

# Chapter 3

## Modeling of Activities, Cost Gathering & Allocation, and Output Measures Establishing

### 3.1 Introduction

In this chapter, the ABC technique will be applied to find out the cost of each activity of the project management of the construction of 2,000 m<sup>3</sup> spherical tank. The methodology of ABC technique that is used in this study is the methodology of Department of Defense of United State of America. This methodology consists of five steps which are activity model developing, cost gathering, cost allocation, output measures establishing, and cost analyzing. However, in this chapter only the first four steps will be described, and the cost of analyzing will be described in the next chapter.

### 3.2 Modeling of Activities

Modeling the activities is the first important step in the Activity Based Costing. In this study, the Work Breakdown Structure and IDEF0 activity modeling technique were used as tools to develop the activity model. To develop the activity model, the scope of the activity model must be set. Activity model developing will consider the prior work captured in IDEF0 models and their related definitions. The detail of each activity is gathered by the interviewing of the key people associated with this process. Furthermore, the validating of the model, the percentage of time involved in each activity by each participant, output volume of each activity will be checked for analyzing.

#### 3.2.1 Work Breakdown Structure

After the investment plan had been approved by the top executive , the PMO developed the operation plan that describes the possible characteristic of the project. In this project, the PMO designed to use in-house manpower to produce the Term of Reference and perform the construction & commissioning supervision. Among various types of contractor Acquisition methods, the PMO considered to select the extra method Acquisition to acquire the construction contractor because this project needs the

construction contractor that has high experience and efficiency. The activities and its description are shown in Table 3-1, and work breakdown structure of this project is shown in Figure 3-1 below:

**Table 3-1 Activities of the Construction of 2,000 m<sup>3</sup> Spherical Tank Project**

Activities	Description of activities
Produce Basic Design & Scope of Work	<ul style="list-style-type: none"> <li>• Survey the location, gather the existing information at site and other sources. The information that required for basic design is such as plot plan, process flow diagram, engineering flow diagram, engineering standard, engineering data, user's problems and requirements, etc.</li> <li>• Produce the Basic Design and Scope of Work.</li> <li>• Estimate the construction Cost.</li> </ul>
Produce Term of Reference	<ul style="list-style-type: none"> <li>• Prepare the Term of Reference (TOR) which consist of Instruction to Bidders, Form of Bid, Condition of Contract, Project Specification, scope of Work, etc.</li> </ul>
Perform Bidding	<ul style="list-style-type: none"> <li>• Produce the letter that requests the approval from the top executive for using the extra method of construction contractor acquisition.</li> <li>• Submit the tender to bid letters to the construction contractor in the approved vendor list of Project Management Department.</li> <li>• Submit the TOR to the bidders.</li> <li>• Co-ordinate with the bidders to survey the site.</li> <li>• Clarify the questions from the bidders.</li> <li>• Receive and register the bid packages (technical and pricing) from the bidders.</li> </ul>
Perform Bid Evaluation	<ul style="list-style-type: none"> <li>• Evaluate the bid packages that the bidders submit to us base on the description in the instruction to bidders in TOR.</li> <li>• Produce the report to the acquisition committee.</li> </ul>
Perform Bid Negotiation	<ul style="list-style-type: none"> <li>• Negotiate with the bidder in pricing and the deviation in technical terms.</li> </ul>
Award the Contract	<ul style="list-style-type: none"> <li>• Request for approval of contract awarding from the Board of Director of the case company.</li> <li>• Issue the Notice to Award letter to the winning bidder.</li> <li>• Issue the letter that informs the project starting date to the contractor.</li> <li>• Produce the Construction Contract.</li> </ul>
Construction Supervision work	<ul style="list-style-type: none"> <li>• Check and approve engineering designs, data sheet, drawings and specifications.</li> <li>• Supervise the construction work.</li> </ul>
Project Management	<ul style="list-style-type: none"> <li>• Manage project planning and control.</li> <li>• Perform project accounting.</li> <li>• Manage the contract – contract amendment.</li> </ul>

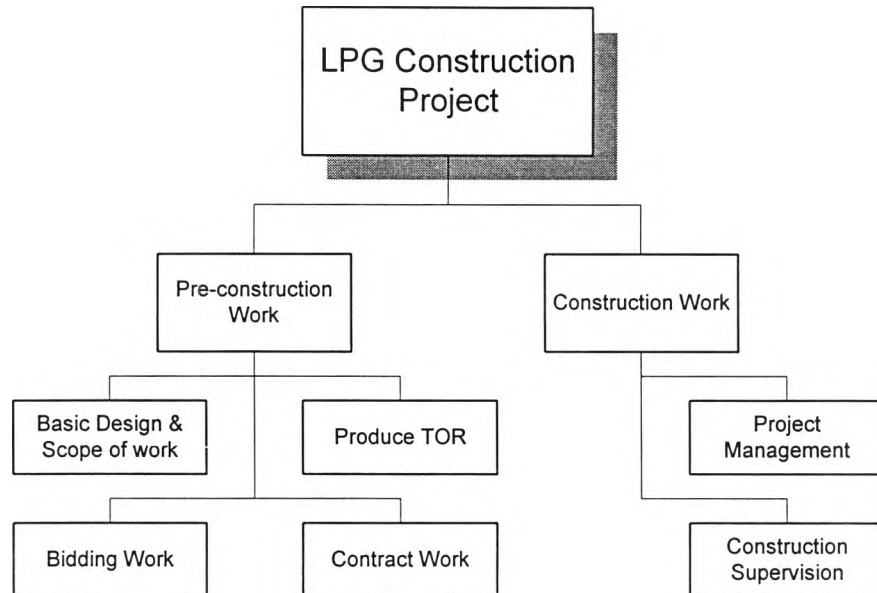


Figure 3-1 Work breakdown structure of the project

### 3.2.2 IDEF0 Activity Modeling

#### Scope of the modeling

In this study, the IDEF0 activity modeling was produced in the concept that the selected process will be decomposed into many activities but not too numerous to be micro-activities. However, it should not be so rough that it cannot be understood. How deep or detail of activities decomposition is complete when one common or homogeneous primary out put per activity is reached. Furthermore, only the primary activities that are performed by the operational elements of the organisation of are interest and are defined in the process. Managerial and support activities that are performed by the managerial and support elements in the organisation are not shown in this model. However, the cost of managerial and support activities will be allocated into operational activities in the step "Cost Allocation".

#### IDEF0 of the Project Management Process

The IDEF0 activity model of the Project Management Process of the Construction of a 2,000 m<sup>3</sup> LPG Spherical Tank Project is shown in Figure 3-2 as follows:

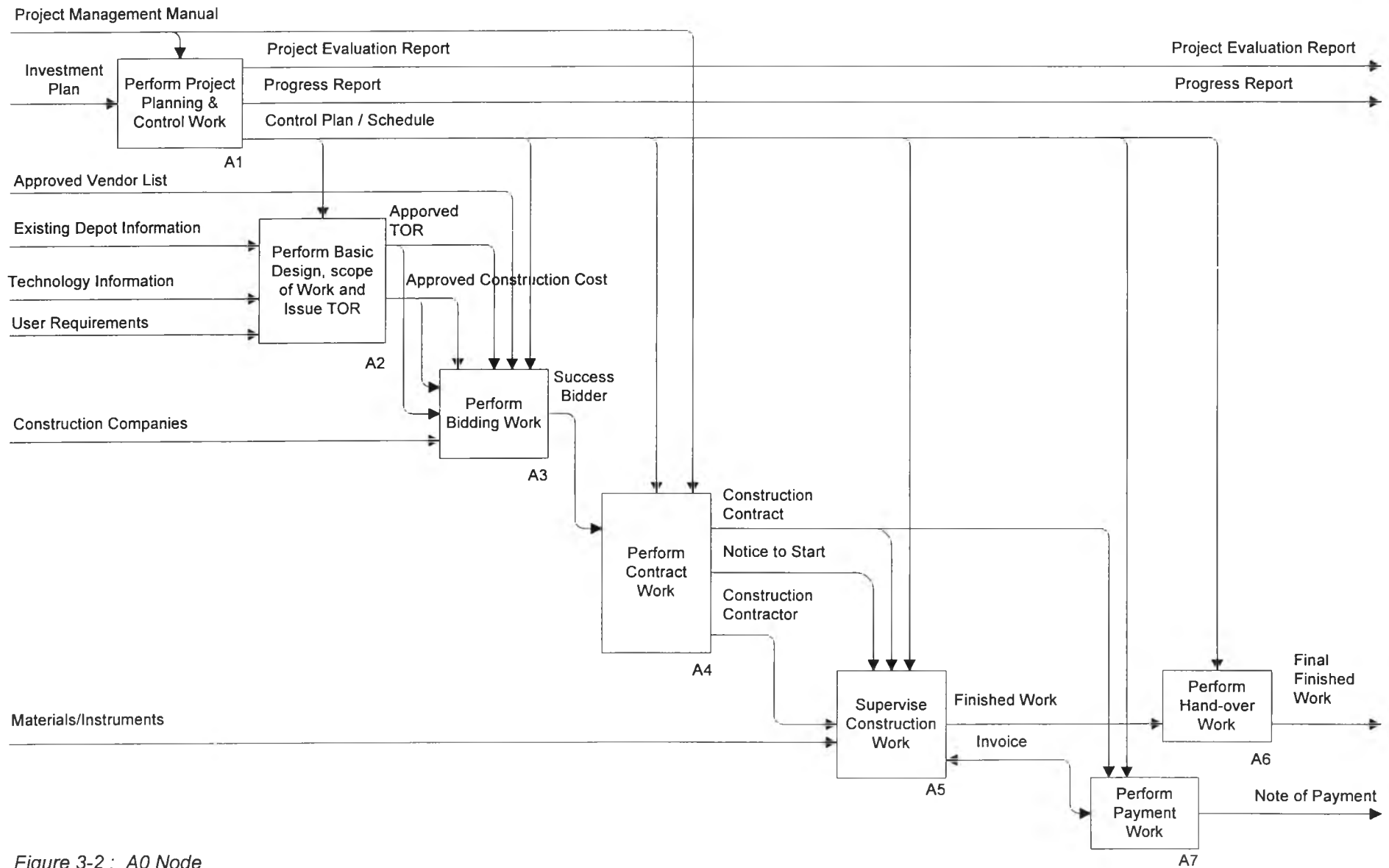


Figure 3-2 : A0 Node

Figure 3-2 shows that the A0 node consists of seven activities as follows:

- A1 Perform Project Planning & Control Work
- A2 Produce Basic Design, Scope of Work, Cost Estimation, and TOR
- A3 Perform Bidding Work
- A4 Perform Contract Work
- A5 Supervise Construction Work
- A6 Perform Hand-over Work
- A7 Perform Payment Work

These activities are described as follows:

### **A1 Perform Project Planning & Control Work**

In Figure 3-3, activity A1 can be decomposed further into three activities as follows:

- A11 Perform Project Planning
- A12 Perform Project Monitoring
- A13 Perform Project Evaluation

These activities are described as follows:

#### **A11 Perform Project Planning**

Project planning and control work consists of preparing of operation plan, control plan, and schedule, project coordinating, etc.

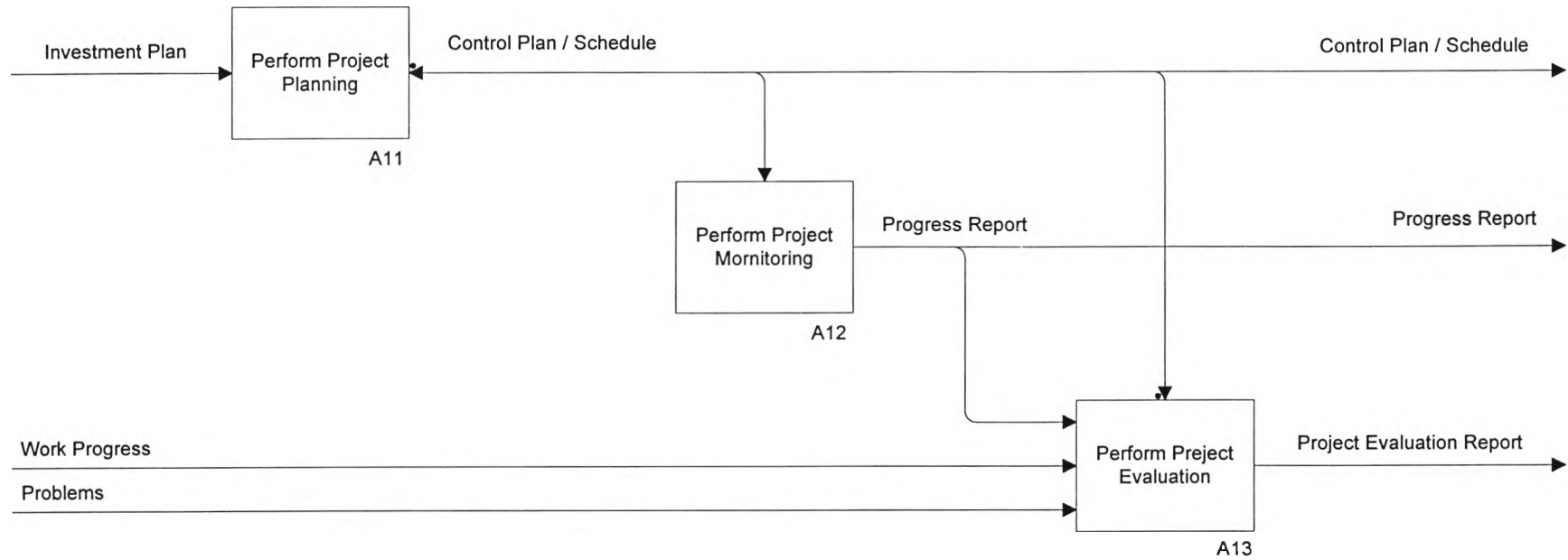


Figure 3-3 A1 - Perform Project Planning & Control Work



### **A12 Perform Project Monitoring**

The Planning and Control Team kept this project under their control by monitoring and reporting the performance of contractor and the progression of the work in periodic basis. If they found some problems that make the project in trouble situation, the more frequent monitoring was assigned. These problems would be analysed for improvement.

### **A13 Perform Project Evaluation**

Project progress, problems, project time, and project cost will be evaluated for improvement.

## **A2 Perform Basic Design, Scope of Work, Cost Estimate Work, and TOR Work**

In Figure 3-4, activity A2 can be decomposed further into five activities as follows:

- A21 Gather the Required Information
- A22 Gather the Updated Technology Information
- A23 Produce Basic Design & Scope of Work
- A24 Estimate Construction Cost
- A25 Produce Term of Reference

These activities are described as follows:

### **A21 Gather the Required Information**

In Figure 3-5, activity A21 can be decomposed further into four activities as follows:

- A211 Gather the User Requirements
- A212 Survey the Location
- A213 Gather the Existing Information
- A314 Check / Updated & Evaluate Information

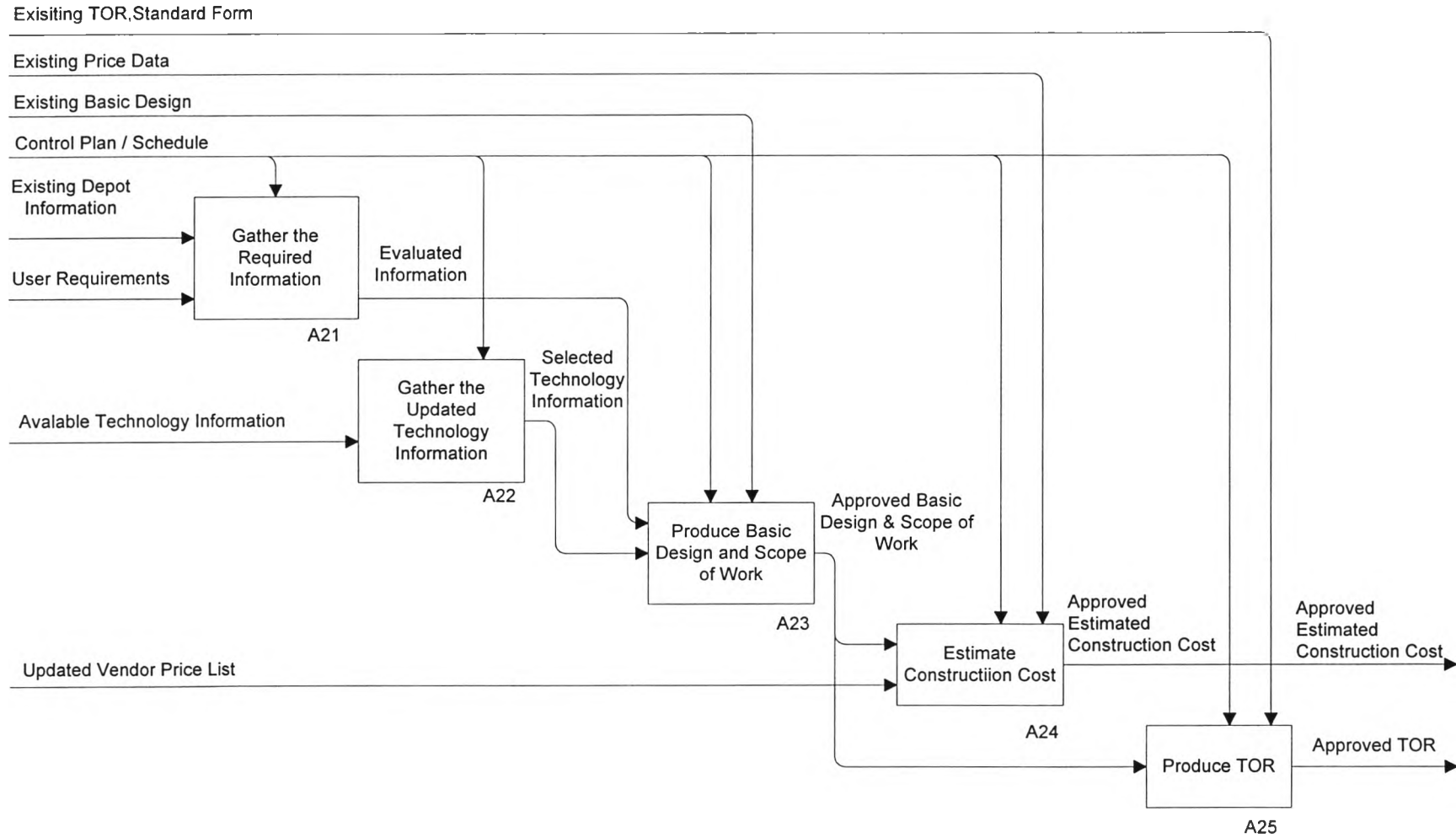


Figure 3-4 : A2 - Produce Basic Design / Scope of Work and TOR



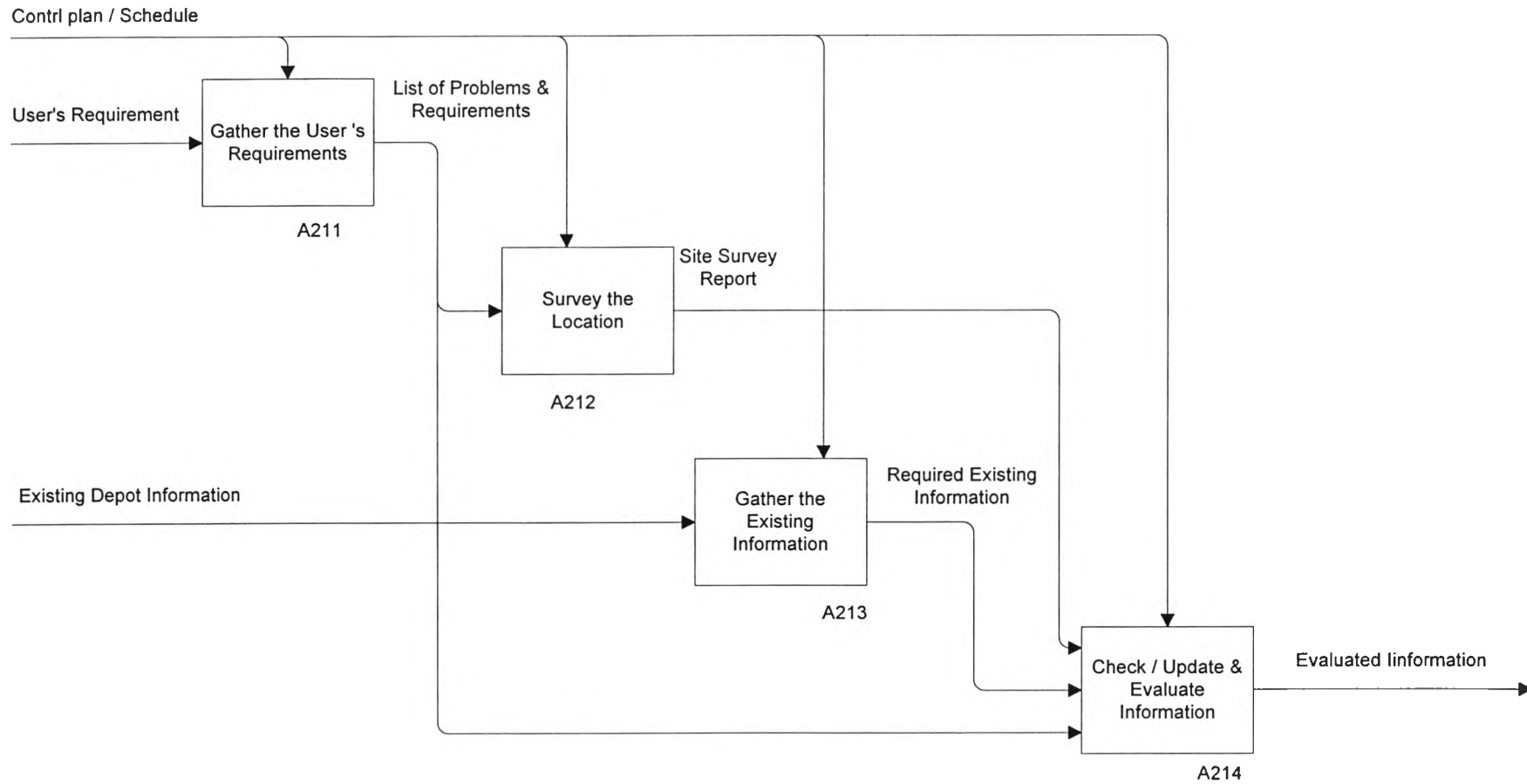


Figure 3-5 : A21- Gather the Required Information

These activities are described as follows:

#### **A211 Gather the User's Requirements**

The project team informed the manager of the depot the objective, scope of work and the budget of the project in the approved investment plan. The manager of the depot and his operators was interviewed for the existing problems and their requirements.

#### **A212 Survey the Location**

The survey team took a note and took photographs of expected tank location, route of process & firewater piping, route of instrument cable, additional control panel position, site office location, contractor's site office location, workshop, store and other utilities supplies, etc.

#### **A213 Gather the Existing Information**

The project team gathered the existing information that required for basic design. This information such as plot plan, process flow diagram, engineering drawing, engineering data, data of depot changing, civil law, etc.

#### **A214 Check/Update and Evaluate Information**

In this Activity, the project team will check the correction of the acquired information. Moreover this information need to be update and evaluate.

#### **A22 Gather the Related Up-to-date Technology Information**

Preparing the basic design and scope of work in next stage, it requires both of existing information and new technology information. So, The data of up-to-date technology information should be prepared. This information such as available of the existing instrument model, new type or new model of instrument or equipment, changing of civil law that involve with LPG container, etc. These information can be gathered from various sources such as vendors, magazines, journals, Internet, etc.

#### **A23 Produce Basic Design and Scope of Work**

All of the information that the project team gathered in the previous stage was developed into basic design and scope of work. They were prepared and corrected by the team with the approval from management level.

### **A24 Estimate Construction Cost**

The basic design and scope of work was developed into estimated construction cost in this stage. This estimated construction cost required the approval from management level to continue to the next stage.

### **A25 Produce Term of Reference**

In this step, the Term of Reference that consists of Instruction to Bidder, Form of Bid, Condition of Contract, Project Specification, scope of Work, and existing drawing was developed for bidding. The finished Term of Reference requires the approval from management level.

### **A3 Perform Bidding Work**

In Figure 3-6, activity A3 can be decomposed further into five activities as follows:

- A31 Request for Extra Method of Acquisition Approval
- A32 Select the Construction Contractor for Bidding
- A33 Perform the Bidder Site Survey & Bid Clarifying Work
- A34 Perform Bid Package Evaluation
- A35 Perform Bid Negotiation

These activities are described as follows:

#### **A31 Request for Extra method of Acquisition Approval**

The note of request for extra method of acquisition approval was prepared for top executive management approval.

