanship of the contractor, they approached the contractor's supervisor to point out the issue. If the contractor did not heed the advice, the NTPC engineer had to report to the NTPC Construction Manager. Any comment that the NTPC engineer made on site was expected to at least be looked into by the contractor. If a contractor’s supervisor disregarded comments or notices, the NTPC could demand that the supervisor be removed from site. If the NTPC engineers had informed the contractor and the contractor made no action, then the issue was deficient quality systems. The NTPC engineers were meant to be an added pair of eyes in the project to point out potential quality issues. Besides the NTPC engineers on site, the Owner's Engineer was required to oversee and witness manufacturing-related testing, equipment testing, and all testing related to the facilities.

2. Schedule

The NTPC placed a great deal of emphasis on the schedule because according to Harrison, “A well planned schedule is the only real tool to managing a project. The schedule won't lie to you if properly assembled. It is the only tool the contractor has to complete the project on time because if he doesn't know where he, is then he can't correct the problem.” A schedule covered all the planning issues inclusive of manufacturing, engineering or design, resource shipments, construction activities, commissioning, and startups. Also, the schedule reflected the full integration of all the subcontractors’ works.
In addition to the schedule, the NT2 Project had method statements created for specific features of equipment or structure in the project. A method statement was a necessary supplement to the schedule and the NTPC emphasized the importance of the method statement. Method statements detailed how the contractor planned to build the work and were necessary for the construction phase. These statements were the needed detail in construction activities that could not be shown in the schedule. An example of how a method statement was applied was for the building of houses in the Nam Theun Residence.

Fig. D-4 Nam Theun Residence, Nam Theun 2 Hydroelectric Project Newsletter-October 2005 (http://www.namtheun2.com/NT2_Newsletter_October_2005.pdf).

Because pre-case panels were used, project contractors needed to indicate how the panels were constructed and put together to build the walls of the houses. The true value of method statements are in their ability to capture all the activities that the schedule can not possibly show even at the detailed levels.

With power projects, the objective is to be ahead of schedule in civil works, which usually is achievable and within the contractor's ability. The reasoning for this is that once electrical and mechanical work begins, getting free float is unlikely and maintaining the schedule is difficult. In the testing and commissioning phase, startups usually get delayed and so, the free float should really be developed in the civil work phase. This requires a very detailed planning program. This allows determining accurate quantities for certain activities such as excavation and identifying methods such as blasting. Taking the time to analyze drilling data or bore logs and see the type of material present will help select the method to use and predict the time it takes to finish the activity. The NT2 Project’s current schedule has a thousand milestones and
has been developed according to knowledge available. Harrison’s philosophy with schedules is "keep working on it until we get it right."

Even if the NTPC’s criterion for monitoring the contractor’s progress was based on its schedule, when the HCC missed a milestone associated with the critical path, the NTPC did not immediately penalize the HCC. Although between the HCC and subcontractors, the understanding was that if a subcontractor missed a milestone it was penalized. The NTPC thought it unnecessary to include intermediate penalty clauses because of the existing LD clause in the Head Construction Contract. If the HCC did not meet defined completion dates, the LD clause would be enforced to cover the NTPC’s risks. What occurred between start date and completion date depended on the HCC’s ability to catch up if the project got behind schedule. Getting the project back on schedule was the HCC’s responsibility. It could start an acceleration plan but if the plan failed and time was not recovered, then the HCC had to pay LD. The LD clause is NTPC’s strongest requirement for the HCC to deliver the project on time.

As a reminder to the HCC of its obligations, monthly meetings between the NTPC and contractors were held. In the event of a delay, the HCC was obligated to provide acceleration plans as specified in the contract such as an accelerated plan for the activities in the powerhouse area. Some factors which caused initial delays were: (1) the contractor’s underestimation of time needed to excavate very deep areas from the powerhouse foundation proceeding forward to the discharge channel and (2) a flood event that the contractor was not properly prepared for, causing a week or 10-day delay. As a result, the contractor was a couple of months behind schedule on concrete placements. As a resolution, the contractor added night shifts to the work and works at 2-full-shifts-per-day schedule that would continue until delays were recovered. Initially, the increase in productivity was lower than anticipated because of the low skill level of the work force. The contractor started the night shift with only 60 trained people and made slow progress. With almost 200 of the laborers tutored by the supervisors, work had progressed much faster. In civil work, acceleration plans involved bringing in more equipment and more people. On the other hand, in the
electrical and mechanical work, adding more people did not necessarily help in increasing productivity but working longer hours or adding shifts helped.

