Application of Lean Enterprise Concept to Construction Firms in Japan

by

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ABSTRACT

Construction firms in Japan are struggling with the change in construction industry environment and need a new business model to meet the change. On the other hand, Japanese manufacturing companies, especially automobile companies, are at their peak standing on their strong production system, which is called the lean production system. The lean production system has its origin in the Japanese automobile industry and has changed the dynamics of international competition of the manufacturing industry. The construction industry is a non-manufacturing business; however, lean concepts could assist in the development of a new business model in the construction context.

This thesis derived lean concepts from the manufacturing industry and examined their applicability for construction firms in Japan, by exploring the business processes of the Japanese construction industry from three perspectives: the production level, the enterprise level, and the extended enterprise level. This thesis revealed that the peculiarities of the construction industry created barriers to reap the full benefit of the lean transformation at the production and the enterprise level. This thesis concluded that the Japanese construction industry should apply lean concepts at the extended enterprise level. A case study of a new airport construction project in Japan supported this conclusion.

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Last but not least, I dedicate this thesis to my beautiful wife, Kimiko. Without her understanding and cooperation, I would not have completed this work.

Hiroshi Taguchi
Cambridge, Massachusetts
May 2004

Biographical Note

The author, Hiroshi Taguchi, was born June 5, 1973, in Morioka, Japan. He earned Bachelor of Engineering degree in Civil Engineering from the University of Tokyo in 1997 with the Sakuzo Tanabe prize for the best undergraduate thesis in the civil engineering department. He is a registered civil engineer and worked for 5 years in the construction industry in Japan, managing large and complex underground construction projects with the pneumatic caisson method. Since 2002, he has been a graduate student and master candidate at the Construction Engineering and Management Program at MIT.

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Chapter 1. Introduction

1.1 Research Objectives

Construction firms in Japan need new business models to meet the change in the construction industry environment. This industry has a long history and its business model has not changed drastically because continuous growth in the Japanese economy has supported the industry until recently. However, this situation won't last long for the future because the Japanese construction market has already reached the matured stage. Most construction firms suffer from a declining amount of orders and lower profitability due to the shrinking market and the fierce competition. To survive this environmental change, currently their basic strategy is changing their cost structure by improving productivity at their construction sites and reducing selling, general and administrative expenses and procurement costs, all to improve their bottom line. However, this strategy is not a long lasting policy and management and employees are stalled with no way out of this situation because there is no backbone to support the strategy.

On the other hand, Japanese manufacturing companies, especially automobile companies, are at their peak standing on their strong production system, which is called the lean production system. The construction industry is a non-manufacturing business; however, lean concepts could assist in the development of a new business model in the construction context.

This thesis explores principles and mechanisms of lean concepts and examines the applicability of lean concepts to construction firms in Japan.

1.2 General Approach

First, basic ideas and methodologies of lean concepts in the manufacturing industries are explored. Through this process, three types of lean concepts are defined: lean production concept, lean enterprise concept, and extended lean enterprise concept. Then, the applicability of these concepts for construction firms in Japan is examined. Finally, a case study shows what kind of approach should be taken to apply lean concepts to the Japanese construction industry.

Chapter 2. Lean Production

2.1 Introduction

Lean production has its origin in the Toyota Production System in Toyota Motor Company. Lean production is a completely different concept from mass production. Before the lean production system, mass production dominated the manufacturing industry. When Toyota made a strategic decision to pursue a different production system after World War II, automobile companies in the United States and European countries were already large and enjoyed the economies of scale of the mass production system. Toyota could not follow the mass production system because the Japanese domestic automobile market was small and fragmented, the workforce was in short supply, natural sources were scarce, land was limited, and little capital was available for investment. To overcome these constraints, Toyota developed a production system that used less of everything compared with mass production – less human effort in the factory, less manufacturing space, less investment in tools, and fewer engineering hours to develop a new product.

At first, the Toyota Production System did not attract other Japanese manufacturing companies' interest because their business went well during the era of high-speed economic growth. However, after the energy crisis in 1973, economic growth slowed down and the companies no longer prospered using mass production. Then Japanese manufacturing companies

started to express considerable interest in the Toyota Production System (TPS).

TPS was introduced with the phrase "lean production system" by James Womack, Daniel Jones, and Dan Roos in *The Machine That Changed The World* (1991), with the key findings that the best Japanese auto companies had developed a fundamentally different way of making things and that these companies had changed the dynamics of international competition. This book summarized the first five years of work in the International Motor Vehicle Program (IMVP), an MIT-based research institute, and found that Japanese-owned assembly plants in Japan, as well as the U.S. plants of Japanese automakers, enjoyed both higher productivity and higher quality compared with the domestically owned plants in Europe and in the United States, where one could find either high productivity or high quality, but not both.