#### **A32 Select the Construction Contractor for Bidding**

In Figure 3-7, activity A32 can be decomposed further into three activities as follows:

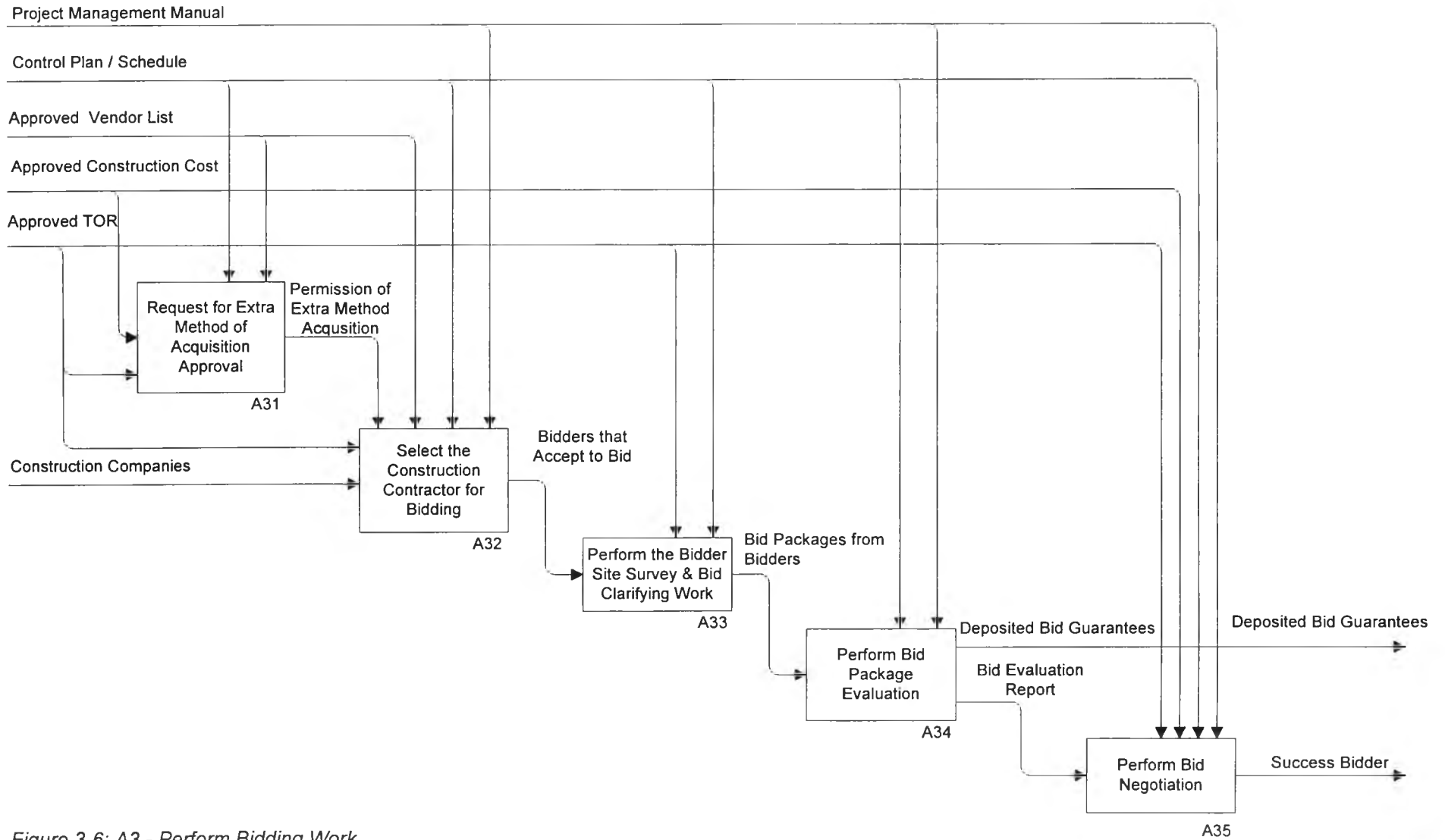


Figure 3-6: A3 - Perform Bidding Work

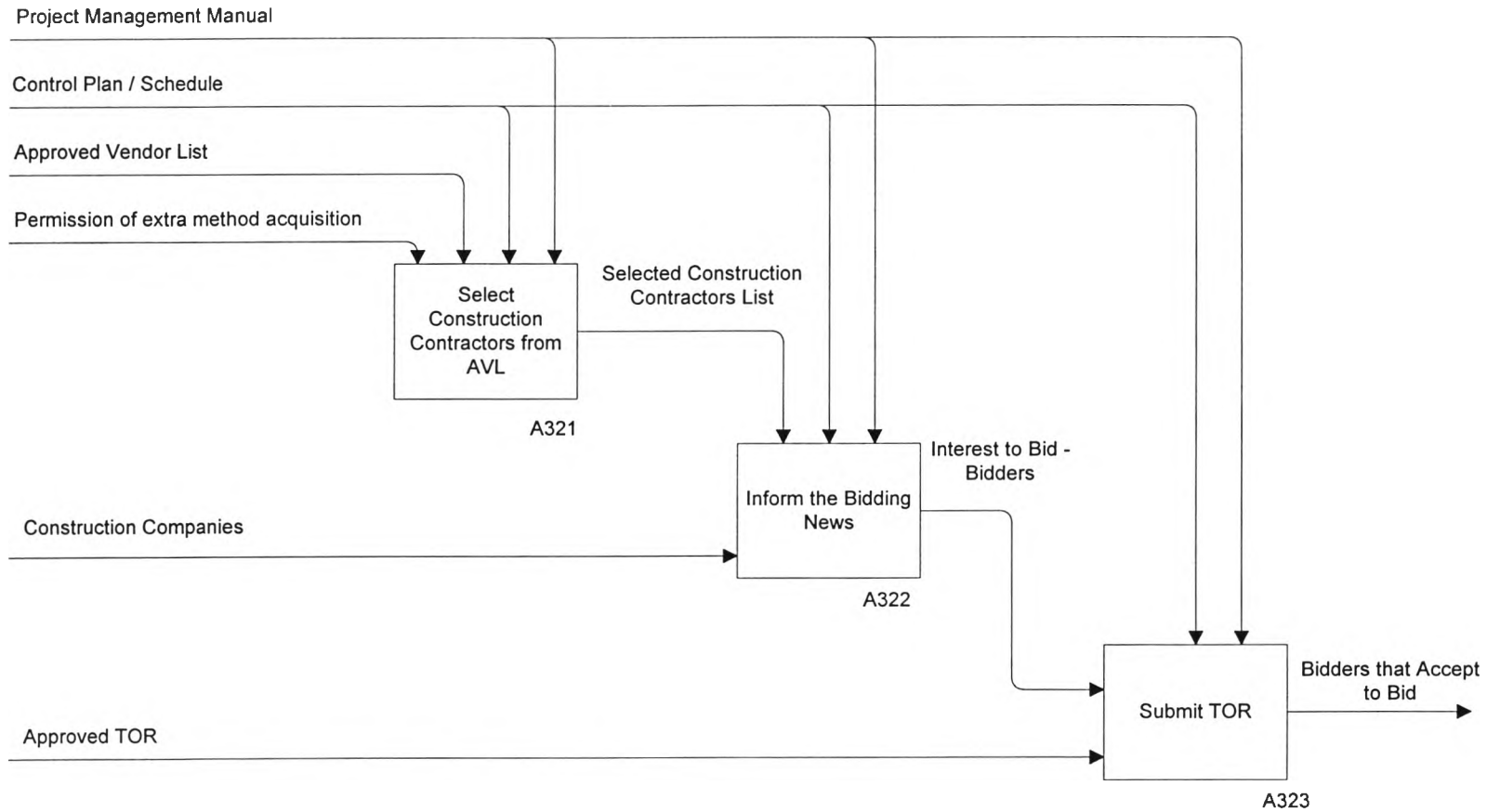


Figure 3-7: A32 - Acquire the Construction Bidder

- A321 Select Construction Contractors from Approved Vendor List
- A322 Inform the Bidding News
- A323 Submit the Term of Reference

These activities are described as follows:

#### **A321 Select the available contractors**

The bidding team selected the available contractors from approval vendor list for bidding.

#### **A322 Inform the bidding news**

The bidding team informed the selected contractors about the bidding of LPG spherical tank construction work.

#### **A323 Submit the Term of Reference**

The bidding team submitted the Term of Reference to the contractors that accept to bid.

#### **A33 Perform the Bidder Site Survey & Bid Clarifying Work**

In Figure 3-8, activity A33 can be decomposed further into three activities as follows:

- A331 Inform the Site Survey Information
- A332 Manage Site Survey
- A333 Clarify the Bid Question

These activities are described as follows:

#### **A331 Inform the Site Survey Information**

The bidding team informed the bidders about the information of site survey such as date, time and scope of site survey.

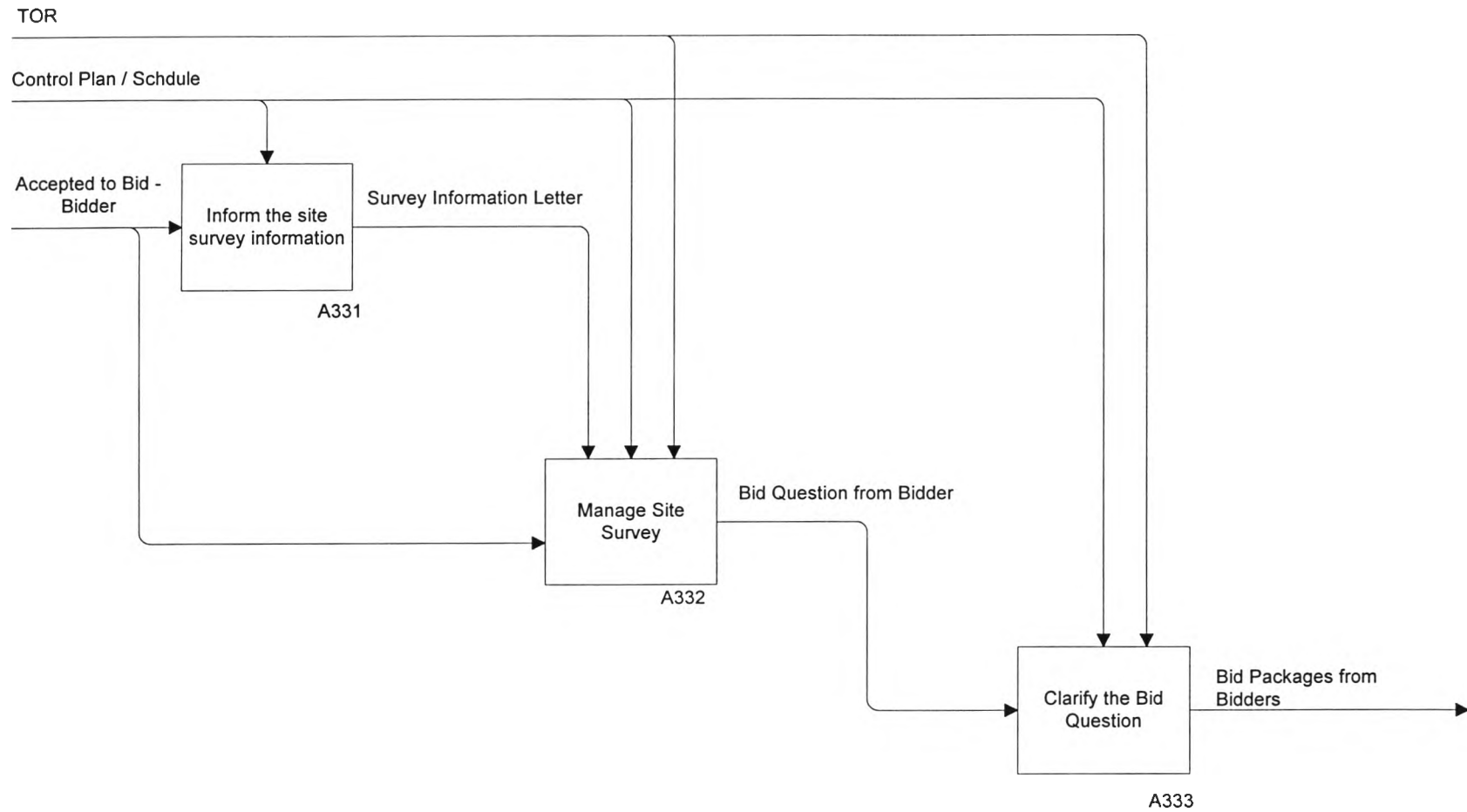


Figure 3-8: A33 - Perform the Bidder Site Survey Work

### **A332 Manage Site Survey**

The bidding team managed site survey and site survey meeting for bidders.

### **A333 Clarify the bid questions**

The question that the bidders ask after the survey was clarified and replied to all bidders.

### **A34 Perform Bid Package Evaluation Work**

In Figure 3-9, activity A34 can be decomposed further into three activities as follows:

- A341 Receive the Bid Packages
- A342 Manage the Bid Guarantees
- A343 Evaluate the Bid Packages

These activities are described as follows:

#### **A341 Receive the Bid Packages**

The bidding team prepared bid package register form and registered the arrival bid package.

#### **A342 Manage the Bid Guarantee**

The bidding team prepared the letters of deposit of bid guarantee and submitted them with bid guarantees to the Assurance Department.

#### **A343 Evaluate the Bid package**

The bidding team evaluated both of technical and commercial packages of bid packages of all bidders, and produced the bid evaluation report for approval from management level.

### **A35 Perform the Bid Negotiation Work**

In Figure 3-10, activity A35 can be decomposed further into three activities as follows:

- A351 Clarify the Bid Evaluation
- A352 Invite the Bidder to Negotiate



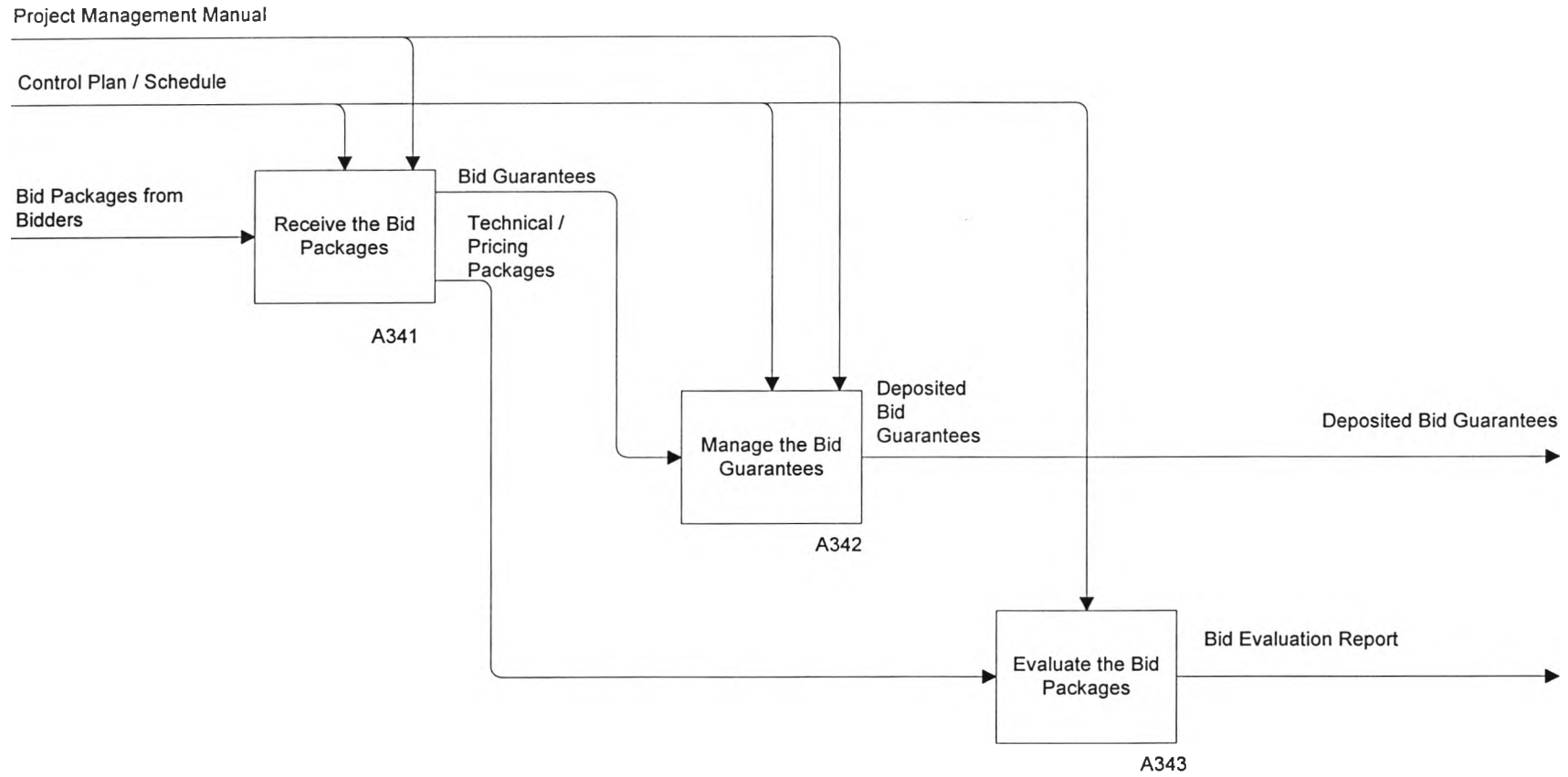


Figure 3-9: A34 - Perform the Bid Package Evaluation Work

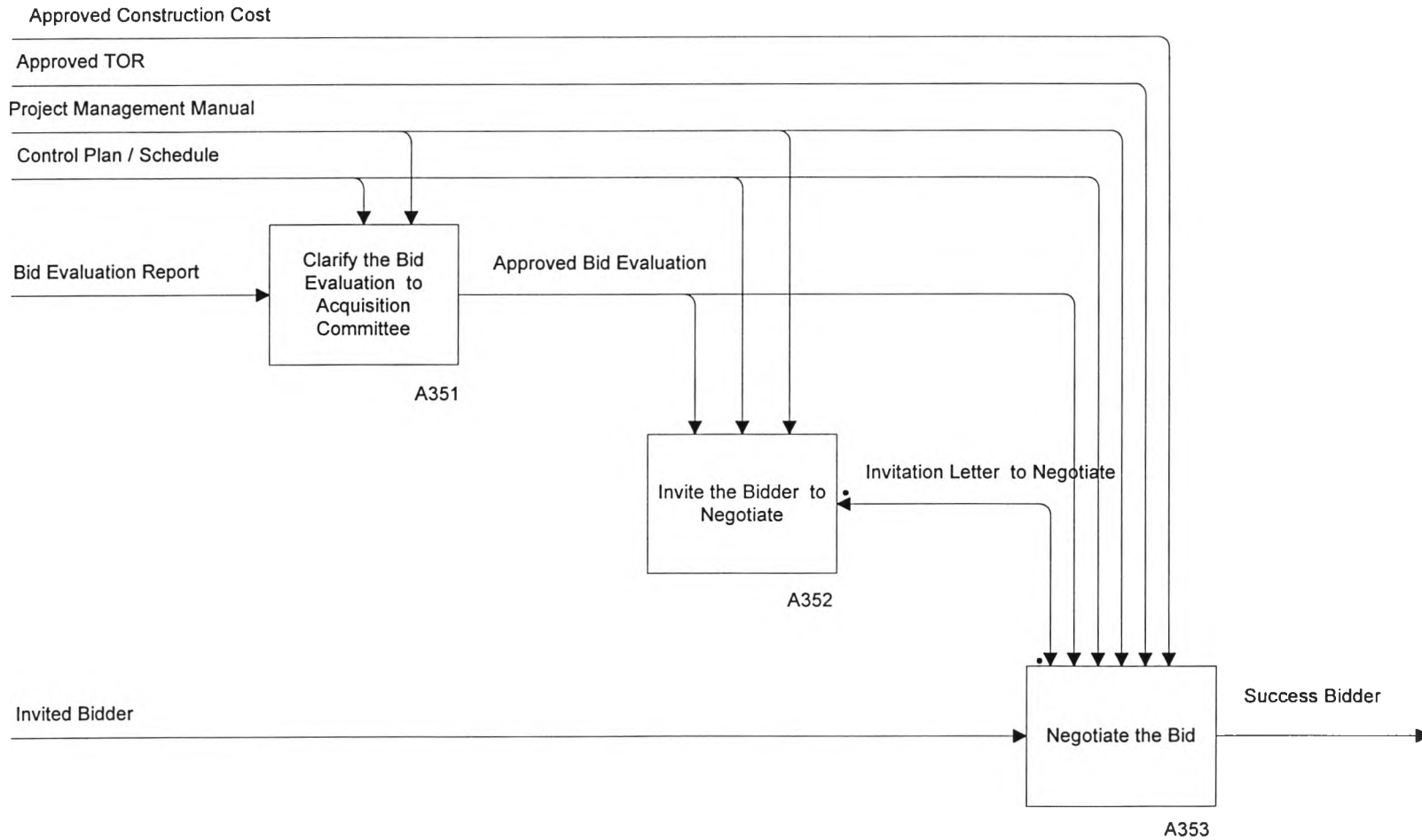


Figure 3-10 : A35 - Perform the Bid Negotiation Work

- A353 Negotiate the Bid

Their description are described as follows:

#### **A351 Clarify the Bid Evaluation**

The bidding team clarified the bid evaluation result to the acquisition committee.

#### **A352 Invite the Bidder to Negotiate**

The bidding team informed the selected bidder about the negotiation meeting

#### **A353 Negotiate the Bid**

The bidding team supported the acquisition committee to negotiate with the selected bidder.

### **A4 Perform Contract Work**

In Figure 3-11, activity A4 can be decomposed further into six activities as follows:

- A41 Request the Permission of Award of Contract
- A42 Issue Notice of Award
- A43 Return the Bid Guarantee
- A44 Manage the Performance Security Bond
- A45 Produce the Construction Contract
- A46 Issue the Notice to Start the Work

The descriptions of these activities are shown as follows:

#### **A41 Request the Permission of Award of Contract**

After the bid negotiation had been finished, the bidding team prepared the note of request for permission of award of contract to the board of director of the case company.

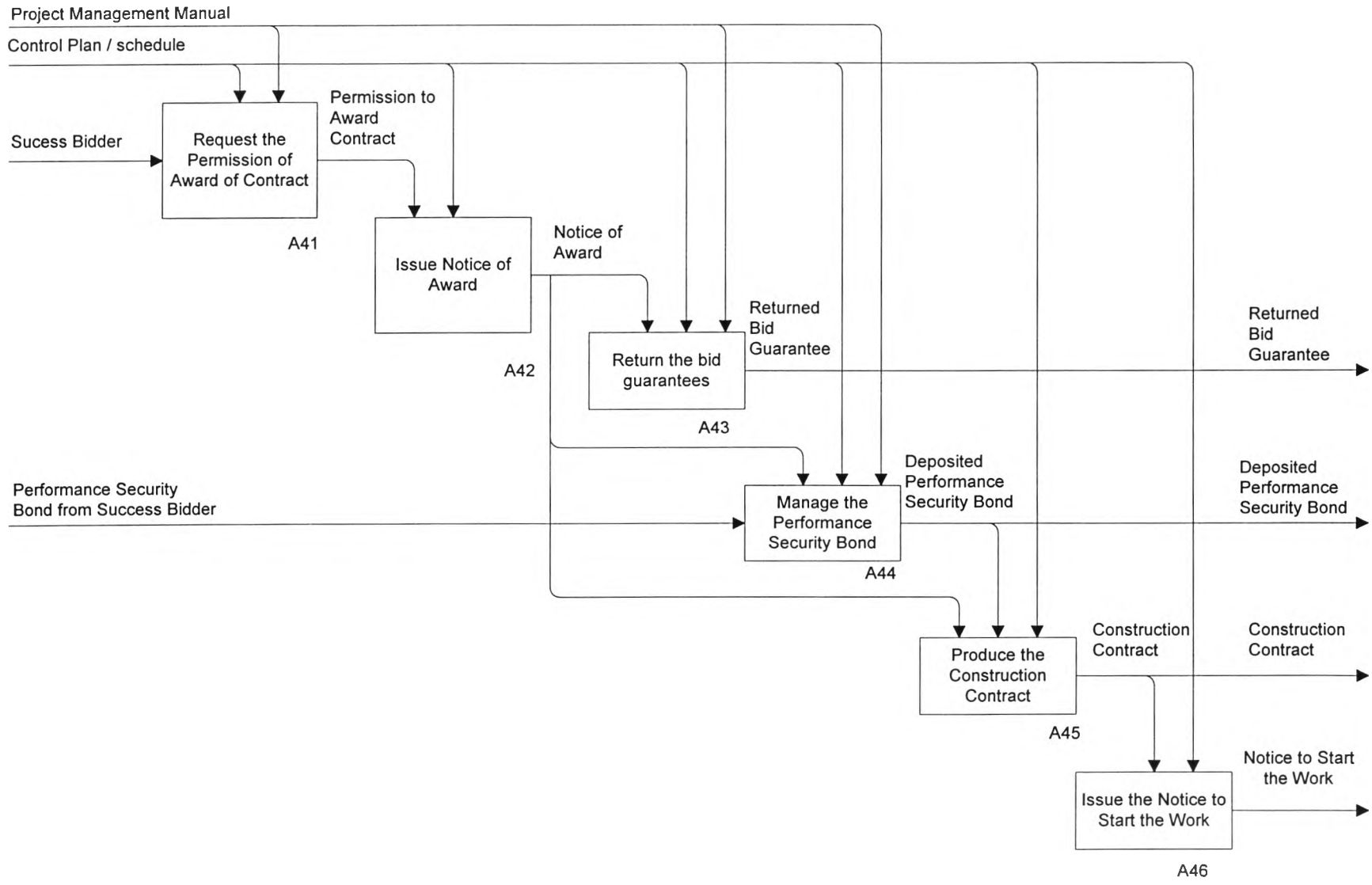


Figure 3- 11 : A4 - Perform Contract Work

**A42 Issue Notice to Award**

With the permission of the board of director, The bidding team issued notice to award the contract to the success bidder.