Planning was the key factor to a well developed schedule. Harrison comments, “[The] problem is some people go out there and say that X amount of time will be needed to excavate Y amount of material per day. Either this is underestimated or (it is) unwilling to deal with the logistics of hauling the material, where to put the material, distances they have to move it, how many vehicles available to move it, and so forth.” He further commented that he was critical of the contractor for losing schedule, although he did not have the knowledge of how deep the contractor planned, but felt very strongly that if the contractor had done a very detailed plan for the activity then the schedule could have been kept.

3. Payment Control

For the NT2 Project, the payments to the contractor are based on well-defined milestones that were achieved. No partial payments are allowed. These milestones were identified during the negotiations and fixed in the milestone schedule. A payment curve, based on the milestone schedule, represented the drawdown amount from the lenders. The lenders are very strict in maintaining this curve throughout the project. There is flexibility with regards to rearranging milestones in the project but not to the point that the payment curve is affected. The reason for that financial restriction to contractor payments is that the lenders have a forecast of the expected cash flow for the project and that would not be changed.

Milestones were not differentiated for critical or non-critical activities. The schedule already considered how critical activities were and milestones were set according to the project’s schedule. The NTPC is allowing the advance accomplishment of milestones. An example was if the contractor missed a milestone set for Month 10 in the project but was able to accomplish a milestone that was set for Month 11. The contractor’s ability to complete a milestone in advance of its intended date and request payment was predicated on the fact that the total amount would not exceed the critical payment curve.
For every milestone that was approved for payment from the NTPC, the NTPC needed evidence in the form of photographs or documentation to validate completion of the activity. The NTPC had to have supporting documentation because the lender's engineer at times needed to verify payments. This created an auditable trail for the lender's engineer to verify that payments were made properly. That way the lender's money was protected. Although not all testing certificates were necessary for payment filing, these documents were collected as proof for completing milestones such as for some testing and commissioning efforts.

An example of a testing or inspection documentation needed for payment processing was for completion of a turbine runner test. This was a very sophisticated test conducted in a model test laboratory and required a great deal of calculations and testing in a two to three day period. From the results of this test, exact dimensions and performance capabilities of the full-size runner was determined. A milestone payment was processed if the final report of the model testing was provided. Release of payments was dependent on the results and acceptability of the model test. For the civil work, the NTPC field engineers checked the status of physical work completed in each area. Each engineer was required to take pictures of completed work on specific dates as indicated on the milestone schedule, e.g., finish concreting in powerhouse on the 31st of March. If the work was completed on the exact date of the milestone, then payment was processed and approved; but if completion was achieved days after the actual milestone date then invoice for the work was rejected for that month and processing would be for the next month. The pictures provided the evidence of what was completed on which specific date as justification for making a payment. The NTPC was very careful about payment processes because the project’s finances were directly linked to the lenders and was managed with utmost discretion.

4. Quality Control

The NTPC has different two different but complementary approaches to quality control for the NT2 Project. Its first approach was to ensure that design details including method statements were finalized and reviewed before actual construction
and the second approach was to check on the actual quality of work on site. These approaches are discussed below:

- The NTPC emphasized on having the designs complete before construction. This included review of the method statements which were part of the engineering and design documents. Even if all the design drawings and calculations showed how the project would perform and show all the components, they do not describe how the contractor planned to build it. The method statement was the “recipe” for putting the pieces together. An example of where a method statement was needed was for the construction of the gravity dam in the project. If the activity were digging a ditch, a thorough design was not expected. But for an activity like concreting work, the full details were reviewed and approved before any work would start on site. If adequate planning were performed, then the engineering applied should be able to support construction. Since the NTPC strongly focused on reviewing design submissions before construction, the NTPC adopted intervention methods. When the contractor failed to submit designs on time, the NTPC’s Director of Construction could escalate the issue to the HCC senior management, ask why they were not complying with the terms of the contract, and let the HCC senior management proceed with in-house intervention. The NTPC’s Director of Construction could also issue suspension of work although he considered this a radical decision. This was within the NTPC’s rights as stated in the contract, until compliance was achieved for all submissions. The NTPC’s Director of Construction evaluated the impact of stopping the work before actually making such a decision. In the event that the contractor did go ahead with work without design review, the action was considered as the contractor’s failure to perform work that the NTPC could document. Rework was also the contractor's liability if the NTPC rejected the design and did not accept the completed work. The contractor had to rework on its own time and money. During an instance of work progressing before design approval, the NTPC did not stop the work but "strong letters" were exchanged and the issue was discussed in monthly meetings with the HCC. It was about an excavation work in the powerhouse that was
performed very close to the foundations. The contractor was able to accelerate the engineering or design and finished on time but the NTPC decided to “keep an eye” on the contractor’s ability to make prompt submissions.