**A43 Return the bid guarantees**

The bidding team withdrew the entire bidding guarantees from Assurance Department and returned to all bidders.

**A44 Manage the Performance Security Bond**

The bidding team received the performance security bond from the success bidder and sent it to keep at Assurance Department

**A45 Produce the Construction Contract**

The bidding team produced the construction contract for signing.

**A46 Issue the Notice to Start the Work**

The bidding team issued the notice to start the work to inform the contractor to start their work.

**A5 Supervise Construction Work**

In Figure 3-12, activity A5 can be decomposed further into four activities as follows:

- A51 Approve the Documents
- A52 Supervise Warehouse Work
- A53 Supervise Main Construction Work
- A54 Supervise Final Commissioning Work

The descriptions of these activities are shown as follows:

**A51 Approve the Documents**

In Figure 3-13, activity A51 can be decomposed further into three activities as follows:

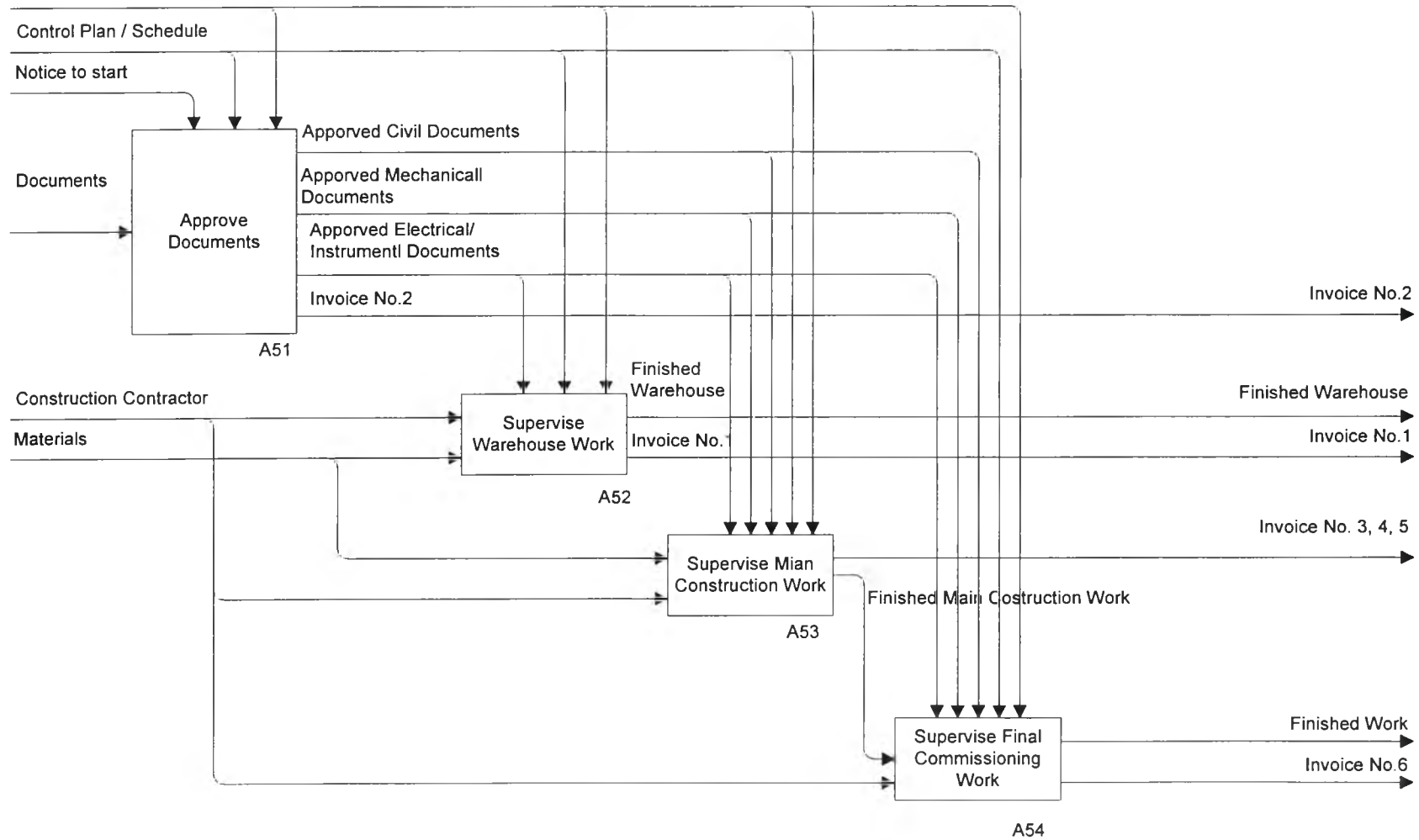


Figure 3-12 : A5 - Supervise the Construction Work

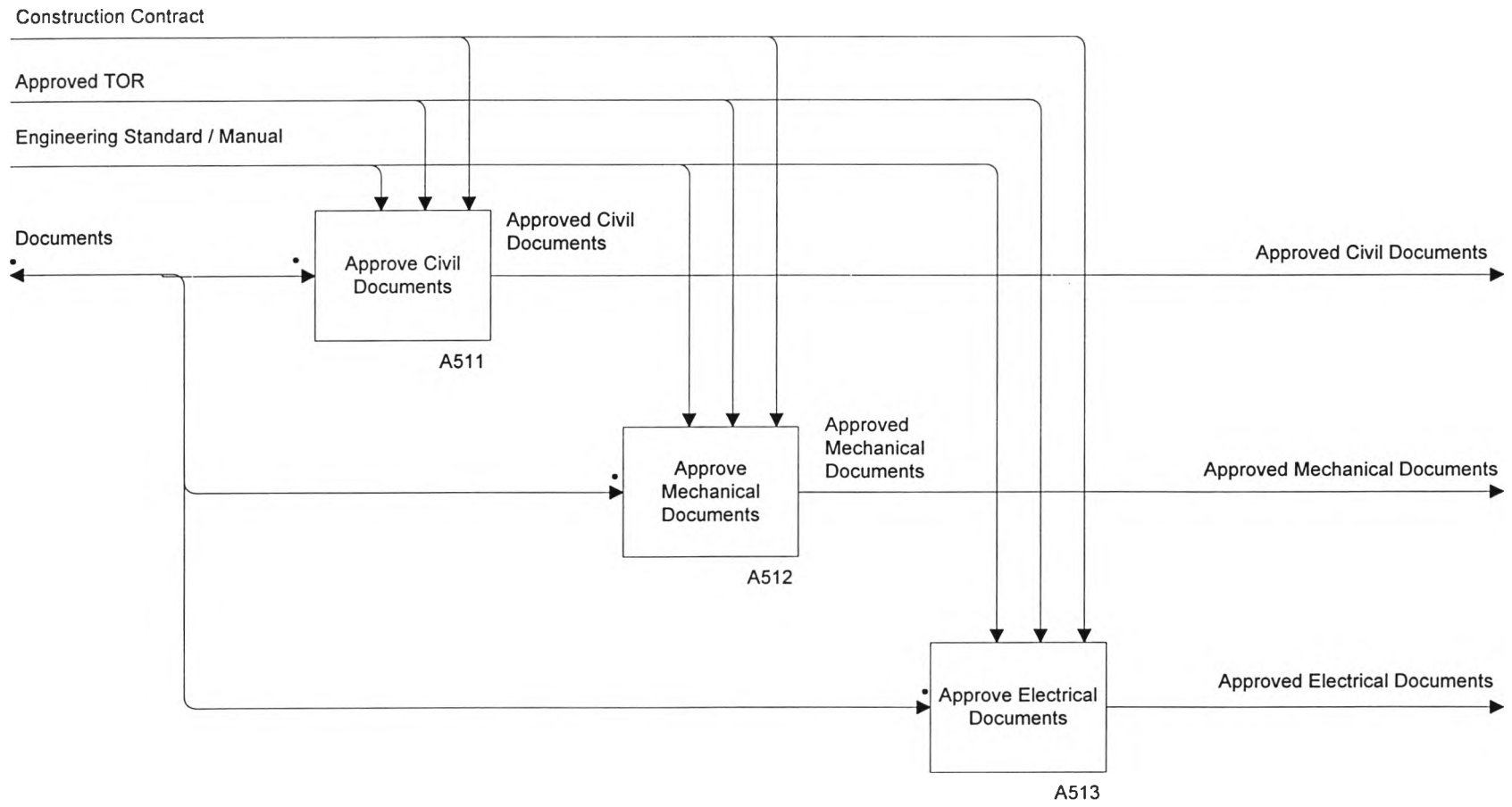


Figure 3-13 A51 - Approve Documents

- A511 Approve Mechanical Documents
  
- A512 Approve Civil Documents
  
- A513 Approve Electrical Documents

These activities are described as follows:

#### **A511 Approve Civil/Architecture Documents**

The engineering team checked and approved all of the civil/architecture documents from the contractor. These documents are such as material specification, civil drawing, shop drawing, etc. The unapproved documents were returned to contractor to correct and produce for approval again until they were approved. The approved as-built documents were sent to the LPG depot for using.

#### **A512 Approve Mechanical Documents**

The engineering team checked and approved all of the mechanical documents from the contractor. These documents are such as material specification, inspection procedure, erection procedure, mechanical drawing, shop drawing, etc. The unapproved documents were returned to contractor to correct and produce for approval again until they were approved. The approved as-built documents were sent to the LPG depot for using.

#### **A513 Approve Electrical/Instrument Documents**

The engineering team checked and approved all of the electrical/instrument documents from the contractor. These documents are such as instrument specification, instrument data, electrical drawing, shop drawing, etc. The unapproved documents were returned to contractor to correct and produce for approval again until they were approved. The approved as-built documents were sent to the LPG depot for using

#### **A52 Supervise Office/ Warehouse Work**

In Figure 3-14, activity A52 can be decomposed further into six activities as follows:



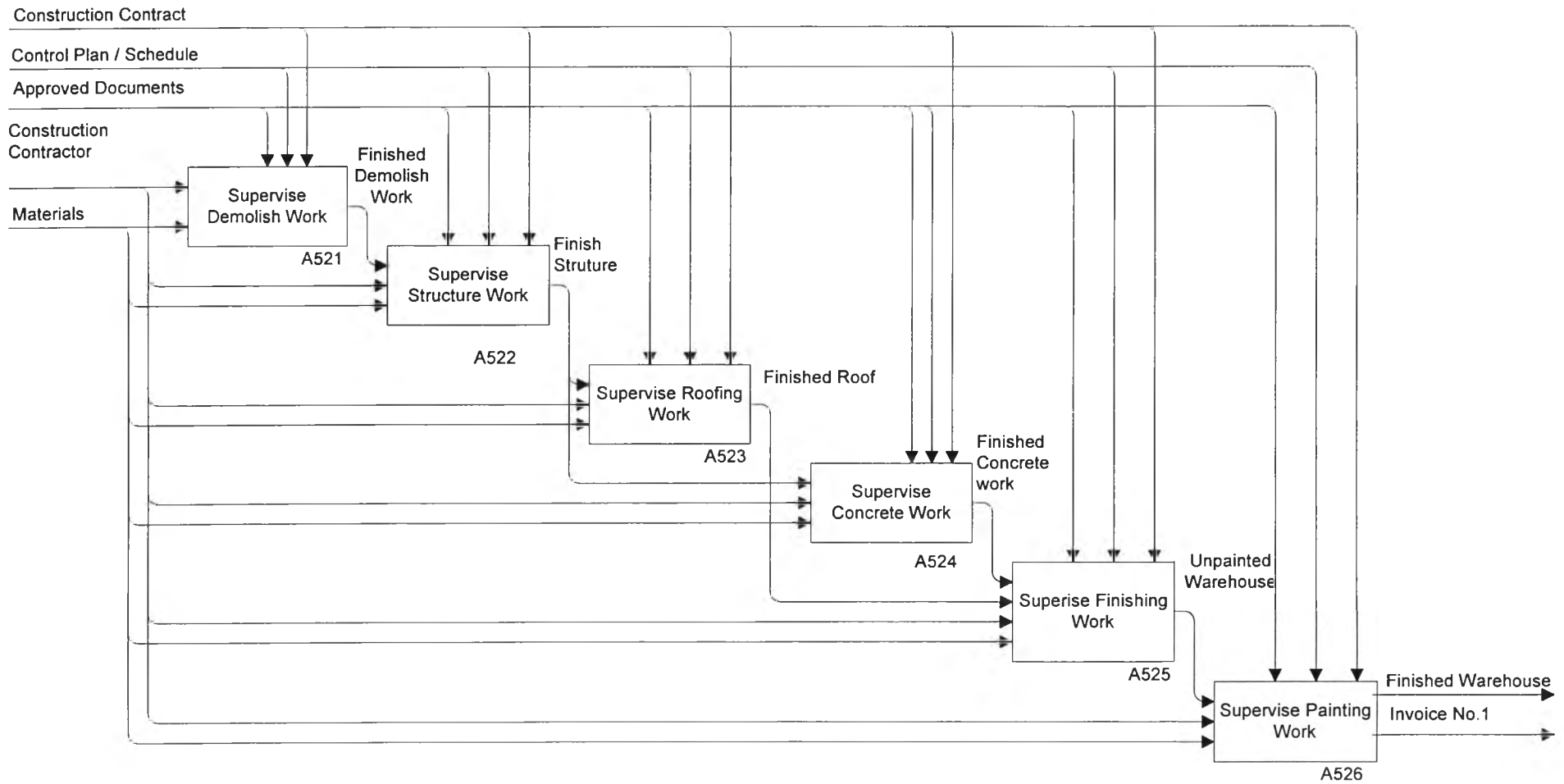


Figure 3-14 : A52 - Supervise Warehouse Work

- A521 Supervise Demolish Work
- A522 Supervise Structure Work
- A523 Supervise Roofing Work
- A524 Supervise Concrete Work
- A525 Supervise Finishing Work
- A526 Supervise Painting Work

These activities are described as follows:

#### **A521 Supervise Demolished Work**

The depot manager required the PMO improve the existing warehouse. So, this warehouse improvement work was in scope of work of this project. The construction team supervised the contractor demolished some part of the existing warehouse to improve the existing office/warehouse that used as the site office and warehouse of the project team and contractor in construction phase.

#### **A522 Supervise Structure Work**

The construction team supervised the contractor built the new structure of the warehouse.

#### **A523 Supervise Roofing Work**

The construction team supervised the contractor built a new roof for the warehouse.

#### **A524 Supervise Concrete Work**

The construction team supervised the contractor built concrete work for the warehouse.

#### **A525 Supervise Finishing Work**

The construction team supervised the contractor performed the warehouse finishing work such as electrical equipment installation, floor finishing, etc.

#### **A526 Supervise Painting Work**

The construction team supervised the contractor painted the warehouse.

### **A53 Supervise Main Construction Work**

In Figure 3-15, activity A53 can be decomposed into further four activities as follows:

- A531 Supervise Tank Work
- A532 Supervise Civil / Architecture Work
- A533 Supervise Mechanical Work
- A534 Supervise Electrical Work

These activities are described as follows:

#### **A531 Supervise Tank Work**

In Figure 3-16, activity A531 can be decomposed further into four activities as follows:

- A5311 Supervise Pre-construction Work
- A5312 Supervise Firewall Installation
- A5313 Supervise Tank Erection Work
- A5314 Supervise Post-erection Work

These activities are described as follows:

#### **A5311 Supervise Pre-erection Work**

In Figure 3-17, activity A5311 can be decomposed further into three activities as follows:

- A53111 Inspect Steel Plates
- A53112 Inspect Tank Materials
- A53113 Supervise Pre-fabrication Work

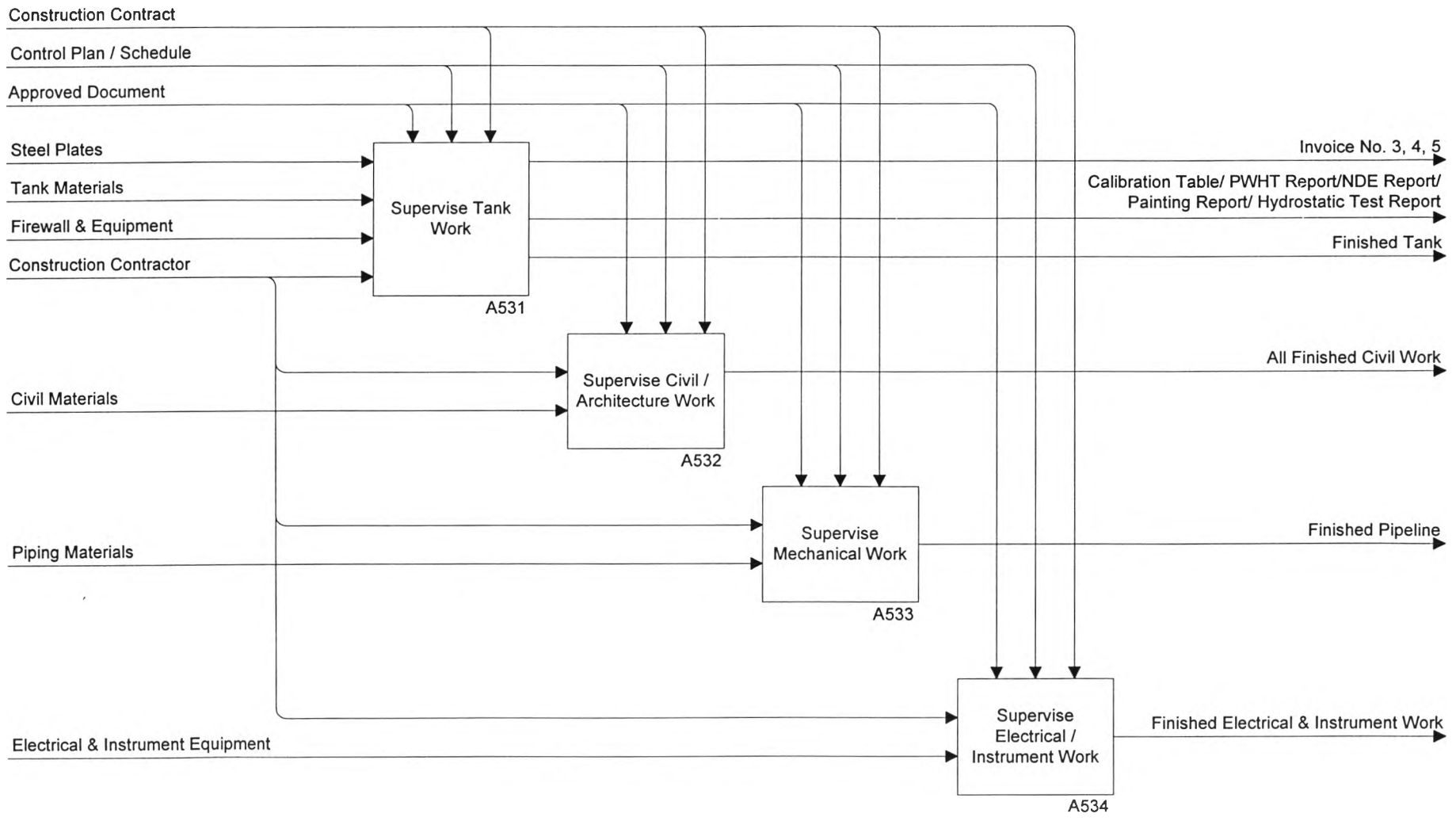


Figure 3-15 : A53 - Supervise Main Construction Work

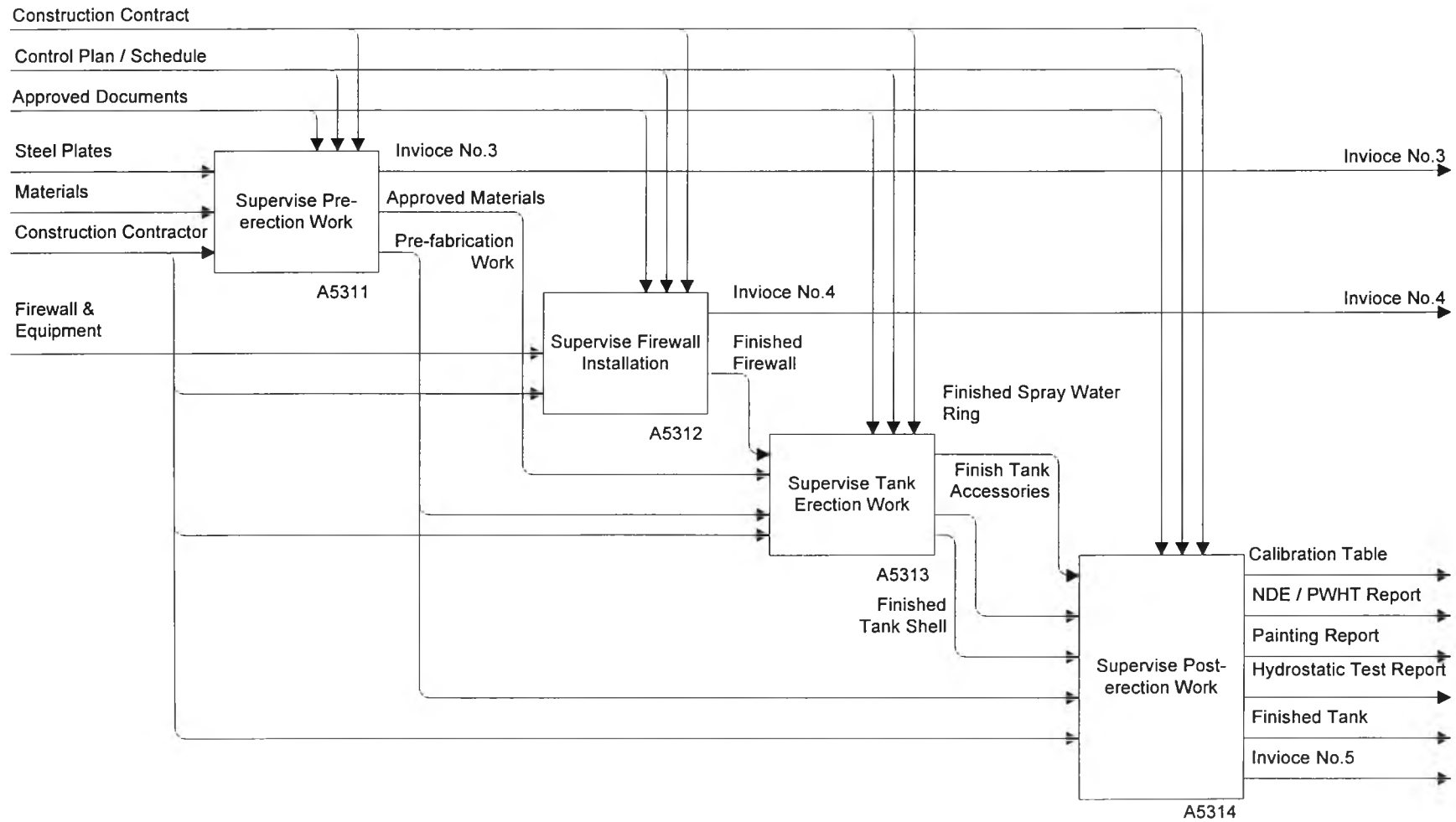


Figure 3-16: A531 - Supervise Tank Work

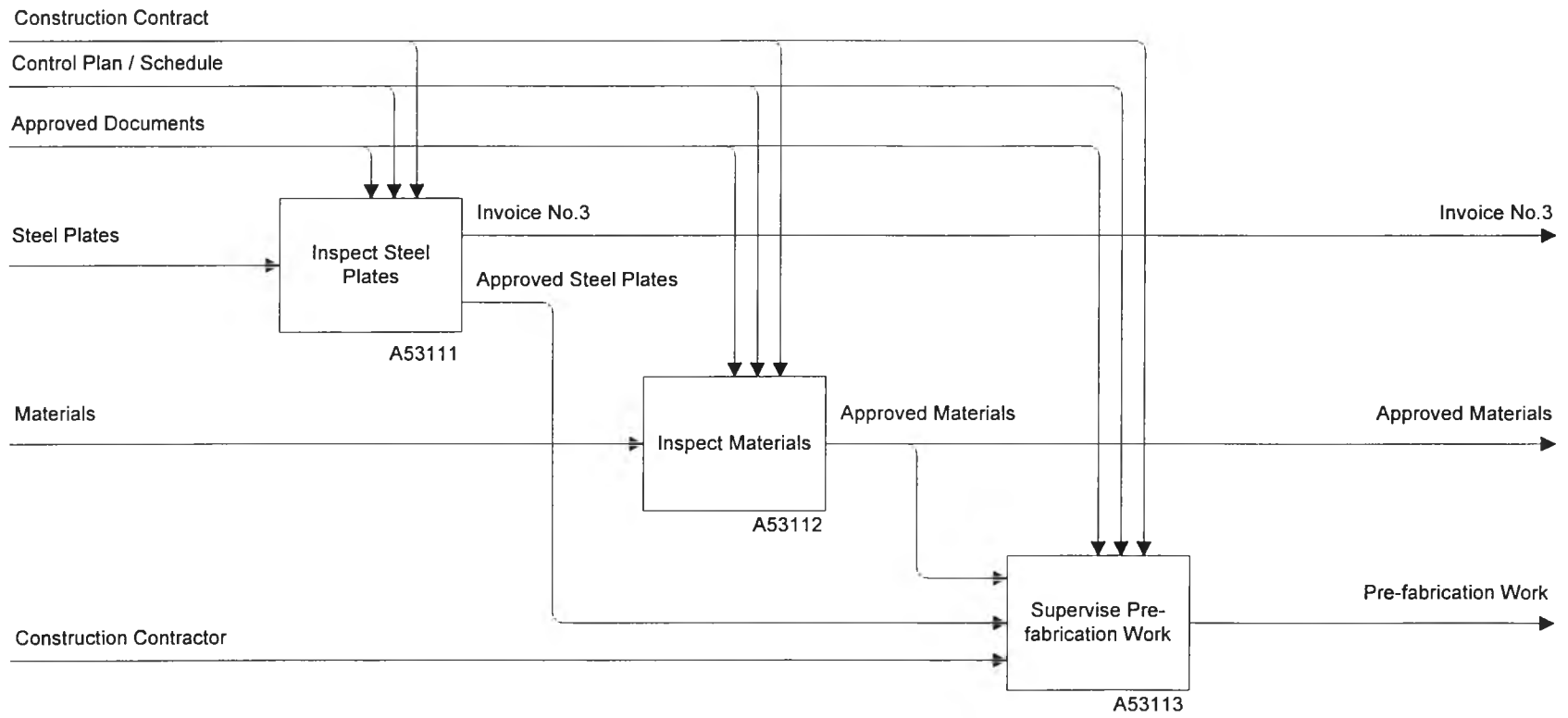


Figure 3-17 : A5311 - Supervise Pre-erection Work

These activities are described as follows:

#### **A53111 Inspection Steel Plates**

The construction team inspected the steel plate that the contractor delivered to the site.

#### **A53112 Inspection Materials**

The construction team inspected other material that the contractor delivered to the site.

#### **A53113 Supervise Pre-fabrication Work**

The construction team supervised the contractor fabricated the pre-fabricated work such as shell plates, spray water rings, and tank accessories at the factory's workshop of the contractor.

#### **A5312 Supervise Firewall Installation Work**

In Figure 3-18, activity A5312 can be decomposed further into three activities as follows:

- A53121 Inspect Firewall Material & Equipment
- A53122 Supervise Firewall Erection
- A53123 Supervise Firewall Equipment Installation

These activities are described as follows:

#### **A53121 Inspect Firewall Materials & Equipment**

The construction team inspected the materials and equipment that used to install firewall.

#### **A53122 Supervise Firewall Erection**

The construction team supervised the contractor installed the firewall.

#### **A53123 Supervise Firewall Equipment Installation**

The construction team supervised the contractor installed the firewall equipment such as water spray nozzle and temporary gas detector.

#### **A5313 Supervise Tank Erection Work**

In Figure 3-19, activity A5313 can be decomposed further into four activities as follows:

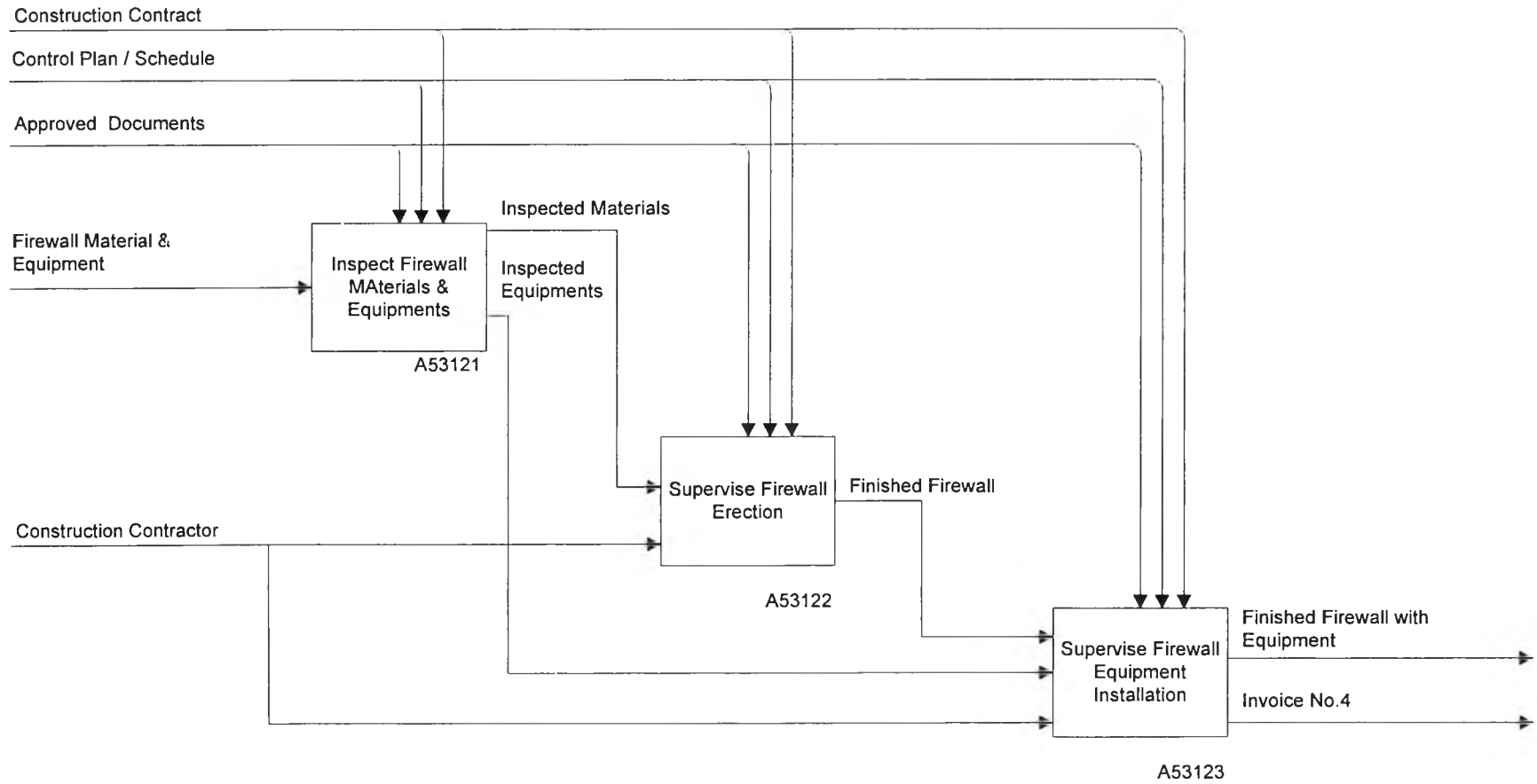


Figure 3-18 : A5312 - Supervise Firewall Installation Work



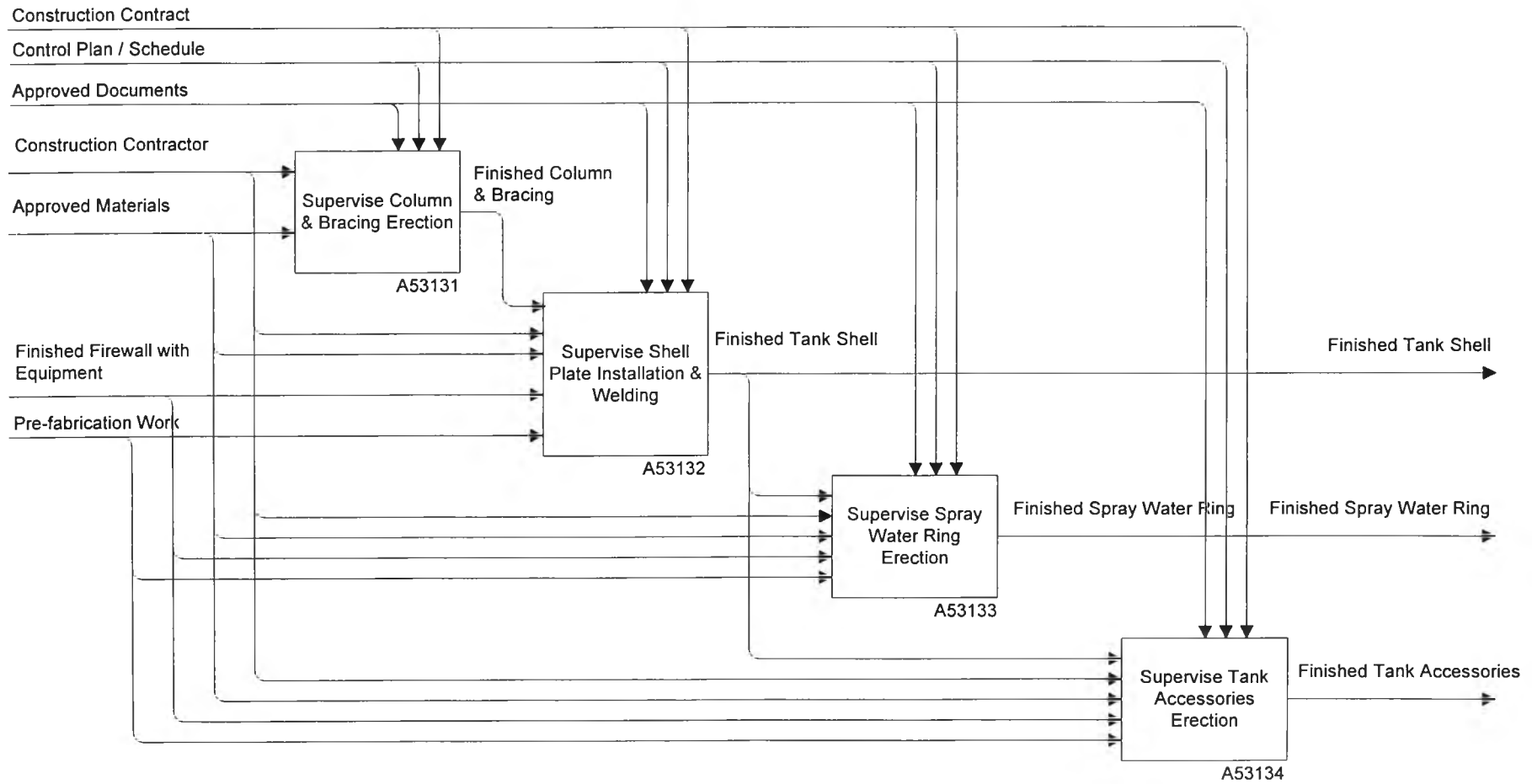


Figure 3-19 : A5313 - Supervise Tank Erection Work

- A53131 Supervise Column & Bracing Erection
  
- A53132 Supervise Shell Plate Installation & Welding
  
- A53133 Supervise Spray Water Ring Erection
  
- A53134 Supervise Tank Accessories Erection

These activities are described as follows:

#### **A53131 Supervise Columns & Bracing Erection**

The construction team supervised the contractor erected the columns and bracing.

#### **A53132 Supervise Shell Plate Welding Work**

The construction team supervised the contractor welded the shell plates that consists of equator plates, bottom plates, and top plates.

#### **A53133 Supervise Spray Water Ring Erection**

The construction team supervise the contractor erect the spray water ring.

#### **A53134 Supervise Tank Accessories Erection**

The construction team supervised the contractor erected tank accessories such as nozzles, manholes, etc.

#### **A5314 Supervise Post-erection Work**

In Figure 3-20, activity A5314 can be decomposed further into five activities as follows:

- A53141 Supervise Non Destroying Examination (NDE) Work
  
- A53142 Supervise Post Weld Heat Treatment (PWHT) Work
  
- A53143 Supervise Painting Work
  
- A53144 Supervise Hydrostatic Test
  
- A53145 Supervise Tank Calibration

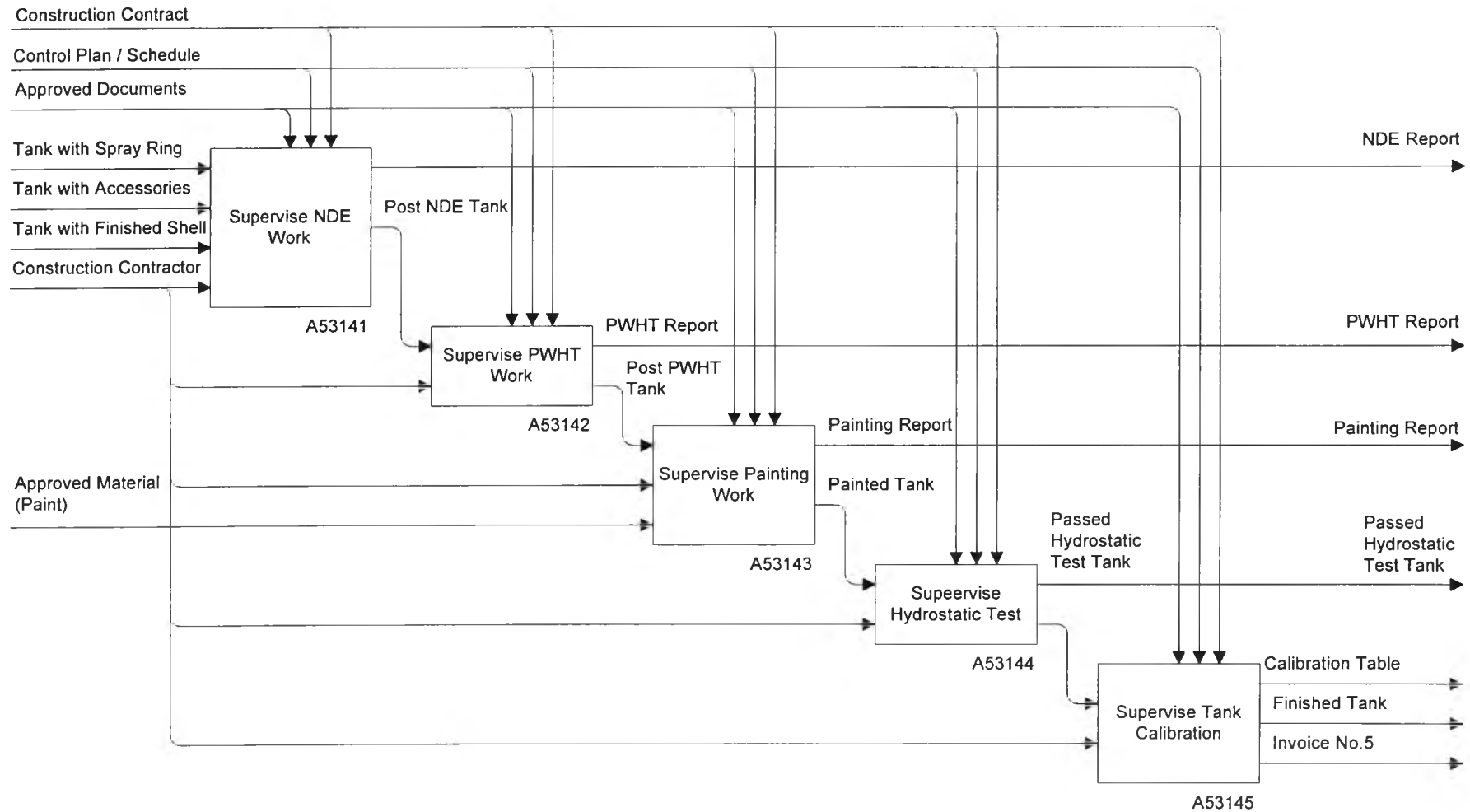


Figure 3-20 : A5314 - Supervise Post-erection Work

These activities are described as follows:

#### **A53141 Supervise NDE Work**

The construction team supervise the contractor perform NDE work such as radiographic test, magnetic examination, and dye penetrate examination.

#### **A53142 Supervise Post-Weld Heat Treatment Work**

The construction team supervised the contractor perform post-weld heat treatment work.

#### **A53143 Supervise Tank Painting Work**

The construction team supervised the contractor painted the tank.

#### **A53144 Supervise Tank Hydrostatic Test**

The construction team supervised the contractor perform tank hydrostatic work.

#### **A53145 Supervise Tank Calibration**

The construction team supervised the contractor perform tank calibration work.

#### **A532 Supervise Civil/Architecture Work**

In Figure 3-21, activity A532 can be decomposed further into five activities as follows:

- A5321 Supervise Drainage System
- A5322 Supervise Concrete Pavement Work
- A5323 Supervise Pipe Support Work
- A5324 Supervise Pipe Crossing Walkway Work
- A5325 Supervise Spillwall / Bundwall Work

These activities are described as follows:

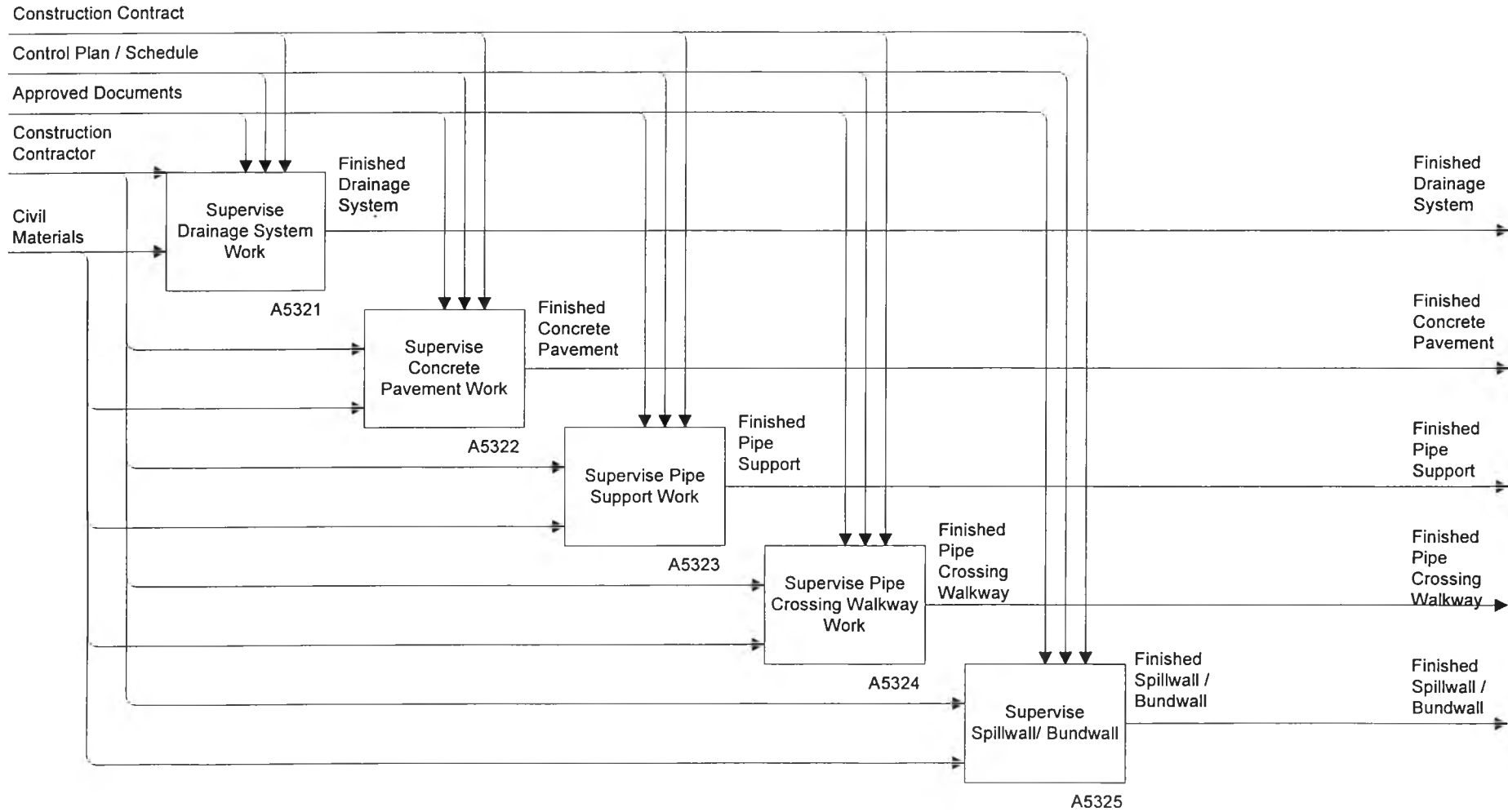


Figure 3-21 : A532 - Supervise Civil / Architecture Work

**A5321 Supervise Drainage System Work**

The construction team supervised the contractor constructed drainage system.

**A5322 Supervise Concrete Pavement Work**

The construction team supervised the contractor constructed concrete pavement.

**A5323 Supervise Pipe Support Work**

The construction team supervised the contractor constructed pipe supports.

**A5324 Supervise Pipe Crossing Walkway Work**

The construction team supervised the contractor constructed the pipe crossing walkways.

**A5325 Supervise Spillwall / Bundwall Work**

The construction team supervised the contractor constructed spillwall / bundwall.

**A533 Supervise Mechanical Work**

In Figure 3-22, activity A533 can be decomposed further into four activities as follows:

- A5331 Inspect Piping Material
- A5332 Supervise Spool Piece Work
- A5333 Supervise Pipeline Installation
- A5334 Supervise Pipeline Pre-commissioning

These activities are described as follows:

**A5331 Inspect Piping Material**

The construction team inspected the piping materials such as pipes, fittings, nuts and bolts, etc.

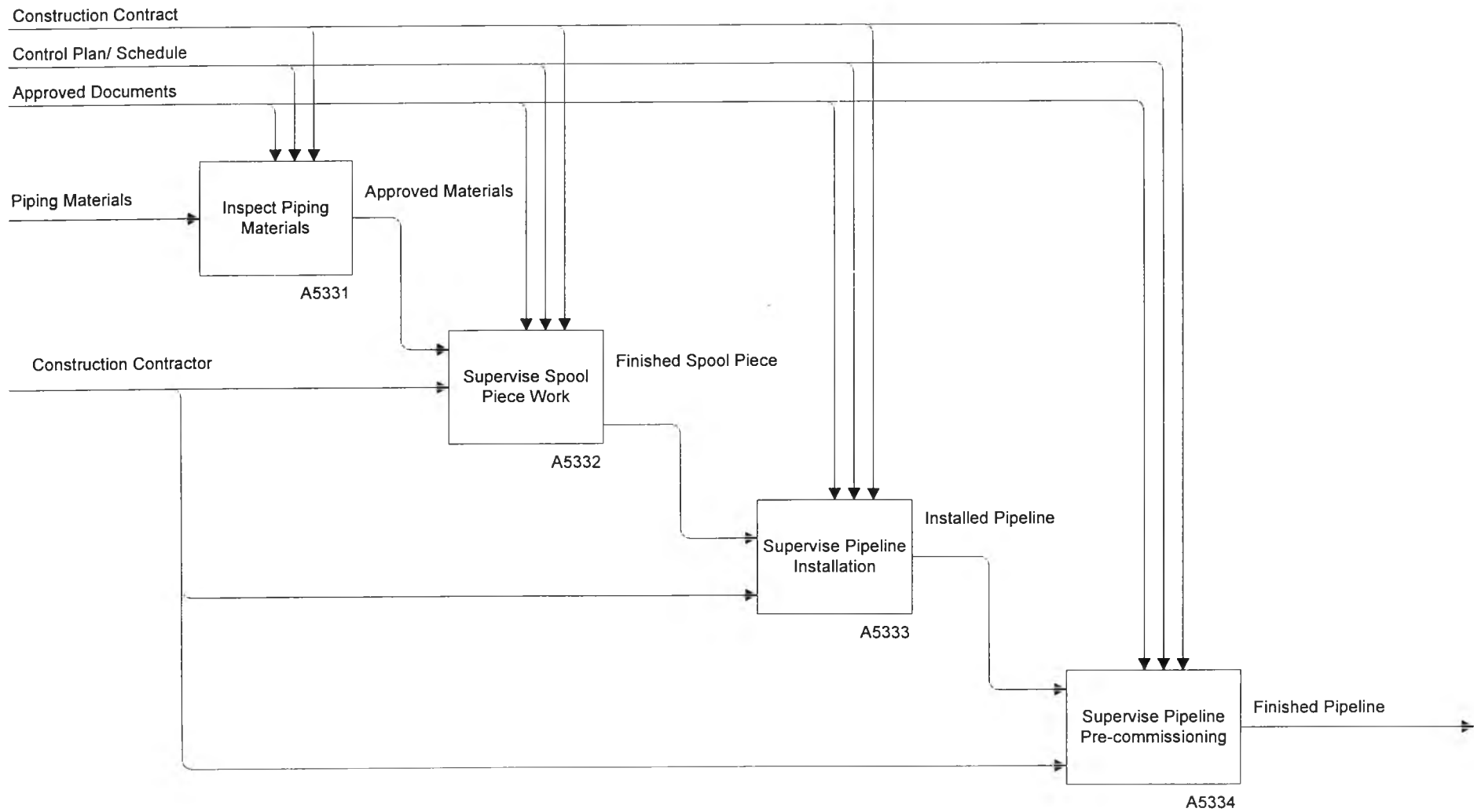


Figure 3-22: A533 - Supervise Mechanical Work

### **A5332 Supervise Spool Piece Work**

The construction team supervised the contractor fabricated the pipe spool piece at site workshop.