○ The issuance of quality plan was a set milestone. The plan is used as a basis for checking the quality of works delivered on site. The NTPC provides the quality checking through visual inspection of actual works which necessitates having and adding more engineers on site. The contractor is expected to do self-certification and has a quality manager to oversee quality. There are no third party inspectors but the NTPC Owner's engineer can provide comments and advice to the NTPC when the Owner’s engineer visits the site. Also the lenders' engineers come out to the site and closely inspect the contractors’ work. Specifically, testing and inspections are witnessed while commissioning is checked off by both the contractor and the NTPC. An example of witnessing a testing was concrete testing on the 7-day, 14-day, and 28-day concrete samples. As mentioned, the NT2 Project has a lot of oversight coming from different 3rd party checking bodies, the NTPC’s, GOL’s, and lender’s engineers, and all the NGOs. Everyone is allowed to make comments regarding the project and the project has been open to them.

E. Impacts on the Project

With the various measures put in place for the NT2 Project, schedule, costs, and quality are being very closely monitored. The NTPC had provided clauses in the contract with the HCC to ensure timely intervention and mitigation when the contractor fails to perform. The NTPC can terminate a contract when the contractor is not fulfilling the contractual obligations. There was a case when a local contractor working under ITD didn’t have the sufficient equipment and personnel to handle the contracted work. The contract was for a 55-kilometer roadwork that was awarded to a Laotian contractor in compliance to the ‘Lao preference’ clause, unfortunately the contractor could not perform the necessary work and so its contract was terminated. Its non-performance was going to impact the schedule. As a result, a new subcontractor was employed and immediately brought in to catch up on work that was getting delayed. This event indicates a potential shortcoming with the existing contractor
selection process. Although a subcontractor’s technical people were listed and evaluated in the proposal evaluation process, the list only included the project managers and site managers but not the actual supervisors. These supervisors are critical to actual implementation of work on site and if they are incapable of managing the work, this manifested in the physical work on site. Another part potentially missing from the evaluation process is a list of projects where the contractors defaulted or where contracts were terminated. This indicates a contractor’s performance and provides basis for assessing the capability of the contractor to finish or default on the contract.

VI. CONSTRUCTION MEANS AND METHODS

The construction techniques section will describe the reasons why particular construction methods were chosen and what construction methods are being used in the project and how these are impacting the outcome of the NT2 Project.

A. Selection Process

The decision as to what particular method to use for the activities in the project is dependent on resource availability, soil properties, climatic conditions, contract clauses, and environmental and social considerations. These will be discussed in further detail below:

○ Availability of Resources

In the United States, large excavation work is completed with big equipment such as a Caterpillar T9 D7G bulldozers, but in this project, smaller equipment such as excavators with 1.5 cubic meter buckets were being used. There was no logistic issue with importing any resources into Lao PDR because of the government’s cooperation regarding importation. So with regards to equipment, what was lacking in size was compensated by the number of machines to meet target dates.

○ Soil Conditions
Some areas in the project were made up of rocky material while others were made up of sandy loam. This difference in soil characteristics dictated which method to use in construction activities. The tunneling operations used either blasting methods or TBM machines to excavate the tunnel.

- **Climatic Conditions**

  Since the project goes through several cycles of the wet and dry season, the contractor’s method should be executable in any type of weather. The productivity rates potentially drop during wet season but the work should continue. With concreting works, the wet season necessitated putting up protective covering to keep water out of the concrete and changes to the method only occurred when water would be an impact.

- **Contract Clauses**

  Due to the turnkey contract, the contractor had the flexibility to use its choice of method or equipment in the project. The contract did not limit what the contractor’s preference over numerous types of equipment and methods as long as the contractor continued to make progress and the schedule was met.

  Another factor affecting construction activities in this project was the “Lao preference” clause. Smaller electrical and mechanical items, instead of being directly imported similar to the larger items such as turbines, were packaged into smaller quantities so that the Laotian suppliers could place their bids for these contracts. Also, although some materials had to be imported, the “Lao preference” clause accommodated having the local suppliers import the materials instead of the contractor directly importing the material itself.