### **A5333 Supervise Pipeline Installation**

In Figure 3-23, activity A5333 can be decomposed further into five activities as follows:

- A53331 Supervise Pipeline Erection
- A53332 Supervise NDE Work
- A53333 Supervise Hydrostatic & Flushing Work
- A53334 Supervise Pipeline Painting Work
- A53335 Supervise Tie-in Work

These activities are described as follows:

#### **A53331 Supervise Pipeline Erection**

The construction team supervised the contractor installed the pipeline that consists of LPG pipeline, Instrument air pipeline, and fire water pipeline.

#### **A53332 Supervise NDE Work**

The construction team supervised the contractor performed the NDE work such as radiographic test.

#### **A53333 Supervise Hydrostatic & Flushing Work**

The construction team supervised the contractor performed the hydrostatic test and flushing work

#### **A53334 Supervise Pipe Painting Work**

The construction team supervised the contractor paint the pipes.

#### **A53335 Supervise Tie-in Work**

The construction team supervised the contractor tied-in the new pipes with the existing pipes.



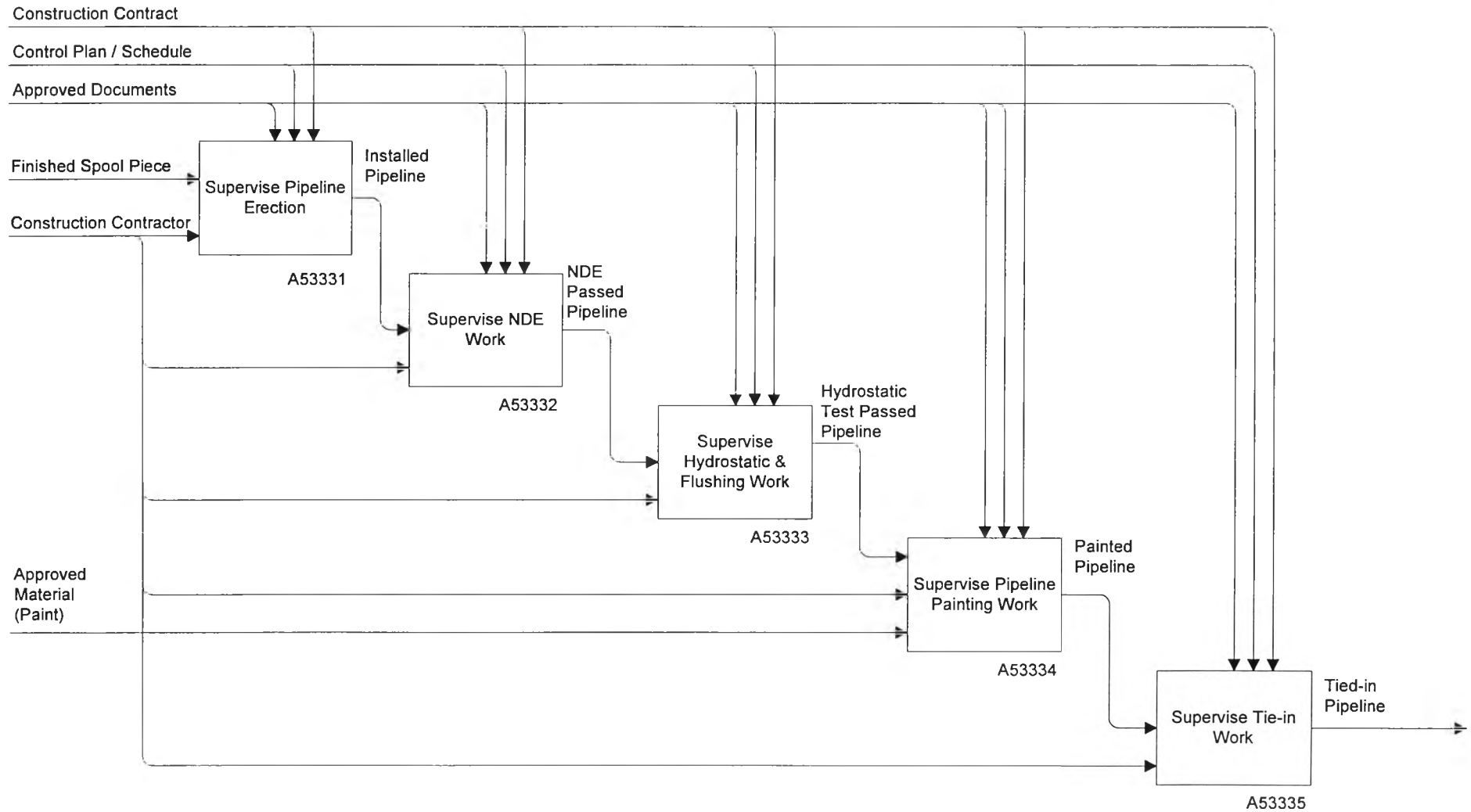


Figure 3-23 : A5333 - Supervise Pipeline Installation

### **A5334 Supervise Pipeline Pre-commissioning**

The construction team supervised the contractor performed pipeline pre-commissioning work.

### **A534 Supervise Electrical Work**

In Figure 3-24, activity A534 can be decomposed further into four activities as follows:

- A5341 Inspect Electrical & Instrument Equipment
- A5342 Supervise Electrical & Instrument Installation
- A5343 Supervise Control Panel Modification
- A5344 Supervise Electrical & Instrument Pre-commissioning

These activities are described as follows:

#### **A5341 Inspect Electrical & Instrument Equipment**

The construction team inspected the electrical and instrument equipment that the contractor delivered to the site for installation.

#### **A5342 Supervise Electrical & Instrument Installation**

The construction team supervised the contractor installed the electrical and instrument equipment.

In Figure 3-25, activity A5342 can be decomposed further into five activities as follows:

- A53421 Supervise Trench Work
- A53422 Supervise Conduit & Support Work
- A53423 Supervise Cable Laying & Wiring
- A53424 Supervise Tank Grounding System Work
- A53425 Supervise Instrument Installation

These activities are described as follows:

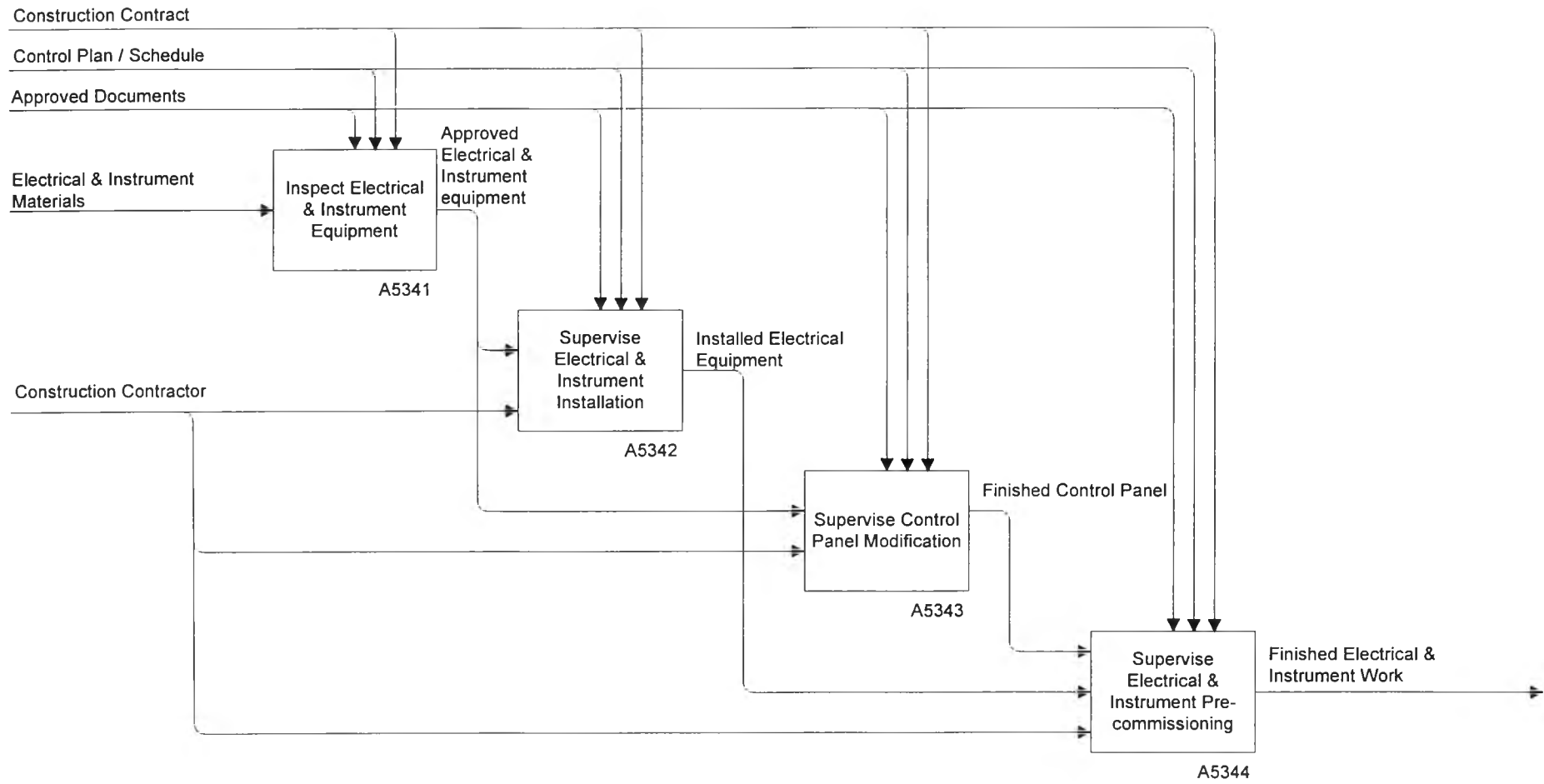


Figure 3-24 : A534 - Supervise Electrical & Instrument Work

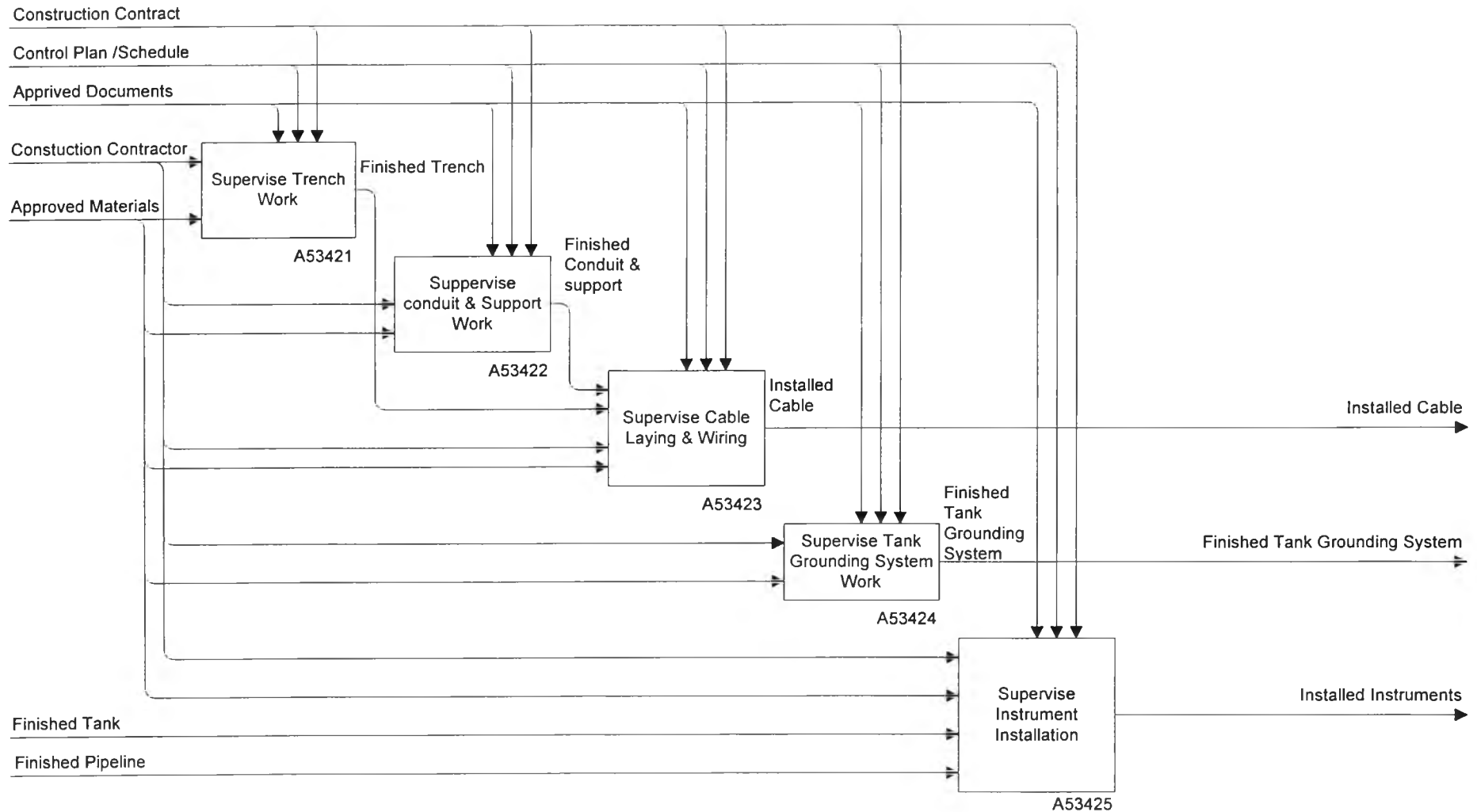


Figure 3-25 : A5342 - Supervise Electrical & Instrument Installation

#### **A53421 Supervise Trench Work**

The construction team supervised the contractor perform trench excavation and backfill work.

#### **A53422 Supervise Conduit & Supporting Work**

The construction team supervised the contractor installed the conduits and supporting.

#### **A53423 Supervise Cable Laying & Wiring Work**

The construction team supervised the contractor laid and wired the cable.

#### **A53424 Supervise Tank Grounding System Work**

The construction team supervised the contractor installed the tank grounding system.

#### **A53425 Supervise Instrument Installation**

The construction team supervised the contractor installed the instruments to pipes and tank.

#### **A5343 Supervise Control Panel Modification**

The construction team supervised the contractor modified the existing control panel and install new instruments.

#### **A5344 Supervise Electrical & Instrument Pre-commissioning**

The construction team supervised the contractor performed electrical and instrument pre-commissioning work.

#### **A54 Supervise Final Commissioning Work**

After all of the work was finished and passed the pre-commissioning work, the contractor performed the final commissioning work under the supervision of the project team.

#### **A6 Perform Hand-Over Work**

In Figure 3-26, activity A6 can be decomposed further into four activities as follows:

- Supervise One Month of Operation
- Supervise Site Cleaning & Demolished Work

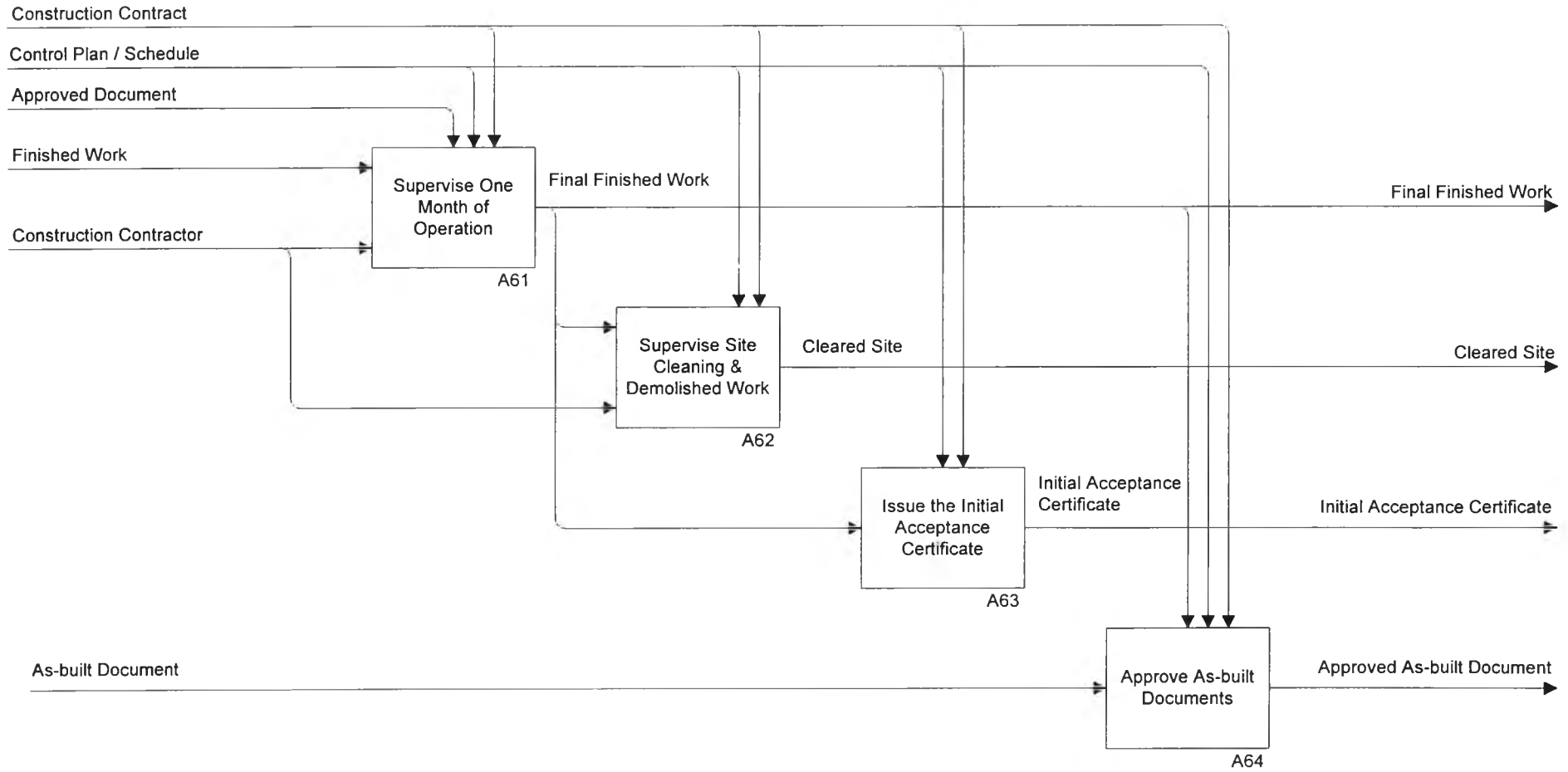


Figure 3-26 : A6 - Perform Hand-over Work

- Issue the Initial Acceptance Certificate
- Approve As-built Documents

These activities are described as follows:

#### **A61 Supervise 1 month of Operation**

After final commissioning was passed, the new process was tested the continuous working for 30 days.

#### **A62 Supervise Site Cleaning & Demolishing**

The construction team supervised the contractor cleaned the site and demolished temporary facilities.

#### **A64 Issue the Initial Acceptance Certificate**

The project team issued the Initial Acceptance Certificate to the contractor after the 1-month of continuous operation was passed.

#### **A7 Perform Payment Work**

After the contractor did the work that met the milestone and issue invoices to the project team. The project team checked the progress of the work whether met the payment milestone in the contract or not. If it met, the accounting team will issue payment note to Accounting Department to pay the money to the contractor.

### **3.3 Cost Gathering**

“Cost Gathering” is the second activity of the ABC process that is very important. This step was performed concurrently with the activity model-developing step for reducing the study time. Cost gathering can be divided into two steps those are organisation cost identifying and distributing organisation cost to the functional element of organisation structure.

At first step, typically historical costs were used as the baseline activity cost. The various type of financial report can be provided the data of cost such as salaries of manpower, rental equipment cost, supplies cost, etc. However, such costs were too summarized for ABC unless detailed ledgers are available. So, cost assignment formulas or calculation must be used. Then, they were traced to the functional element of the selected organisation in the second step.

#### **3.3.1 Scope of Cost Data**

The scope of cost data required relates to the scope of the activity model or process under study. In this study, the activity model under review is the process of the project management of the construction of a 2,000 m<sup>3</sup> LPG spherical tank project that perform by the assigned project team. It only one in many projects under responsible of the PMO. The cost of the construction is the fixed cost that pay to the construction contractor. The project management cost of this project was set in budgetary accounting. However, it is not the real cost of the project management of this project. For example, the salaries of the personnel in the project team are not charged to the project management cost. Moreover, the manpower salary and some expense is the share cost of all project under responsible of the PMO. So, to gather the cost in this study, all the related cost should be captured as possible. Then, the calculation is required to synthesize the correct cost of this project.

#### **3.3.2 Identify Organisation Cost**

In this study, The cost data is captured from various sources. The accounting records are the major source of the cost data. The cost was captured from many categories of costs. They are identified as follows:

- Manpower Cost



- Allowance
- Supplies
- Rental Equipment
- Facilities
- Overhead Expenses



### **Manpower**

The manpower cost is the most important expense of the organisation. From the theoretical viewpoint, it will account for 60 to 80 percent of the organisation cost. So, in this study, the cost estimate should be as accurate as possible. The manpower cost have two components. First is the cost of manpower, and second is the number of the manpower. The Manpower cost is considered in three factors as follows:

#### **Salaries**

Due to the company's policy, the real salary or monthly wages of the people in the case company is confidential. However, There is the salary table data from Human Resource Department, which describes the minimum, midpoint and maximum salary of each level of personnel to gather. So, to gather the cost of salaries of the personnel in this project, the midpoint salaries of each level of the personnel were captured instead, as shown in Table 3-2.

#### **Fringe Benefits**

The fringe benefits of the personnel of the case company are such as hospital fee, uniform suit, bus, etc. The cost of fringe benefits can be gathered from the data of Human Resource Department. It is approximately 60,000 Baht per person per year or 5,000 Baht per person per month.

#### **Training Cost**

The training cost of the personnel of the PMO can be gathered from the data of the accounting data of the PMO. It is approximately 6,000 Baht per person per year or 500 Baht per person per month.

**Table 3-2: The midpoint salary of each level of personnel in the case company**

Level	Midpoint Salary (Baht)
12	80,860
11	66,100
10	56,500
9	45,860
8	39,480
7	31,530
6	26,660
5	21,680
Contract Employee	10,000

So, the manpower cost of the personnel of PMO who worked for this project is shown in Table 3-3.

### **Allowance**

The allowance is the cost that the case company pays the personnel who work outside their based office. The allowance of the case company is set by the level of the personnel as follows:

- Level 7 and lower : 300 Baht /person/day or 9,000 Baht/person/month
- Level 8 and upper : 350 Baht/person/day or 10,500 Baht/person/month

Table 3-3: The manpower cost of the personnel of the PMO who worked for this project

Personnel		Manpower Cost (Baht/month)			Total Manpower Cost (Baht/month)
Name	Level	Salary	Fringe Benefit	Training	
K.P.	12	80,860	5,000	500	86,360
N.W.	11	66,100	5,000	500	71,600
K.W.	11	66,100	5,000	500	71,600
D.K.	9	45,860	5,000	500	51,360
P.R.	9	45,860	5,000	500	51,360
K.D.	8	39,480	5,000	500	44,980
I.N.	8	39,480	5,000	500	44,980
P.S.	7	31,530	5,000	500	37,030
K.T.	7	31,530	5,000	500	37,030
W.S.	5	21,680	5,000	500	27,180
J.B.	5	21,680	5,000	500	27,180
N.S.	Contract Employee	10,000	-	-	10,000
R.K.	Contract Employee	10,000	-	-	10,000
N.I.	Contract Employee	10,000	-	-	10,000

## **Supplies**

The supplies cost are such as paper, files, printer ink, office stationery, and other office equipment that are identified by accounting system to be supplies. The supply cost of PMO can be captured from the accounting data of the PMO and the accounting data from the web page of inventory control system of the case company's Intranet. This web page can report the supplies cost of each department consumed. The supplies cost of the PMO is approximately 10,000 Baht per month.

## **Rental Equipment**

The categories of the rental equipment used in this project are defined as follows:

### **Cars**

The car rental cost can be gathered from the data of the Vehicle Service Department. The cost of a rental car of the PMO is approximately 30,000 Baht per month.

### **Computer & Accessories**

The rental cost of computer and accessories can be gathered from the data of Information Technology Department. The cost of the rental computer & accessories of the PMO is approximately 1,650 Baht per set per month.

### **Mobile Phone**

The rental cost of mobile phone can be gathered from the data of Information Technology Department. The cost of the rental mobile phone of the PMO is 2,500 Baht per set per month.

### **Pager**

The rental cost of pager can be gathered from the data of Information Technology Department. The cost of the rental pagers of the PMO is 436 Baht per set per month.

### **Copy Machine**

The rental cost of copy machine of the case company depends upon the number of using (copies). The rental cost of the PMO can be gathered from the accounting data of the PMO. The rental cost of the copy machine of the PMO is approximately 54,000 Baht per year or 4,500 Baht per month

## **Facilities**

The cost of facilities is usually included and distributed as depreciation, which represents the cost of using the facilities. In this study, the facilities cost is the depreciation of the office building that the PMO used. The total value of the office building that gather from the Accounting Department is 333,888,185 Baht. The straight-line method is used for depreciation over the estimated useful life of the building. The useful life of the building of the case company is 30 years. The residual values of the building after year 30 is zero. So, the cost of office building using is 927,467 Baht per month. The PMO use the area one-third floor of all eleven floors. So, the cost of office building using was charge to the PMO is 28,105 Baht per month

## **Overhead Expenses**

### **Utilities**

#### **Utility water supply**

The cost of water supply of the office building was gathered from the accounting data of Facilities & Building Administration Department. This cost is approximately 26,000 Baht per month. The PMO use the area one-third floor of all eleven floors. So, the cost of utility water supply was charged to the PMO approximately 788 Baht per month.

#### **Electric Supply**

The cost of electric supply of the office building was gathered from the accounting data of Facilities & Building Administration Department. This cost is approximately 500,000 Baht per month. The PMO use a floor of area of one-third floor out of a total area of eleven floors. So, the cost of electric supply was charged to the PMO approximately 15,152 Baht per month.

#### **Telephone Fee**

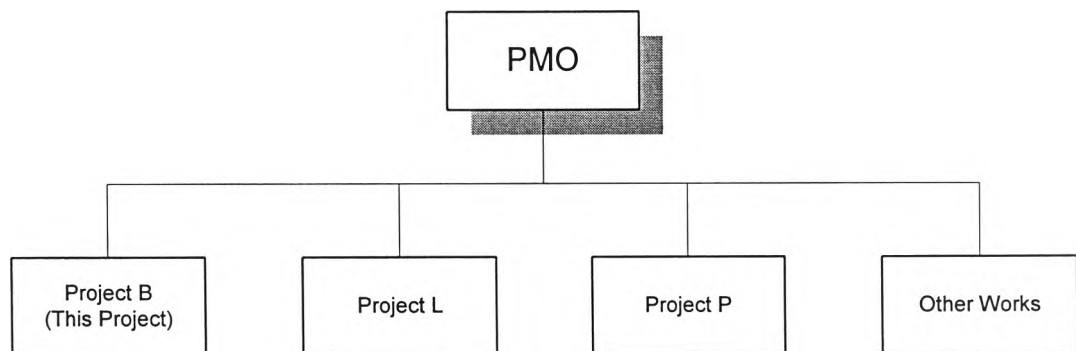
The cost of the telephone fee of the PMO was gathered from the accounting data of the Information Technology Department. The telephone fee of the PMO is approximately 4,000 Baht per month.

## Security

The cost of security of the office building that employed 15 security guards can be gathered from the accounting data of the Facilities & Building Administration Department. This cost is approximately 185,645 Baht per month. The PMO uses the area one-third floor of all eleven floors. So, the cost of security was charged to the PMO approximately 5,626 Baht per month.

### 3.3.3 Distribute Organisation Costs to the Organisation Structure

This step, the costs that was gathered in section 3.3.2 were distributed into the organisation structure. The cost should be allocated to the functional elements within the organisation. The costs must not be moved from one element to another or individually allocate the overhead cost to one element. The organisation structure should be divided into the smallest functional element that has the assigned manager. In this study, the organisation structure is not the PMO organisation structure but the project team organisation structure. The PMO set the project team to operate each project in its responsibility. During the study time of this project, the PMO had three projects and other works under its responsibility as shown in Figure 3-27



*Figure 3-27: The project team of the PMO*

The organisation of the project team of this project is shown in Figure 3-28 below:

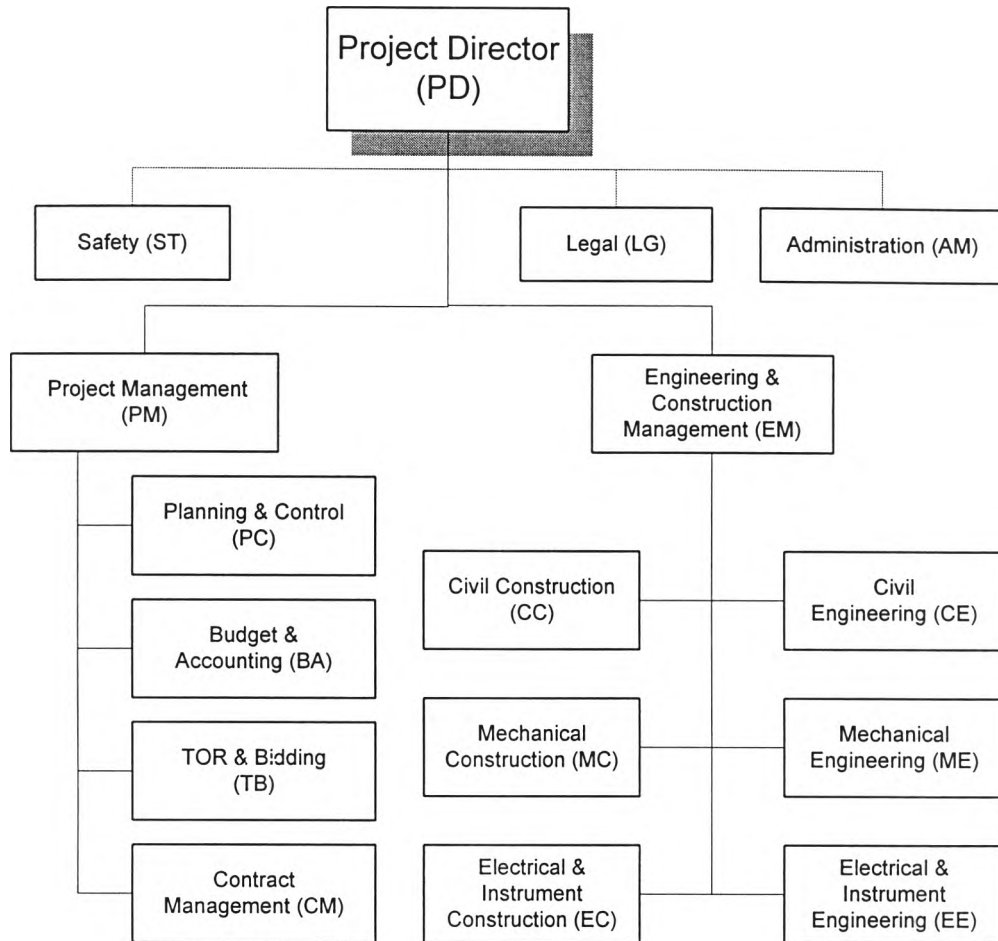


Figure 3-28: The project team organisation

According to Figure 3-28, the organisation structure of this project team is divided into sixteen functional elements. The project director is the leader in chief of this project; the PMO manager is automatically occupied this position. There are two divisions under the project director. They are project management division and engineering & construction division. The project management division consists of four operational elements: Planning & control, Budget & accounting, TOR & Bidding, and Contract management. The engineering & construction management consists of six operational elements: civil construction, mechanical construction, electrical & instrument construction, civil engineering, mechanical engineering, and electrical & instrument engineering. There are three supporting elements that furthersupport these elements. They are safety, legal, and administration.

The personnel of the PMO that are assigned into this project team organisation are as shown in Table 3-4.

**Table 3-4: The personnel in the project team organisation**

<b>Organisation Element</b>	<b>Personnel</b>
Project Director (PD)	K.P.
Project Management( PM)	N.W.
Planning & Control (PC)	D.K., P.S., J.B.
Budget & Accounting (BA)	P.S., W.S.
TOR & Bidding (TB)	D.K., P.S., W.S., J.B.
Contract Management (CM)	P.S., W.S.
Engineering & Construction (EM)	K.W.
Civil Construction (CC)	K.D., N.S.
Mechanical Construction (MC)	P.S., W.S.
Electrical & Instrument Construction (EC)	J.B.
Civil Engineering (CE)	K.D.
Mechanical Engineering (ME)	D.K., P.S., W.S.
Electrical Engineering (EE)	J.B.
Safety (ST)	I.N.
Legal (LG)	P.R.
Administration (AM)	K.T., R.K., K.W.

### **Manpower Cost**

All of the personnel in this project were not the full-time manpower that worked in only one project. All people in this project team worked for many projects that are under the responsibility of the PMO at the same time. So, it needs to calculate the real manpower cost of the personnel that worked for this project.



In this study, the factor that is used to calculate the real manpower cost of this project is the ratio of the time allocation of each personnel on each functional element of this project. In other words, the manpower cost of each personnel of this project will be divided by the ratio of the time that they work on each functional element of this project. For more understanding, the rational of time allocation is shown in Figure 3-29 below.

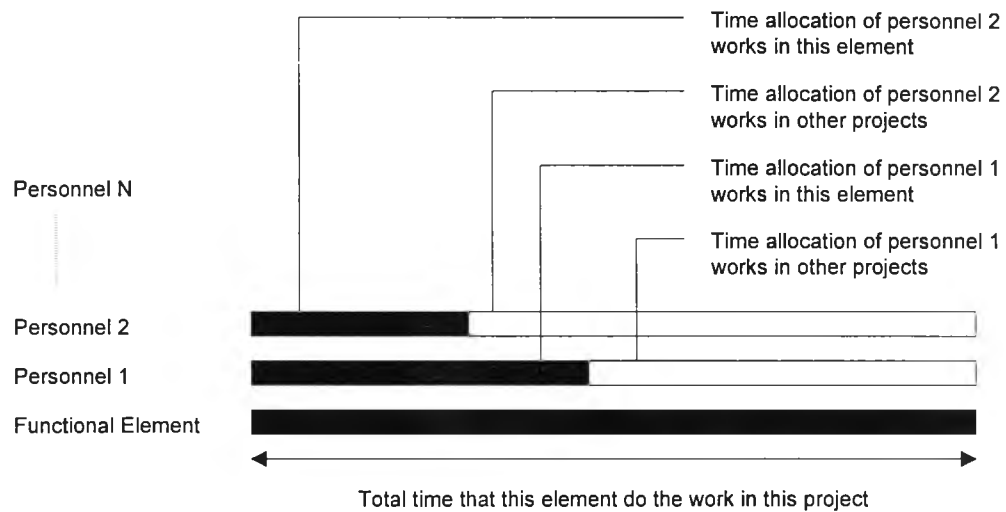


Figure 3-29: Time Allocation of each personnel in each functional element

The data of ratio of time allocation of each personnel in each functional element when compared with other work that worked at the total during time of that functional element was gathered by interviewing and using gathering form. Using the project schedule and the gathering form, the personnel that worked for this project was interviewed and asked to fill the form. The percentage of the time allocation that each personnel spent in a functional element compared to the total time available was gathered and shown in Table 3-5 for each functional element.

The manpower cost of each functional element is calculate by following formula:

$$\text{Manpower cost}_{\text{functional element}} = \sum (\text{Manpower Cost}_i \times \text{Percentage of Time Allocation}_i)$$

While  $i$  = personnel that works in that functional element

According to Table 3-3 and Table 3-5, the manpower cost of each personnel and the percentage of time allocation are used to calculated the manpower cost of functional element.

**Table 3-5: The percentage of time allocation of this project of each personnel in each functional element**

Personnel	Time Allocation (%)															
	PD	PM	PC	BA	TB	CM	EM	CC	MC	EC	CE	ME	EE	ST	LG	AM
K.P.	30															
N.W.		30														
K.W.							30									
D.K.			10		30							5				
P.R.															10	
K.D.								100			10					
I.N.														10		
P.S.			10	10	10	10			20			10				
K.T.																20
W.S.				10	10	10			80			10				
J.B.			10		20					100			10			
N.S.								100								
R.K.																30
N.I.																30

For example, the manpower cost of mechanical engineering elements (ME) is:

$$\begin{aligned}
 \text{Manpower Cost}_{ME} &= \text{Manpower Cost}_{ME} (\text{D.K}) + \text{Manpower Cost}_{ME} (\text{P.S.}) + \text{Manpower Cost}_{ME} (\text{W.S.}) \\
 &= (51,360 \times 5\%) + (37,030 \times 10\%) + (27,180 \times 10\%) \\
 &= 2,568 + 3,703 + 2,718 \\
 &= 8,989 \text{ Baht/month}
 \end{aligned}$$

The manpower cost of all element is calculated and shown in Table 3-6 below:

Table 3-6: The manpower cost of all elements in this project

Functional Element	Personnel	Manpower Cost (Baht/month)	Time Allocation (%)	Cost Distribution (Baht/month)	Manpower Cost (Baht/month)
Project Director (PD)	K.P.	86,360	30	25,908	25,908
Project Management (PM)	N.W.	71,600	30	21,480	21,480
Planning & Control (PC)	D.K.	51,360	10	5,136	11,557
	P.S.	37,030	10	3,703	
	J.B.	27,180	10	2,718	
Budget & Accounting (BA)	P.S.	37,030	10	3,703	6,421
	W.S.	27,180	10	2,718	
TOR & Bidding (TB)	D.K.	51,360	30	15,408	27,265
	P.S.	37,030	10	3,703	
	W.S.	27,180	10	2,718	
	J.B.	27,180	20	5,436	
Contract Management (CM)	P.S.	37,030	10	3,703	6,421
	W.S.	27,180	10	2,718	
Engineering & Construction Management (EM)	K.W.	71,600	30	21,480	21,480
Civil Construction (CC)	K.D.	44,980	100	44,980	54,980
	N.S.	10,000	100	10,000	
Mechanical Construction (MC)	P.S.	37,030	20	7,406	29,150
	W.S.	27,180	80	21,744	
Electrical & Instrument Construction (EC)	J.B.	27,180	100	27,180	27,180
Civil Engineering (CE)	K.D.	44,980	10	4,498	4,498
Mechanical Engineering (ME)	D.K.	51,360	5	2,568	8,989
	P.S.	37,030	10	3,703	
	W.S.	27,180	10	2,718	
Electrical & Instrument Engineering (EE)	J.B.	27,180	10	2,718	2,718
Safety (ST)	I.N.	44,980	10	4,498	4,498
Legal (LG)	P.R.	51,360	10	5,136	5,136
Administration (AM)	K.T.	37,030	20	7,406	13,406
	R.K.	10,000	30	3,000	
	N.I.	10,000	30	3,000	

The total manpower cost of each functional element for the total 31 months of this project is calculated as follows:

$$\text{Total Manpower Cost}_{\text{functional element}} = \text{Manpower Cost}_{\text{functional element}} \times \text{Total Working Time}_{\text{functional element}}$$

The total working time of each functional element that is gathered from the project schedule is shown in Table 3-7 below:

**Table 3-7: Total working time of each functional element**

Functional Element	Total Working Time (month)
Project Director (PD)	31
Project Management (PM)	31
Planning & Control (PC)	2.5
Budget & Accounting (BA)	0.5
TOR & Bidding (TB)	7.5
Contract Management (CM)	1
Engineering & Construction Management (EM)	31
Civil Construction (CC)	13.75
Mechanical Construction (MC)	11.75
Electrical & Instrument Construction (EC)	7.5
Civil Engineering (CE)	6.5
Mechanical Engineering (ME)	6.5
Electrical & Instrument Engineering (EE)	6.5
Safety (ST)	17
Legal (LG)	8.5
Administration (AM)	31

According to Tables 3-6 and 3-7, the manpower cost of each functional element and total working time of each element are used to calculate the total manpower cost of each functional element as shown in Table 3-8 below:

Table 3-8: Total manpower cost of each functional element

Functional Element	Manpower Cost (Baht/month)	Total Working Time (month)	Total Manpower Cost (Baht)
Project Director (PD)	25,908	31	803,148
Project Management (PM)	21,480	31	665,880
Planning & Control (PC)	11,557	2.5	28,893
Budget & Accounting (BA)	6,421	0.5	3,211
TOR & Bidding (TB)	27,265	7.5	204,488
Contract Management (CM)	6,421	1	6,421
Engineering & Construction Management (EM)	21,480	31	665,880
Civil Construction (CC)	54,980	13.75	755,975
Mechanical Construction (MC)	29,150	11.75	342,513
Electrical & Instrument Construction (EC)	27,180	7.5	203,850
Civil Engineering (CE)	4,498	6.5	29,237
Mechanical Engineering (ME)	8,989	6.5	58,429
Electrical & Instrument Engineering (EE)	2,718	6.5	17,667
Safety (ST)	4,498	17	76,466
Legal (LG)	5,136	8.5	43,656
Administration (AM)	13,406	31	415,586

## Allowance

The allowance cost of this project was the cost that the case company paid for the civil construction, mechanical construction, and electrical & instrument construction to supervise the contractor do the work at site. The allowance cost of each functional element is calculated by the formula as follows:

$$\text{Allowance cost}_{\text{functional element}} = \sum (\text{Allowance Cost}_i \times \text{Percentage of Time Allocation}_i)$$

While  $i$  = personnel that works in that functional element

Using Table 3-5, the percentage of time allocation of each personnel is used to calculate the allowance cost of each functional element. For example, the calculation of allowance cost of civil construction elements is as follows:

$$\begin{aligned}
 \text{Allowance cost}_{\text{Civil Construction}} &= (\text{Allowance Cost}_{\text{K.D.}} \times \% \text{ of Time Allocation}_{\text{K.D.}}) + (\text{Allowance Cost}_{\text{N.S.}} \times \\
 &\quad \% \text{ of Time Allocation}_{\text{N.S.}}) \\
 &= (10,500 \times 100\%) + (0 \times 100\%) \\
 &= 10,500 \text{ Baht/month}
 \end{aligned}$$

From Calculation, the allowance cost of Civil Construction, Mechanical Construction, and Electrical & Instrument Construction is shown as follows:

- Civil Construction : 10,500 Baht/month
- Mechanical Construction : 9,000 Baht/month
- Electrical Construction : 9,000 Baht/month

The total allowance cost of each functional element during the total 31 months of this project is calculated as follows:

$$\text{Total Allowance Cost}_{\text{functional element}} = \text{Allowance Cost}_{\text{functional element}} \times \text{Total Working Time}_{\text{functional element}}$$

Using Table 3-7, the total working time is used to calculate the total allowance cost of each functional element during the total 31 months of this project as shown in Table 3-9 below:

**Table 3-9: Total allowance cost of each functional element**

Functional Element	Allowance Cost (Baht/month)	Total Working Time (month)	Total Allowance Cost (Baht)
Civil Construction	10,500	13.75	144,375
Mechanical Construction	9,000	11.75	105,750
Electrical & Instrument Construction	9,000	7.5	67,500

## Supplies

The supplies cost of the PMO is approximately 10,000 Baht per month. This project consumed supplies approximately 30% of all supplies that the PMO consumed. So the supplies cost of this project is

approximately 3,000 Baht per month. So, the total cost of supplies of this project in 31 months is 93,000 Baht.

To distribute the supplies cost into each functional element, The percentage of supplies usage is required. The percentage of supplies usage of this project was gathered from interviewing all personnel in this project. The percentage of supplies usage and total supplies cost of each functional element is calculated as shown in Table 3-10 below:

**Table 3-10: The percentage of supplies usage and total supplies cost of each functional element**

Functional Element	Supplies Cost (Baht)	Usage (%)	Total Supplies Cost (Baht)
Project Director (PD)	93,000	2	1,860
Project Management (PM)	93,000	2	1,860
Planning & Control (PC)	93,000	4	3,720
Budget & Accounting (BA)	93,000	2	1,860
TOR & Bidding (TB)	93,000	8	7,440
Contract Management (CM)	93,000	4	3,720
Engineering & Construction Management (EM)	93,000	2	1,860
Civil Construction (CC)	93,000	2	1,860
Mechanical Construction (MC)	93,000	2	1,860
Electrical & Instrument Construction (EC)	93,000	2	1,860
Civil Engineering (CE)	93,000	12	11,160
Mechanical Engineering (ME)	93,000	12	11,160
Electrical & Instrument Engineering (EE)	93,000	12	11,160
Safety (ST)	93,000	2	1,860
Legal (LG)	93,000	2	1,860
Administration (AM)	93,000	30	27,900

## Rental Equipment

### Cars

Three cars were supplied to management level of the PMO: Project Director, Project Management, and Engineering & Construction. Furthermore, one car was supplied to be shared among operational elements of this project. This car can be used by other project if it is available.

The management level used their car in this project about 30% for 31 months. The pooled car was used by TOR & Bidding element about 10% for 7.5 months and used 100% by construction elements in construction phase as follows:

- Used by Civil Construction : 4.25 months
- Used by Mechanical Construction : 2 months
- Used by Civil Construction and Mechanical Construction : 2.25 months
- Used by Civil Construction, Mechanical Construction, and Elec. & Inst. Construction : 8 months

So, the car usage time of these elements can be calculated as follows:

- Civil Construction =  $4.25 + (2.25/2) + (8/3)$   $\approx 8.04$  months
- Mechanical Construction =  $2 + (2.25/2) + (8/3)$   $\approx 5.74$  months
- Electrical & Instrument Construction =  $8/3$   $\approx 2.67$  months

The total car rental cost of functional elements of this project for the total 31 months of this project can be calculated by the formula as follows:

**Total Car Rental Cost** functional element =

**Car Rental Cost** functional element x **Percentage of usage time** functional element x **Total Working Time** functional element

The total car rental cost of each functional element is shown in Table 3-11 below:



**Table 3-11: Total car rental cost of each functional element**

Functional Element	Car Rental Cost (Baht / month)	Usage Time (%)	Working Time (month)	Total Car Rental Cost (Baht)
Project Director (PD)	30,000	30	31.00	279,000
Project Management (PM)	30,000	30	31.00	279,000
TOR & Bidding (TB)	30,000	10	7.50	22,500
Engineering & Construction Management (EM)	30,000	30	31.00	279,000
Civil Construction (CC)	30,000	100	8.04	241,250
Mechanical Construction (MC)	30,000	100	5.74	173,720
Electrical & Instrument Construction (EC)	30,000	100	2.67	80,000

### Computer & Accessories

Three sets of computers were occupied by management level (Project Director, Project Management, and Engineering & Construction Management). Two sets of computer were occupied by administration element. Two sets of computer were assigned to be the shared computers for other functional elements.

The total rental cost of computer and accessories of functional elements of this project for the total 31 months of this project can be calculated by the formula as follows:

**Total Rental Cost of Computer & Accessories** *functional element* =

**Rental Cost of Computer & Accessories** *functional element* x **Number of Computer & Accessories** *functional element* x

**Percentage of usage time** *functional element* x **Total Working Time** *functional element*

The data of number of computer & accessories, percentage of time usage, working time of each functional element, and the total rental cost of computer & accessories is shown in Table 3-12 below:

**Table 3-12: Total rental cost of computer & accessories of each functional element**

Functional Element	Rental Cost of Computer (Baht / month)	Number of Computer	Usage Time (%)	Working Time (month)	Total Rental Cost of Computer (Baht)
Project Director (PD)	1,650	1	30	31	15,345
Project Management (PM)	1,650	1	30	31	15,345
Planning & Control (PC)	1,650	2	30	2.5	2,475
Budget & Accounting (BA)	1,650	1	30	0.5	248
TOR & Bidding (TB)	1,650	2	30	7.5	7,425
Contract Management (CM)	1,650	1	30	1	495
Engineering & Construction Management (EM)	1,650	1	30	31	15,345
Administration (AM)	1,650	2	30	31	30,690

### Mobile Phones

Three sets of mobile phones are occupied by management level of the project team and one set of mobile phone is occupied by D.K.

The total rental cost of mobile phone of functional elements for the total 31 months of this project can be calculated by the formula as follows:

**Total Rental Cost of Mobile Phone** *functional element* =

**Rental Cost of Mobile Phone** *functional element* x **Percentage of usage time** *functional element*

x **Total Working Time** *functional element*

The data of percentage of time usage of mobile phone, working time of each functional element, and the total rental cost of mobile phone is shown in Table 3-13 below:



**Table 3-13: Total rental cost of mobile phone of each functional element**

Functional Element	Rental Cost of Mobile Phone (Baht / month)	Usage Time (%)	Working Time (month)	Total Rental Cost of Mobile Phone (Baht)
Project Director (PD)	2,500	30	31	23,250
Project Management (PM)	2,500	30	31	23,250
Planning & Control (PC)	2,500	10	2.5	625
TOR & Bidding (TB)	2,500	30	7.5	5,625
Engineering & Construction Management (EM)	2,500	30	31	23,250
Mechanical Construction (MC)	2,500	5	6.5	813

### Pagers

In this project, all personnel except administration personnel occupied pagers. Since the pager is the personnel equipment, the rental cost of pager will be calculated and distribute to functional element follow the time allocation in each functional element of user.