- **Environmental and Social Considerations**

  The contractor was required to submit Site Specific Environmental Plans. In these plans, the contractor identified mitigating or environmental safeguarding measures. To comply with the environmental regulations imposed in the NT2 Project, the contractor constructed sediment ponds to filter out sediments from water involved in construction related activities before entering the natural water ways. Social considerations were also affecting the way the contractor set up the
schedule for its activities. The contractor timed the commencement of construction activities to avoid impacting the harvesting of wet season crops. As for land turnover to support construction activities, the NTPC and the contractor had to reach a compromise and defer the turnover of lands which would not cause too much impact on the contractor’s progress because villager resettlements had not concluded yet.

B. Types of Construction Methodologies

1. Gravity Dam Construction

The gravity dam to be built in the Nakai River consisted of roller compacted concrete. This type of concrete is drier than the standard structural concrete with lower water content in the design mix. It is compacted as it is placed with large dumptrucks instead of concrete trucks doing the placements. Concrete from the plant is taken directly to the location where placement is needed. The method is very fast and straightforward. As a construction aid to building the RCC dam, the contractor is building a cofferdam upstream of the dam area to send the water to the diversion tunnel. After this first structure, another upstream cofferdam, closer to the dam site, of a higher elevation than the first structure but lower than the actual gravity dam is being built with RCC similar to the actual dam. This structure will be used to test the RCC before the actual dam is built. The intent is to use this second upstream
structure as a trial structure to arrive at the right concrete design mix to use as well as provide experience to the people who will be constructing the actual dam. Another RCC structure downstream of the dam foundation will be built to allow working in the area between this structure and the upstream RCC cofferdam. The main purpose of this downstream is to contain the backwater effect or eliminate the water from coming back after release from the diversion tunnel. This would keep the dam site area dry during discharge periods. These added design features are dependent on the location of the dam in relation to the rivers being isolated, characteristics of the rivers, and how large the diversion tunnel actually is. Since the designed diversion tunnel is not sufficient to handle the complete flow of the river, there is a need to contain backflow using the downstream cofferdam. With the use of these cofferdams, the size of the diversion tunnel was minimized to 200 meters long with a flow capacity of 500 m$^3$/s, 20% the needed size, and saved the contractor construction cost of approximately USD 6,000,000. Building the cofferdams was a cheaper alternative to accommodate work at the dam site area and mitigate impacts of the river flow than enlarging the diversion tunnel.

2. **Tunneling Construction Method**

Two out of the three civil contract packages included tunneling work. The tunneling works were for the diversion tunnel for the Nakai Dam, headrace tunnel, power conduit intake tunnel, and power station manifold tunnels. Some tunnels had very hard structural shelf faces. Excavating these tunnels required boring a series of holes using Tunnel Jumbos in the size and shape of the actual tunnel, placing dynamite in the bored holes, detonating dynamite, and hammering out the cracked rock pieces. When the soil was not as hard or rocky, the contractor brought in Tunnel Boring Machines and

![Fig. D-6 Tunnel Jumbo at Water Intake Inlet, Gallery Construction Progress Page](http://www.namtheun2.com/gallery/Constr_Progress/constr2.htm)
bored pilot holes into the face before continuing along the face until the tunnel was excavated to designed size. To haul excavated materials out, the contractors used dump trucks which were adequate to convey the materials since tunnel excavation only proceeded at a rate of four to six meters per day.

3. **Excavation Work**

   Excavation for the downstream and headrace channel was done in lifts. The sides of the channels were vertical and benched and not sloped due to the rocky formation of the soil. In excavation works, the contractor used excavators, bulldozers, and backhoes while hauling of excavated material used dump trucks. The equipment used in this project is smaller than that usually used in the United States. Harrison commented that in Asia, equipment used are usually smaller and being “worked to death.” An example was using excavators with 1.5 cubic meter buckets rather using really big equipment with at least four cubic meter buckets which could complete the work faster.

**C. Impacts on the Project**

Due to various factors that affect the construction activities, the contractor’s initial plans will be followed but in cases such as the concreting work in the power house, the contractor will have to implement acceleration plans to speed up the progress. Because of a great deal of Laotian involvement in this project, the local skill level will increase through the trainings provided by the different contractors involved in this project.
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