The rental cost of pager of each functional element is calculated by the following formula:

$$\text{Rental Cost of Pager}_{\text{functional element}} = \Sigma (\text{Rental Cost of Pager}_i \times \text{Percentage of Time Allocation}_i)$$

While  $i$  = personnel that works in that functional element

Based on Table 3-5, the percentage of time allocation is used to calculate the rental cost of pager of each functional element as shown in Table 3-14 below:

Table 3-14: The rental cost of pager of each element in this project

Functional Element	Personnel	Rental Cost of Pager (Baht/month)	Time Allocation (%)	Cost Distribution (Baht/month)	Rental Cost of Pager (Baht/month)
Project Director (PD)	K.P.	436	30	131	131
Project Management (PM)	N.W.	436	30	131	131
Planning & Control (PC)	D.K.	436	10	44	131
	P.S.	436	10	44	
	J.B.	436	10	44	
Budget & Accounting (BA)	P.S.	436	10	44	87
	W.S.	436	10	44	
TOR & Bidding (TB)	D.K.	436	30	131	305
	P.S.	436	10	44	
	W.S.	436	10	44	
	J.B.	436	20	87	
Contract Management (CM)	P.S.	436	10	44	87
	W.S.	436	10	44	
Engineering & Construction Management (EM)	K.W.	436	30	131	131
Civil Construction (CC)	K.D.	436	100	436	872
	N.S.	436	100	436	
Mechanical Construction (MC)	P.S.	436	20	87	436
	W.S.	436	80	349	
Electrical & Instrument Construction (EC)	J.B.	436	100	436	436
Civil Engineering (CE)	K.D.	436	10	44	44
Mechanical Engineering (ME)	D.K.	436	5	22	109
	P.S.	436	10	44	
	W.S.	436	10	44	
Electrical & Instrument Engineering (EE)	J.B.	436	10	44	44
Safety (ST)	I.N.	436	10	44	44
Legal (LG)	P.R.	436	10	44	44

The total rental cost of pager of each functional element for the total 31 months of this project is calculated as follows:

$$\text{Rental Cost of Pager}_{\text{functional element}} = \text{Rental Cost of Pager}_{\text{functional element}} \times \text{Total Working Time}_{\text{functional element}}$$

Using Tables 3-14 and 3-7, the pager rental cost of each functional element and total working time of each element is used to calculate the total rental cost of pager of each functional element as shown in Table 3-15 below:

**Table 3-15: Total rental cost of pager of each functional element**

Functional Element	Rental Cost of Pager (Baht/month)	Total Working Time (month)	Total Rental Cost of Pager (Baht)
Project Director (PD)	131	31	4,055
Project Management (PM)	131	31	4,055
Planning & Control (PC)	131	2.5	327
Budget & Accounting (BA)	87	0.5	44
TOR & Bidding (TB)	305	7.5	2,289
Contract Management (CM)	87	1	87
Engineering & Construction Management (EM)	131	31	4,055
Civil Construction (CC)	872	13.75	11,990
Mechanical Construction (MC)	436	11.75	5,123
Electrical & Instrument Construction (EC)	436	7.5	3,270
Civil Engineering (CE)	44	6.5	283
Mechanical Engineering (ME)	109	6.5	709
Electrical & Instrument Engineering (EE)	44	6.5	283
Safety (ST)	44	17	741
Legal (LG)	44	8.5	371

### Copy Machine

The rental cost of copy machine of the PMO is approximately 4,500 Baht per month. This project used the copy machine approximately 30% of all usage of PMO. So the rental cost of copy machine of this project is approximately 1,350 Baht per month. So, the total cost of copy machine of this project in 31months is 41,850 Baht.

To distribute the rental cost of copy machine into each functional element, The percentage of usage is required for calculation. The percentage of usage of copy machine of this project was gathered from interviewing all personnel in this project. The percentage of usage of copy machine and total rental cost of copy machine of each functional element is calculated as shown in Table 3-16 below:

**Table 3-16: The percentage of usage of copy machine and total rental cost of copy machine of each functional element**

Functional Element	Rental Cost of Copy Machine (Baht)	Usage (%)	Total Rental Cost of Copy Machine (Baht)
Project Director (PD)	41,850	2	837
Project Management (PM)	41,850	2	837
Planning & Control (PC)	41,850	5	2,093
Budget & Accounting (BA)	41,850	3	1,256
TOR & Bidding (TB)	41,850	9	3,767
Contract Management (CM)	41,850	5	2,093
Engineering & Construction Management (EM)	41,850	2	837
Civil Engineering (CE)	41,850	12	5,022
Mechanical Engineering (ME)	41,850	12	5,022
Electrical & Instrument Engineering (EE)	41,850	12	5,022
Safety (ST)	41,850	3	1,256
Legal (LG)	41,850	3	1,256
Administration (AM)	41,850	30	12,555

### Facilities

Facilities cost was charged to all elements in the project team except the construction elements because they worked outside the office. The facilities cost was divided by the number of personnel of all personnel of the PMO. The cost of office building using was charged to the PMO is 28,105 Baht per month. There are 24 people who worked for the PMO. So, the facilities cost per personnel is 1,171 Baht per person per month.

The facilities cost of each functional element is calculate by the following formula:

$$\text{Facility Cost}_{\text{functional element}} = \sum (\text{Facilities Cost}_i \times \text{Percentage of Time Allocation}_i)$$

While  $i$  = personnel that works in that functional element

Using Table 3-5, the percentage of time allocation is used to calculate the rental cost of pager of each functional element as shown in Table 3-17 below:

**Table 3-17: The facilities cost of each element in this project**

Functional Element	Personnel	Facilities Cost (Baht/month)	Time Allocation (%)	Cost Distribution (Baht/month)	Facilities Cost (Baht/month)
Project Director (PD)	K.P.	1,171	30	351	351
Project Management (PM)	N.W.	1,171	30	351	351
Planning & Control (PC)	D.K.	1,171	10	117	351
	P.S.	1,171	10	117	
	J.B.	1,171	10	117	
Budget & Accounting (BA)	P.S.	1,171	10	117	234
	W.S.	1,171	10	117	
TOR & Bidding (TB)	D.K.	1,171	30	351	820
	P.S.	1,171	10	117	
	W.S.	1,171	10	117	
	J.B.	1,171	20	234	
Contract Management (CM)	P.S.	1,171	10	117	234
	W.S.	1,171	10	117	
Engineering & Construction Management (EM)	K.W.	1,171	30	351	351
Civil Engineering (CE)	K.D.	1,171	10	117	117
Mechanical Engineering (ME)	D.K.	1,171	5	59	293
	P.S.	1,171	10	117	
	W.S.	1,171	10	117	
Electrical & Instrument Engineering (EE)	J.B.	1,171	10	117	117
Safety (ST)	I.N.	1,171	10	117	117
Legal (LG)	P.R.	1,171	10	117	117
Administration (AM)	K.T.	1,171	20	234	937
	R.K.	1,171	30	351	
	N.I.	1,171	30	351	

The total facilities cost of each functional element for the total 31 months of this project is calculated as follows:

$$\text{Facilities Cost}_{\text{functional element}} = \text{Facilities Cost}_{\text{functional element}} \times \text{Total Working Time}_{\text{functional element}}$$

Using Table 3-17 and 3-7, the facilities cost of each functional element and total working time of each element is used to calculate the total facilities cost of each functional element as shown in Table 3-18 below:

**Table 3-18: Total facilities cost of each functional element**

Functional Element	Facilities Cost (Baht/month)	Total Working Time (month)	Total Facilities Cost (Baht)
Project Director (PD)	351	31	10,890
Project Management (PM)	351	31	10,890
Planning & Control (PC)	351	2.5	878
Budget & Accounting (BA)	234	0.5	117
TOR & Bidding (TB)	820	7.5	6,148
Contract Management (CM)	234	1	234
Engineering & Construction Management (EM)	351	31	10,890
Civil Engineering (CE)	117	6.5	761
Mechanical Engineering (ME)	293	6.5	1,903
Electrical & Instrument Engineering (EE)	117	6.5	761
Safety (ST)	117	17	1,991
Legal (LG)	117	8.5	995
Administration (AM)	937	31	29,041

## Overhead Expenses

### Utilities

#### Water supply

Water supply cost was charged to all functional elements in the project team except the construction elements because they worked outside the office. The water supply cost was divided by the number of personnel of all personnel of the PMO. The water supply cost was charged to the PMO is 788 Baht per



month. There are 24 people who worked for the PMO. So, the facilities cost per personnel is 33 Baht per person per month

### **Electric Supply**

Electric supply cost was charged to all functional elements in the project team except the construction elements because they worked outside the office. The electric supply cost was divided by the number of personnel of all personnel of the PMO. The electric supply cost was charged to the PMO is 15,152 Baht per month. There are 24 people who worked for the PMO. So, the facilities cost per personnel is 631 Baht per person per month

### **Telephone Fee**

Telephone fee was charged to all functional elements in the project team except the construction elements because they worked outside the office. The telephone fee was divided by the number of personnel of all personnel of the PMO. The telephone was charged to the PMO is 4,000 Baht per month. There are 24 people who worked for the PMO. So, the facilities cost per personnel is 167 Baht per person per month

The utilities cost of the PMO is the sum of water supply cost, electric supply cost, and telephone fee. So, the utilities cost of the PMO is 831 Baht per person per month.

The utilities cost of each functional element is calculate by the following formula:

$$\text{Utilities Cost}_{\text{functional element}} = \sum (\text{Utilities Cost}_i \times \text{Percentage of Time Allocation}_i)$$

*While i = personnel that works in that functional element*

Using Table 3-5, the percentage of time allocation of personnel is used to calculate the rental cost of pager of each functional element as shown in Table 3-19 below:

Table 3-19: The utilities cost of each element in this project

Functional Element	Personnel	Utilities Cost (Baht/month)	Time Allocation (%)	Cost Distribution (Baht/month)	Utilities Cost (Baht/month)
Project Director (PD)	K.P.	831	30	249	249
Project Management (PM)	N.W.	831	30	249	249
Planning & Control (PC)	D.K.	831	10	83	249
	P.S.	831	10	83	
	J.B.	831	10	83	
Budget & Accounting (BA)	P.S.	831	10	83	166
	W.S.	831	10	83	
TOR & Bidding (TB)	D.K.	831	30	249	582
	P.S.	831	10	83	
	W.S.	831	10	83	
	J.B.	831	20	166	
Contract Management (CM)	P.S.	831	10	249	166
	W.S.	831	10	83	
Engineering & Construction Management (EM)	K.W.	831	30	249	249
Civil Engineering (CE)	K.D.	831	10	83	83
Mechanical Engineering (ME)	D.K.	831	5	42	208
	P.S.	831	10	83	
	W.S.	831	10	83	
Electrical & Instrument Engineering (EE)	J.B.	831	10	83	83
Safety (ST)	I.N.	831	10	83	83
Legal (LG)	P.R.	831	10	83	83
Administration (AM)	K.T.	831	20	166	665
	R.K.	831	30	249	
	N.I.	831	30	249	

The total utilities cost of each functional element for the total 31 months of this project is calculated as follows:

$$\text{Utilities Cost}_{\text{functional element}} = \text{Utilities Cost}_{\text{functional element}} \times \text{Total Working Time}_{\text{functional element}}$$

According to Table 3-19 and 3-7, the utilities cost of each functional element and total working time of each element is used to calculate the total utilities cost of each functional element as shown in Table 3-20 below:

**Table 3-20: Total utilities cost of each functional element**

Functional Element	Utilities Cost (Baht/month)	Total Working Time (month)	Total Utilities Cost (Baht)
Project Director (PD)	249	31	7,728
Project Management (PM)	249	31	7,728
Planning & Control (PC)	249	2.5	623
Budget & Accounting (BA)	166	0.5	83
TOR & Bidding (TB)	582	7.5	4,363
Contract Management (CM)	166	1	166
Engineering & Construction Management (EM)	249	31	7,728
Civil Engineering (CE)	83	6.5	540
Mechanical Engineering (ME)	208	6.5	1,350
Electrical & Instrument Engineering (EE)	83	6.5	540
Safety (ST)	83	17	1,413
Legal (LG)	83	8.5	706
Administration (AM)	665	31	20,609

### Security

Security cost was charged to all elements in the project team except the construction elements because they worked outside the office. The security cost was divided by the number of personnel of all personnel of the PMO. The cost of security cost was charged to the PMO is 5,626 Baht per month. There are 24 people who worked for the PMO. So, the facilities cost per personnel is 234 Baht per person per month.

The facilities cost of each functional element is calculated by the following formula:

$$\text{Security Cost}_{\text{functional element}} = \sum (\text{Security Cost}_i \times \text{Percentage of Time Allocation}_i)$$

While  $i$  = personnel that works in that functional element

Using Table 3-5, the percentage of time allocation is used to calculate the rental cost of pager of each functional element as shown in Table 3-21 below:

**Table 3-21: The security cost of each element in this project**

Functional Element	Personnel	Security Cost (Baht/month)	Time Allocation (%)	Cost Distribution (Baht/month)	Security Cost (Baht/month)
Project Director (PD)	K.P.	234	30	70	70
Project Management (PM)	N.W.	234	30	70	70
Planning & Control (PC)	D.K.	234	10	23	70
	P.S.	234	10	23	
	J.B.	234	10	23	
Budget & Accounting (BA)	P.S.	234	10	23	47
	W.S.	234	10	23	
TOR & Bidding (TB)	D.K.	234	30	70	164
	P.S.	234	10	23	
	W.S.	234	10	23	
	J.B.	234	20	47	
Contract Management (CM)	P.S.	234	10	23	47
	W.S.	234	10	23	
Engineering & Construction Management (EM)	K.W.	234	30	70	70
Civil Engineering (CE)	K.D.	234	10	23	23
Mechanical Engineering (ME)	D.K.	234	5	12	59
	P.S.	234	10	23	
	W.S.	234	10	23	
Electrical & Instrument Engineering (EE)	J.B.	234	10	23	23
Safety (ST)	I.N.	234	10	23	23
Legal (LG)	P.R.	234	10	23	23
Administration (AM)	K.T.	234	20	47	187
	R.K.	234	30	70	
	N.I.	234	30	70	

The total security cost of each functional element for the total 31 months of this project is calculated as follows:

$$\text{Security Cost}_{\text{functional element}} = \text{Security Cost}_{\text{functional element}} \times \text{Total Working Time}_{\text{functional element}}$$

Using Table 3-21 and 3-7, the security cost of each functional element and total working time of each element is used to calculate the total security cost of each functional element as shown in Table 3-22 below:

**Table 3-22: Total security cost of each functional element**

Functional Element	Security Cost (Baht/month)	Total Working Time (month)	Total Security Cost (Baht)
Project Director (PD)	70	31	2,176
Project Management (PM)	70	31	2,176
Planning & Control (PC)	70	2.5	176
Budget & Accounting (BA)	47	0.5	23
TOR & Bidding (TB)	164	7.5	1,229
Contract Management (CM)	47	1	47
Engineering & Construction Management (EM)	70	31	2,176
Civil Engineering (CE)	23	6.5	152
Mechanical Engineering (ME)	59	6.5	380
Electrical & Instrument Engineering (EE)	23	6.5	152
Safety (ST)	23	17	398
Legal (LG)	23	8.5	199
Administration (AM)	187	31	5,803

The final calculations of all costs that were charged to the functional elements of this project are shown in Table 3-23 below:

**Table 3-23: All costs of each functional element of this project**

Functional Element	Manpower Cost (Baht)	Allowance	Supplies (Baht)	Rental Cost (Baht)					Facilities (Baht)	Utilities (Baht)	Security (Baht)
				Car	Computer	Mobile Phone	Pager	Copy Machine			
PD	803,148	0	1,860	279,000	15,345	23,250	4,055	837	10,890	7,728	2,176
PM	665,880	0	1,860	279,000	15,345	23,250	4,055	837	10,890	7,728	2,176
PC	28,893	0	3,720	0	2,475	625	327	2,093	878	623	176
BA	3,211	0	1,860	0	248	0	44	1,256	117	83	23
TB	204,488	0	7,440	22,500	7,425	5,625	2,289	3,767	6,148	4,363	1,229
CM	6,421	0	3,720	0	495	0	87	2,093	234	166	47
EC	665,880	0	1,860	279,000	15,345	23,250	4,055	837	10,890	7,728	2,176
CC	755,975	144,375	1,860	241,250	0	0	11,990	0	0	0	0
MC	342,513	105,750	1,860	173,750	0	0	5,123	0	0	0	0
EC	203,850	67,500	1,860	80,000	0	0	3,270	0	0	0	0
CE	29,237	0	11,160	0	0	0	283	5,022	761	540	152
ME	58,429	0	11,160	0	0	813	709	5,022	1,903	1,350	380
EE	17,667	0	11,160	0	0	0	283	5,022z	761	540	152
ST	76,466	0	1,860	0	0	0	741	1,256	1,991	1,413	398
LG	43,656	0	1,860	0	0	0	371	1,256	995	706	199
AM	415,586	0	27,900	0	30,690	0	0	12,555	29,041	20,609	5,803

According to Table 3-23, the total cost that was allocated to each element was calculated and shown in Table 3-24.

**Table 3-24: Total cost of each functional element of this project**

<b>Organisation Element</b>	<b>Cost (Baht)</b>
Project Director (PD)	1,148,290
Project Management( PM)	1,011,022
Planning & Control (PC)	39,809
Budget & Accounting (BA)	6,841
TOR & Bidding (TB)	265,272
Contract Management (CM)	13,263
Engineering & Construction (EM)	1,011,022
Civil Construction (CC)	1,155,450
Mechanical Construction (MC)	628,996
Electrical & Instrument Construction (EC)	356,480
Civil Engineering (CE)	47,156
Mechanical Engineering (ME)	79,765
Electrical Engineering (EE)	35,586
Safety (ST)	84,124
Legal (LG)	49,043
Administration (AM)	542,184
<b>Total Cost</b>	<b>6,474,300</b>

### 3.4 Cost Allocation

Cost allocation is the step that traces costs to activities. This step combines “Analyse Activities” step with “Gather Cost” step. This means the costs that were gathered and divided within the organisation structure will be allocated to the activity of the activity model. So, the cost of each activity is the cost of resource that the activity converts inputs into outputs.

In this study, the cost of each functional element of the project team will be allocated into the activity model by the process as follows:

- Identify categories of organisation elements
- Select the appropriate level of representative costs
- Redistribute organisation cost to operational elements
- Allocate final distribution cost to the activity model

#### 3.4.1 Identify Categories of Organisational Elements

Each organisational element serves as one of these three functions: managerial, support, or operational. The descriptions of each of these functions are as follows:

- **Managerial** – Managerial elements serve as the leadership and coordination of the organisation. Management element does not contribute directly to the organisation's output and must be distributed to the operational elements.
- **Support** – Support elements perform services that benefit the entire operation but do not contribute directly to the output. Cost of these elements will be distributed to managerial and operational elements that they support.
- **Operational** – Operational elements are the elements that do the work and contribute directly to the output.

In this study, the categories of organisational elements of this project team are identified in Table 3-25.



**Table 3-25: The categories of organisation element of this project**

Organisation Element	Organisation Categories
Project Director (PD)	Managerial
Project Management( PM)	Managerial
Planning & Control (PC)	Operational
Budget & Accounting (BA)	Operational
TOR & Bidding (TB)	Operational
Contract Management (CM)	Operational
Engineering & Construction (EM)	Managerial
Civil Construction (CC)	Operational
Mechanical Construction (MC)	Operational
Electrical & Instrument Construction (EC)	Operational
Civil Engineering (CE)	Operational
Mechanical Engineering (ME)	Operational
Electrical Engineering (EE)	Operational
Safety (ST)	Support
Legal (LG)	Support
Administration (AM)	Support

### 3.4.2 Select the appropriate Level of Representative Costs

There are three tiers of costs to be selected for cost allocation. They are direct costs, incremental costs, and full costs. The selection of direct cost, incremental costs, and full costs depends upon the effort of capturing and identifying of organisation cost in "Cost Gathering" step. In this study, although the full cost or all of the organisation's cost could not be captured, the incremental costs that consist of direct costs plus the support costs of the organisation were captured. Furthermore, some of the general overheads were captured and added to the incremental cost to add the cost to reach the full cost as much as possible.

### 3.4.3 Redistribute Organisation Costs to Operational Elements

To redistribute organisation costs to operational elements, first of all, requires additional information to determine how much cost is distributed into each operational element.

## Support Cost Allocation

Information in Table 3-26 is the data of percentage of average service of support elements that service other functional elements. The service cost of Administration, Safety, and Legal will be divided by the ratio that they service other elements. The elements that are served by these support elements will be charged the service cost by the ratio of service they receive. The data of percentage of average service of support elements can be gathered by interviewing the personnel who worked in these support elements.

**Table 3-26: Percentage of service that the supported elements served other elements**

Organisation Element	Percentage of Service (%)		
	Administration	Safety	Legal
Project Director	10	-	-
Project Management	10	-	-
Planning & Control	10	-	-
Budget & Accounting	8	-	-
TOR & Bidding	12	-	20
Contract Management	3	-	60
Engineering & Construction Management	10	-	-
Civil Construction	3	60	20
Mechanical Construction	3	24	-
Electrical & Instrument Construction	2	10	-
Civil Engineering	9	2	-
Mechanical Engineering	9	2	-
Electrical Engineering	9	2	-
Safety	1	-	-
Legal	1	-	-
Administration	-	-	-

## Managerial Cost Allocation

Each of the managerial elements was interviewed to determine what percentage of their total time went to each of the elements under their responsibility. The time allocation of managerial allocation from interview is shown in Table 3-27.

**Table 3-27: Time allocation of managerial elements**

Organisation Element	Time Allocations of Management Elements (%)		
	Project Director	Project Management	Engineering & Construction
Project Management	30		
Engineering & Construction Management	70		
Planning & Control		26	
Budget & Accounting		24	
TOR & Bidding		30	
Contract Management		20	
Civil Construction			20
Mechanical Construction			20
Electrical & Instrument Construction			10
Civil Engineering			20
Mechanical Engineering			20
Electrical Engineering			10

## Redistribution of Support Cost and Managerial Cost

In incremental cost distribution, support costs will be redistributed first followed by the managerial cost. In this study, there are three support elements: Administration, Safety, and Legal. They cannot be distributed simultaneously because the circular calculations will occur. So, the priority must be decided to proceed this process in logical order. This rule is described as follows:

- 1) The support functions that support other support functions will be divided first.

- 2) The support functions that interface the greatest number of elements will have higher priority to be divided than others.
- 3) If the number of interfaces is the same, the support function that use the highest cost value will have higher priority to be divided than others.

Reviewing the information in Table 3-26, Administration element supports Safety and Legal element, Safety element interfaces 6 elements, Legal element interfaces 3 elements. Therefore, the priority for distribution will be:

- 1) Administration
- 2) Safety
- 3) Legal

Using this prioritisation, the distribution will be done in two parts, first the support costs will be divided and distributed into the support, managerial, and operational elements one at a time in the order given by the rule until all the support costs have been totally divided. The cost of support element that is distributed into other elements is calculated based on the percentage of service that was gathered in the previous process. In this study, the distribution of the support costs to the other elements is shown in Table 3-28.

Table 3-28: Support cost allocation of this project

Organisation Elements	Initial Cost (Baht)	Support Cost Allocation (Baht)					
		Administration Allocation	Sub-total	Safety Allocation	Sub-total	Legal Allocation	Total Support Allocation
Administration	542,184						
Safety	84,124	5,422	89,546				
Legal	49,043	5,422	54,465	0	54,465		
Project Director	1,148,290	54,218	1,202,508	0	1,202,508	0	1,202,508
Project Management	1,011,022	54,218	1,065,240	0	1,065,240	0	1,065,240
Engineering & Construction Management	1,011,022	54,218	1,065,240	0	1,065,240	0	1,065,240
Planning & Control	39,809	54,218	94,027	0	94,027	0	94,027
Budget & Accounting	6,841	43,375	50,215	0	50,215	0	50,215
TOR & Bidding	265,272	65,062	330,334	0	330,334	10,893	341,227
Contract Management	13,263	16,266	29,528	0	29,528	32,679	62,207
Civil Construction	1,155,450	16,266	1,171,716	53,727	1,225,443	10,893	1,236,336
Mechanical Construction	628,996	16,266	645,261	21,491	666,752	0	666,752
Electrical Construction	356,480	10,844	367,324	8,955	376,278	0	376,278
Civil Engineering	47,156	48,797	95,952	1,791	97,743	0	97,743
Mechanical Engineering	79,765	48,797	128,562	1,791	130,352	0	130,352
Electrical Engineering	35,586	48,797	84,382	1,791	86,173	0	86,173

In Table 3-28, the support cost of administration element was distributed to the remaining elements based on the percentage of service from Table 3-26. The new cost of each element was calculated by adding the administration cost that was distributed into it. Then the next support function was divided.

This repeated itself until all support costs were distributed. The results of this table will be used in the next step, managerial cost allocation.

In the second part, the managerial costs that included support cost will be distributed into the operational elements. In this study, the distribution of the managerial cost to the operational elements is shown in Table 3-29.

**Table 3-29: Managerial Cost Allocation of this project**

Organisation Element	Direct & Support Cost (Baht)	Managerial Cost Allocation (Baht)			
		Project Director Allocation	Subtotal Division	Division Allocation	Final Distribution
Project Director	1,202,508				
Project Management	1,065,240	360,752	1,425,992		
Engineering & Construction Management	1,065,240	841,756	1,906,996		
Planning & Control	94,027			370,758	464,785
Budget & Accounting	50,215			342,238	392,454
TOR & Bidding	341,227			427,798	769,025
Contract Management	62,207			285,198	347,406
Civil Construction	1,236,336			381,399	1,617,735
Mechanical Construction	666,752			381,399	1,048,151
Electrical Construction	376,278			190,700	566,978
Civil Engineering	97,743			381,399	479,142
Mechanical Engineering	130,352			381,399	511,752
Electrical Engineering	86,173			190,700	276,873

In Table 3-29, the management cost of the Project Director element was distributed into the Project Management element and Engineering & Construction Management element based on the time

allocation from Table 3-27. The new cost of Project Management element and Engineering & Construction Management element were calculated by adding the Project Director cost that was distributed into them. Next, both the costs of Project Management element and Engineering & Construction element were distributed to the operational elements under their responsibility. A new cost of each operational element was calculated by adding its management cost that was distributed into it. The result of this step was the operational costs that already included the support cost and managerial cost. These costs were used to distribute to the activity model in next step.

#### **3.4.4 Allocate Final Distribution Costs to the Activity Model**

To allocate final distribution to the activity model requires additional information. The additional information is the percentage of time allocation of operational elements on each activity. This information comes from interviewing the personnel(s) in each operational element and their manager. The percentage of time allocation will be distributed into the activity model level by level. First, the percentage of workload of operational element will be distributed into the first level activities of this model (A1, A2, A3, A4, A5, A6, and A7). Next step, the value of percentage of time allocation of each first level activity of this model will be distributed into the next sub-activities of each node (e.g. A21, A22, A23, and A24). The percentage of time allocation of each activity will be equal to the summation of percentage of time allocation of its next level sub-activities.

For example, the TOR & Bidding element worked for this project only two major activities, activity A2 (Produce basic design, scope of work, cost estimation, and TOR) and A3 (Perform bidding work). The time allocation that this team worked for activity A2 and A3 are 2.5 and 5.5 months respectively. The total time that this team worked for this project is eight months. So, the percentage of time allocation on activity A2 and A3 will be 31.25 % and 68.75 % respectively. When considering activity A2, it consists of five sub-activities, A21 (Gather the require information), A22 (Gather the update technology information), A23 (Produce basic design & scope of work), A24 (Estimate construction cost), A25 (Produce term of reference). The time allocation of activity A21, A22, A24, and A25 are 0.5 month and the time allocation of activity A23 is 1 month. So, the percentage of time allocation of these activities will be distributed from the value of time allocation of activity A2 (31.25%). In addition, the percentage of





**Table 3-30 (Continued): Percentage of time allocation of each operational element on each activity**

Activity	Percentage of Time Allocation (%)									
	PC	BA	TB	CM	CC	MC	EC	CE	ME	EE
A211	0.000	0.000	0.174	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A212	0.000	0.000	0.174	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A213	0.000	0.000	2.430	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A214	0.000	0.000	2.430	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A22	0.000	0.000	5.208	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A23	0.000	0.000	10.418	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A24	0.000	0.000	5.208	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A25	0.000	0.000	5.208	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A3	0.000	0.000	68.750	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A31	0.000	0.000	3.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A32	0.000	0.000	3.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A321	0.000	0.000	1.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A322	0.000	0.000	1.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A323	0.000	0.000	0.625	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A33	0.000	0.000	12.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A331	0.000	0.000	3.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A332	0.000	0.000	3.125	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A333	0.000	0.000	6.250	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A34	0.000	0.000	12.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A341	0.000	0.000	0.420	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A342	0.000	0.000	0.840	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A343	0.000	0.000	11.240	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A35	0.000	0.000	37.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A351	0.000	0.000	0.420	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A352	0.000	0.000	3.090	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A353	0.000	0.000	33.990	0.000	0.000	0.000	0.000	0.000	0.000	0.000
A4	0.000	0.000	0.000	93.750	0.000	0.000	0.000	0.000	0.000	0.000
A41	0.000	0.000	0.000	23.440	0.000	0.000	0.000	0.000	0.000	0.000
A42	0.000	0.000	0.000	3.360	0.000	0.000	0.000	0.000	0.000	0.000
A43	0.000	0.000	0.000	6.690	0.000	0.000	0.000	0.000	0.000	0.000
A44	0.000	0.000	0.000	6.690	0.000	0.000	0.000	0.000	0.000	0.000
A45	0.000	0.000	0.000	46.880	0.000	0.000	0.000	0.000	0.000	0.000
A46	0.000	0.000	0.000	6.690	0.000	0.000	0.000	0.000	0.000	0.000
A5	0.000	0.000	0.000	0.000	90.625	91.667	86.667	92.308	92.308	92.308

**Table 3-30 (Continued): Percentage of time allocation of each operational element on each activity**

Activity	Percentage of Time Allocation (%)									
	PC	BA	TB	CM	CC	MC	EC	CE	ME	EE
A51	0.000	0.000	0.000	0.000	0.000	0.000	0.000	92.308	92.308	92.308
A511	0.000	0.000	0.000	0.000	0.000	0.000	0.000	92.308	0.000	0.000
A512	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	92.308	0.000
A513	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	92.308
A52	0.000	0.000	0.000	0.000	24.166	0.000	0.000	0.000	0.000	0.000
A521	0.000	0.000	0.000	0.000	5.370	0.000	0.000	0.000	0.000	0.000
A522	0.000	0.000	0.000	0.000	5.370	0.000	0.000	0.000	0.000	0.000
A523	0.000	0.000	0.000	0.000	2.685	0.000	0.000	0.000	0.000	0.000
A524	0.000	0.000	0.000	0.000	4.028	0.000	0.000	0.000	0.000	0.000
A525	0.000	0.000	0.000	0.000	4.028	0.000	0.000	0.000	0.000	0.000
A526	0.000	0.000	0.000	0.000	2.685	0.000	0.000	0.000	0.000	0.000
A53	0.000	0.000	0.000	0.000	57.395	79.167	66.667	0.000	0.000	0.000
A531	0.000	0.000	0.000	0.000	25.173	45.581	0.000	0.000	0.000	0.000
A5311	0.000	0.000	0.000	0.000	1.007	24.862	0.000	0.000	0.000	0.000
A53111	0.000	0.000	0.000	0.000	0.000	0.994	0.000	0.000	0.000	0.000
A53112	0.000	0.000	0.000	0.000	1.007	0.994	0.000	0.000	0.000	0.000
A53113	0.000	0.000	0.000	0.000	0.000	22.874	0.000	0.000	0.000	0.000
A5312	0.000	0.000	0.000	0.000	4.028	0.000	0.000	0.000	0.000	0.000
A53121	0.000	0.000	0.000	0.000	0.403	0.000	0.000	0.000	0.000	0.000
A53122	0.000	0.000	0.000	0.000	2.719	0.000	0.000	0.000	0.000	0.000
A53123	0.000	0.000	0.000	0.000	0.906	0.000	0.000	0.000	0.000	0.000
A5313	0.000	0.000	0.000	0.000	16.110	14.503	0.000	0.000	0.000	0.000
A53131	0.000	0.000	0.000	0.000	1.790	0.000	0.000	0.000	0.000	0.000
A53132	0.000	0.000	0.000	0.000	10.740	10.877	0.000	0.000	0.000	0.000
A53133	0.000	0.000	0.000	0.000	1.790	1.813	0.000	0.000	0.000	0.000
A53134	0.000	0.000	0.000	0.000	1.790	1.813	0.000	0.000	0.000	0.000
A5314	0.000	0.000	0.000	0.000	4.028	6.216	0.000	0.000	0.000	0.000
A53141	0.000	0.000	0.000	0.000	0.000	1.036	0.000	0.000	0.000	0.000
A53142	0.000	0.000	0.000	0.000	1.007	1.036	0.000	0.000	0.000	0.000
A53143	0.000	0.000	0.000	0.000	2.014	2.072	0.000	0.000	0.000	0.000
A53144	0.000	0.000	0.000	0.000	0.000	1.036	0.000	0.000	0.000	0.000
A53145	0.000	0.000	0.000	0.000	1.007	1.036	0.000	0.000	0.000	0.000
A532	0.000	0.000	0.000	0.000	24.166	0.000	0.000	0.000	0.000	0.000
A5321	0.000	0.000	0.000	0.000	3.452	0.000	0.000	0.000	0.000	0.000





Table 3-31 (Continued): Final cost distribution of each operational element on each activity

Activity	Final Cost Distribution										
	PC	BA	TB	CM	CC	MC	EC	CE	ME	EE	Total
A213	0	0	18,687	0	0	0	0	0	0	0	18,687
A214	0	0	18,687	0	0	0	0	0	0	0	18,687
A22	0	0	40,051	0	0	0	0	0	0	0	40,051
A23	0	0	80,117	0	0	0	0	0	0	0	80,117
A24	0	0	40,051	0	0	0	0	0	0	0	40,051
A25	0	0	40,051	0	0	0	0	0	0	0	40,051
A3	0	0	528,704	0	0	0	0	0	0	0	528,704
A31	0	0	24,032	0	0	0	0	0	0	0	24,032
A32	0	0	24,032	0	0	0	0	0	0	0	24,032
A321	0	0	9,613	0	0	0	0	0	0	0	9,613
A322	0	0	9,613	0	0	0	0	0	0	0	9,613
A323	0	0	4,806	0	0	0	0	0	0	0	4,806
A33	0	0	96,128	0	0	0	0	0	0	0	96,128
A331	0	0	24,032	0	0	0	0	0	0	0	24,032
A332	0	0	24,032	0	0	0	0	0	0	0	24,032
A333	0	0	48,064	0	0	0	0	0	0	0	48,064
A34	0	0	96,128	0	0	0	0	0	0	0	96,128
A341	0	0	3,230	0	0	0	0	0	0	0	3,230
A342	0	0	6,460	0	0	0	0	0	0	0	6,460
A343	0	0	86,438	0	0	0	0	0	0	0	86,438
A35	0	0	288,384	0	0	0	0	0	0	0	288,384
A351	0	0	3,230	0	0	0	0	0	0	0	3,230
A352	0	0	23,763	0	0	0	0	0	0	0	23,763
A353	0	0	261,391	0	0	0	0	0	0	0	261,391
A4	0	0	0	325,693	0	0	0	0	0	0	325,693
A41	0	0	0	81,432	0	0	0	0	0	0	81,432
A42	0	0	0	11,673	0	0	0	0	0	0	11,673
A43	0	0	0	23,241	0	0	0	0	0	0	23,241
A44	0	0	0	23,241	0	0	0	0	0	0	23,241
A45	0	0	0	162,864	0	0	0	0	0	0	162,864
A46	0	0	0	23,241	0	0	0	0	0	0	23,241
A5	0	0	0	0	1,466,072	960,809	491,383	442,287	472,388	255,576	4,088,514
A51	0	0	0	0	0	0	0	442,287	472,388	255,576	1,170,250

Table 3-31 (Continued): Final cost distribution of each operational element on each activity

Activity	Final Cost Distribution										
	PC	BA	TB	CM	CC	MC	EC	CE	ME	EE	Total
A511	0	0	0	0	0	0	0	442,287	0	0	442,287
A512	0	0	0	0	0	0	0	0	472,388	0	472,388
A513	0	0	0	0	0	0	0	0	0	255,576	255,576
A52	0	0	0	0	390,942	0	0	0	0	0	390,942
A521	0	0	0	0	86,872	0	0	0	0	0	86,872
A522	0	0	0	0	86,872	0	0	0	0	0	86,872
A523	0	0	0	0	43,436	0	0	0	0	0	43,436
A524	0	0	0	0	65,162	0	0	0	0	0	65,162
A525	0	0	0	0	65,162	0	0	0	0	0	65,162
A526	0	0	0	0	43,436	0	0	0	0	0	43,436
A53	0	0	0	0	928,499	829,790	377,987	0	0	0	2,136,276
A531	0	0	0	0	407,232	477,758	0	0	0	0	884,990
A5311	0	0	0	0	16,291	260,591	0	0	0	0	276,882
A53111	0	0	0	0	0	10,419	0	0	0	0	10,419
A53112	0	0	0	0	16,291	10,419	0	0	0	0	26,709
A53113	0	0	0	0	0	239,754	0	0	0	0	239,754
A5312	0	0	0	0	65,162	0	0	0	0	0	65,162
A53121	0	0	0	0	6,519	0	0	0	0	0	6,519
A53122	0	0	0	0	43,986	0	0	0	0	0	43,986
A53123	0	0	0	0	14,657	0	0	0	0	0	14,657
A5313	0	0	0	0	260,617	152,013	0	0	0	0	412,630
A53131	0	0	0	0	28,957	0	0	0	0	0	28,957
A53132	0	0	0	0	173,745	114,007	0	0	0	0	287,752
A53133	0	0	0	0	28,957	19,003	0	0	0	0	47,960
A53134	0	0	0	0	28,957	19,003	0	0	0	0	47,960
A5314	0	0	0	0	65,162	65,153	0	0	0	0	130,315
A53141	0	0	0	0	0	10,859	0	0	0	0	10,859
A53142	0	0	0	0	16,291	10,859	0	0	0	0	27,149
A53143	0	0	0	0	32,581	21,718	0	0	0	0	54,299
A53144	0	0	0	0	0	10,859	0	0	0	0	10,859
A53145	0	0	0	0	16,291	10,859	0	0	0	0	27,149
A532	0	0	0	0	390,942	0	0	0	0	0	390,942
A5321	0	0	0	0	55,844	0	0	0	0	0	55,844



Using Table 3-31, the cost of each activity that is performed by each operational element is calculated. The total cost of each operational element that is calculated by the sum of the cost of each operational element that performed that activity. For example, activity A5 is performed by six operational elements which are Civil Construction element, Mechanical Construction element, Electrical & Instrument Construction element, Civil Engineering element, Mechanical engineering element, and electrical & Instrument Engineering element. Therefore, the cost of activity A5 is the summation of the cost that these operational elements performed activity A5. The total cost of activity A5 is calculated as follows:

$$\begin{aligned}\text{Cost of activity A5} &= \text{Summation of cost of each operational element that do activity A5} \\ &= 1,466,072 + 960,809 + 491,383 + 442,287 + 472,388 + 255,576 \\ &= 4,088,514 \text{ Baht}\end{aligned}$$

The total cost of other activities or sub-activities can be calculated in the same manner.



### 3.5 Output Measure Establishing

“Establish output measures” is the step that examines the components of the activity. These components are used as a source of improvement in the evaluation analysis. Output measures aim to know the cost of an activity is used for a unit of output and how much actual time and elapsed time it takes for one unit of output. In this study, the output measure was established first, and then used for analysis in the next chapter.

#### 3.5.1 Analyse Activity Output and Performance

To analyse activity requires the fully understanding of the activity and its components before making the decision. This step requires a complete review to answer the questions of what the activity does what it produces, and the time to produce the output. The analysis of activity output and performance in this study is shown in Table 3-32.

#### 3.5.2 Select the Output Measures

In this step, the appropriate output measures that are used for this activity are selected. The output measures of this study are shown in Table 3-32.

#### 3.5.3 Determine the Activity Output Cost Per Unit of Output

The activity output cost per unit of output is the factor that is used to allocate the consumption of the activity to the output in process flow based on the units of output produced. Calculating the activity output cost per unit of output requires the mathematical calculation. For this calculation, the amount of output that was selected in the previous step and the total cost of the activity that was calculated in the step “Trace cost to activity” is used. The calculation can be described in the equation as follows:

$$\text{Cost Per Output Unit} = \text{Total Activity Cost} / \text{Total Units of Output}$$

For example, the cost per output of activity A12 (Produce progress report) that consumed the cost of 232,393 Baht to produce 31 sets of progress reports are calculated as follows:

$$\text{Cost per unit of output of activity A12} = 232,393 / 31 = 7,497 \text{ Baht per report}$$

The calculation result of this study is shown in Table 3-32.

**Table 3-32: Analysis of output measure**

Activity	Output	Time	Output Measure	No. of Output	Cost per unit of output (Baht/unit)
A1	Control plan/ Schedule	2.5 months	Number of control plan	31	14,993
A11	Control plan/ Schedule	2.5 months	Number of control plan	31	5,997
A12	Progress Report	2.5months	Number of progress report	31	7,497
A13	Project Evaluation Report	2.5 months	Number of Evaluation report	31	1,499
A2	Approved TOR and estimated cost	2.5 months	Number of Approved TOR / estimated cost	1	240,320
A21	Evaluated Information	0.5months	Number of evaluation information	1	40,051
A211	List of problem & requirements	0.5 day	Number of list of problem / requirement	1	1,338
A212	Site survey report	0.5 day	Number of site survey report	1	1,338
A213	Required existing information	0.25 month	Number of required existing information	1	18,687
A214	Evaluate information	0.25 month	Number of evaluate information	1	18,687
A22	Selected technology information	0.5 month	Number of technology information	1	40,051
A23	Approved Basic Design & Scope of Work	1 month	Number of approved Basic Design & Scope of Work	1	80,117
A24	Approved estimated construction cost	0.5 month	Number of estimated construction cost	1	40,051
A25	Approved TOR	0.5 month	Number of approved TOR	1	40,051
A3	Success Bidder	5.5 month	Number of success bidding	1	528,704
A31	Permission of Extra Method Acquisition	0.25 month	Number of permission of extra method acquisition	1	24,032
A32	Bidders that accept to bid	0.25 month	Number of bidders that accept to bid	2	12,016
A321	List of selected construction contractors	2 day	Number of list	1	9,613
A322	Interest to bid bidders	2 day	Number of interest to bid bidder	4	2,403
A323	Bidders that accept to bid	1 day	Number of bidders that accept to bid	2	2,403

Table 3-32 (Continued): Analysis of output measure

Activity	Output	Time	Output Measure	No. of Output	Cost per unit of output (Baht/unit)
A33	Bid package from bidders	1 month	Number of bid package	2	48,064
A331	Survey information letter	0.25 month	Number of survey information letter	2	12,016
A332	Note of bid question from bidders	0.25 month	Number of note of bid questions	2	12,016
A333	Bid packages from bidders	0.5 month	Number of bid package	2	24,032
A34	Bid evaluation report	1 month	Number of bid evaluation report	1	96,128
A341	Technical & Pricing Packages	1 day	Number of technical & pricing package	2	1,615
A342	Deposited bid guarantee	2 day	Number of deposited bid guarantee	2	3,230
A343	Bid evaluation report	1 month	Number of bid evaluation report	1	86,438
A35	Success Bidder	3 months	Number of success bidder	1	288,384
A351	Approved bid evaluation	1 day	Number of approval	1	3,230
A352	Invite letter to negotiate	0.25 month	Number of invite letters to negotiate	4	5,941
A353	Success bidder	2.75 months	Number of success bidding	1	261,391
A4	Construction contract / contractor	1 month	Number of construction contract	1	325,693
A41	Permission to award contract	0.25 month	Number of permission	1	81,432
A42	Notice of award	1 day	Number of notice to award	1	11,673
A43	Returned bid guarantee	2 day	Number of returned bid guarantee	2	11,621
A44	Deposited Performance Security Bond	2 day	Number of deposited performance security bond	1	23,241
A45	Construction contract	0.5 month	Number of construction contract	1	162,864
A46	Notice to start	2 day	Number of notice to start	1	23,241
A5	Finished work	20 months	Number of finished work	1	4,088,514
A51	Approved engineering documents	6 months	Number of approved engineering documents	1	1,170,250
A511	Approved civil documents	6 months	Number of approved civil document	1	442,287
A512	Approved mechanical documents	6 months	Number of approved mechanical document	1	472,388

Table 3-32 (Continued): Analysis of output measure

Activity	Output	Time	Output Measure	No. of Output	Cost per unit of output (Baht/unit)
A513	Approved electrical / instrument documents	6 months	Number of approved electrical / instrument document	1	255,576
A52	Finished office/ warehouse	4 months	Number of finished office/ warehouse	1	390,942
A521	Finished demolish work	1 months	Number of finished demolish work	1	86,872
A522	Finished warehouse structure	1 months	Number of finished warehouse structure	1	86,872
A523	Finished warehouse roof	0.5 month	Number of finished warehouse roof	1	43,436
A524	Finished concrete work	0.5 month	Number of finished concrete work	1	65,162
A525	Unpainted warehouse	0.75 month	Number of unpainted office/warehouse	1	65,162
A526	Finished office/warehouse	0.75 month	Number of finished office/warehouse	1	43,436
A53	Finished main construction work	9.5 months	Number of finished main construction work	1	2,136,276
A531	Finished main construction work	9.5 months	Number of finished main construction work	1	884,990
A5311	Finished pre-fabncation work	6 months	Number of finished pre-fabrication work	1	276,882
A53111	Approved steel plates	0.25 day	Number of approved steel plates	1	10,419
A53112	Approved materials	0.25day	Number of approved materials	1	26,709
A53113	Finished pre-fabrication work	5.75 months	Number of finished pre-fabrication work	1	239,754
A5312	Finished firewall	1 month	Number of finished firewall	1	65,162
A53121	Approved firewall material & equipment	3 day	Number of firewall material & equipment	1	6,519
A53122	Finished firewall	0.75 month	Number of finished firewall	1	43,986
A53123	Finished firewall with equipment	0.25 month	Number of firewall with equipment	1	14,657
A5313	Finished erection tank	4 months	Number of finished erection tank	1	412,630
A53131	Finished column & bracing	0.5 month	Number of tank	1	28,957
A53132	Finished shell plate erection	3 months	Number of tank	1	287,752

Table 3-32 (Continued): Analysis of output measure

Activity	Output	Time	Output Measure	No. of Output	Cost per unit of output (Baht/unit)
A53133	Finished spray water ring	0.5 months	Number of tank	1	47,960
A53134	Finished tank accessories	0.5 months	Number of tank	1	47,960
A5314	Finished Tank	1.5 months	Number of tank	1	130,315
A53141	Post NDE tank	0.25 month	Number of tank	1	10,859
A53142	Post PWHT tank	0.25 month	Number of tank	1	27,149
A53143	Painted tank	0.5 month	Number of tank	1	54,299
A53144	Passed hydrostatic test tank	0.25 month	Number of tank	1	10,859
A53145	Finished tank	0.25 month	Number of tank	1	27,149
A532	All finished civil work	6 months	Number of finished civil work	1	390,942
A5321	Finished drainage system	1 month	Number of finished drainage system	1	55,844
A5322	Finished concrete pavement	1 month	Number of finished concrete pavement	1	55,844
A5323	Finished pipe supports	2 months	Number of pipe support	1	7,447
A5324	Finished pipe crossing walkway	1 month	Number of set of pipe crossing walkway	1	18,615
A5325	Finish spillwall / bundwall	2 months	Number of spillwall / bundwall	1	111,705
A533	Finished pipeline	7 months	Number of finished pipeline	1	70,406
A5331	Approved pipe materials	0.25 month	Number of set of pipe material	1	9,025
A5332	Finished spool piece	4 months	Number of set of spool piece	1	144,425
A5333	Install pipeline	5 months	Number of installed pipeline	1	36,107
A53331	Installed pipeline	4 months	Number of installed pipeline	1	28,308
A53332	NDE passed pipeline	0.25 month	Number of NDE passed pipeline	1	1,769
A53333	Hydrostatic test passed pipeline	0.25 month	Number of hydrostatic test passed pipeline	1	1,769
A53334	Painted pipeline	0.5 month	Number of painted pipeline	1	3,539
A53335	Tie-in pipeline	3 day	Number of tie-in pipeline	1	721
A5334	Finished pipeline	0.5 month	Number of finished pipeline	1	3,610
A534	Passed pre-commissioning electrical & instrument work	5 months	Number of passed pre-commissioning electrical & instrument work	1	508,312

Table 3-32 (Continued): Analysis of output measure

Activity	Output	Time	Output Measure	No. of Output	Cost per unit of output (Baht/unit)
A5341	Approved electrical & instrument equipment	0.25 month	Number of approved electrical & instrument equipment	1	18,897
A5342	Installed electrical equipment	3.5 months	Number of installed electrical equipment	1	394,916
A53421	Finished trench work	2 months	Number of trench work	1	200,885
A53422	Finished conduit & supporting work	1 month	Number of conduit & supporting work	1	35,277
A53423	Installed cable	1.5 months	Number of installed cable	1	52,916
A53424	Finished tank grounding system	2 months	Number of finished tank grounding system	1	70,560
A53425	Installed instruments	1 month	Number of set of installed instrument	1	35,277
A5343	Finished control panel	1 month	Number of finished control panel	1	75,601
A5344	Finished electrical & instrument work	0.25 month	Number of finished electrical & instrument system	1	18,897
A54	Finished Work	1.5 month	Number of finished work	1	391,046
A6	Final finished work	2 months	Number of final finished work	1	433,830
A61	Final finished work	1 month	Number of final finished work	1	264,046
A62	Cleared site	0.5 month	Number of cleared site	1	50,554
A63	Initial Acceptance Certificate	2 day	Number of Initial Acceptance Certificate	1	21,713
A64	Approved as-built documents	0.5 month	Number of as-built document	1	97,517
A7	Note of payment	0.5 month	Number of payment	1	43,606

### 3.5.4 Determine the Time Requirement

The amount of time required to produce one unit of output was analysed in the first step. Basically, this data should be captured in two parts. The first part is the amount of actual time required to complete one unit of output without the time delay. The second part is the total elapsed time to produce one unit

of output including all of the time delays. Unfortunately, this study began long after the start of this Project . Therefore, only the elapsed time was available.

In conclusion, modeling of activity and cost gathering & allocation is a comprehensive and controlled process flow of ABC technique. Following the procedure outline herein, the activity model and organisational data will result in a set of activity cost that will be the basis for evaluating decisions and recommendations for cost reduction and process improving. Output measures are established as sources of improvement in evaluation analysis. In conjunction with the activity model and activity cost, these factors will enable the team to conduct intensive reviews and evaluations on the model and the process represented throughout the model. It is important that these determined factors be best representation of the data and time available. If the data is not a fair representation, then the decisions that are made will be not so good.