Table 2.1 shows the difference among three types of production system. We know both craft and mass production systems from our daily life. However, lean production looks unfamiliar at first. In this chapter, we will explore principles and techniques of the lean production concept that will be expanded to the lean enterprise concept later.

	Craft	Mass Production	Lean Thinking
Focus	Task	Product	Customer
Operations	Single items	Batch and queue	Synchronized flow and pull
Overall Aim	Mastery of craft	Reduce cost and increase efficiency	Eliminate waste and add value
Quality	Integration (part of the craft)	Inspection (a second stage, after production)	Prevention (built in by design and methods)
Business Strategy	Customization	Economies of scale and automation	Flexibility and adaptability
Improvement	Master-driven continuous improvement	Expert-driven periodic improvement	Workforce-driven continuous improvement

Table 2.1 Three types of production system (Murman et al.)

2.2 Lean production principles

The main idea of the Toyota Production System is absolute elimination of waste, and this mantra is supported by two pillars: just-in-time production and autonomation (automation with a human touch) (Ohno 1988).

Just-in-time production

Just-in-time production is the situation of producing or conveying only the items that are needed by the next process when they are needed and in the quantity needed. This situation will create fewer inventories in the factory and help financially and physically as inventories approach the zero level.

Traditional production management practices that create a production plan for each production process do not work well to achieve this goal. This is because small changes in each process create shortages of parts in some areas while unnecessary inventory pile up in other areas; this does not allow an inventory-free production system.

The breakthrough to achieve just-in-time production was to think about production flow in the reverse direction: a later process would pull back on an earlier process to pick up only the right part, in the quantity needed, and exactly when needed. In an earlier process, the number of parts made would be only that number withdrawn by the next process downstream. By applying this concept, each production line is highly synchronized to the final assembly line and creates a dramatically low inventory as a whole.

Autonomation (Automation with a human touch)

Automation is a key part of mass production. Mass production uses high-performance, high-speed machines to improve productivity. However this system creates many defective products once trouble happens. "Autonomation" means designing in an element of machines so

as to prevent this problem. Sakichi Toyoda, the founder of Toyota Motor Company, invented an automatic weaving machine that stopped if any of the threads broke. An autonomated machine is therefore one that can distinguish between normal and abnormal conditions, and if abnormal conditions are detected by the machine, it stops immediately. This basic idea goes beyond the machine level. Production lines are also stopped by line workers when an abnormal condition happens. These approaches prevent defective products and overproduction and stop malfunctions in production lines automatically.

The basis for the idea of absolute elimination of waste is rooted in the following two points:

(1) Improving efficiency makes sense only when it is tied to cost reduction. To achieve this, only the things needed must be produced, using minimum manpower.

(2) Look at the efficiency of each operator and each line, then look at the operators as a group, and then at the efficiency of the entire plant (all lines). The efficiency must be improved at each step, and at the same time, for the plant as a whole.

Ohno defined the activities needed to produce the product as divided into real work and waste, and the following equation would hold true whether considering individual workers or an entire production line: Present capacity = work + waste.

Eliminating waste is the true productivity improvement and should be followed by reducing the present capacity. If the elimination of waste is replaced by increased work and present capacity is retained, this only creates new waste. To avoid this situation, Ohno defined seven types of waste in manufacturing.

(1) Overproduction: Producing more than is required or producing something before it is required; any work performed which is not "pulled" by the next production process.

(2) Waiting: A condition caused by (a) a production operation waiting for maintenance, for

material/parts from a previous operation, tooling, operator readiness, etc., or (b) production parts waiting in a queue (perhaps in batches).

(3) Transportation: Excessive movement of material/tools between production operations, between facilities, or to and from storage.

(4) Over-processing: Using oversized equipment or equipment not designed for the task at hand, thereby requiring excess running time and costs; using equipment that has not been properly maintained, thereby requiring excess processing.

(5) Excessive Inventories: Maintaining stocks of raw materials in excess of current production requirements; or stocks of finished goods in excess of current customer demand; or stocks of work in progress as buffers between un-synchronized production operations.

(6) Unnecessary Motion: Human actions/motions beyond the minimum required to achieve the task at hand, i.e., tasks which, in themselves, do not add value.

(7) Defective Products: Parts, materials, sub-assemblies, or products that do not meet specifications and which must be scrapped or reworked to bring them into conformance

2.3 Lean production mechanisms

Various tools and techniques have been developed to realize just-in-time production and autonomation. Table 2.2 shows these tools and techniques. At first glance, the Toyota Production System just throws together detailed activities and techniques at production lines. Many companies tried to implement TPS but failed because they saw it as know-how of the manufacturing techniques and did not understand the underlying ideas.

TPS has the mechanism of specifying the problem and the production-line-based rapid problem-solving cycle, and both of them enable fast-track improvement within the organization. For example, just-in-time production requires reduction of inventories, which makes inventory in

Ohno's Pillars of Leanness	Tools to Become Lean	
	Name	Function
Waste Elimination		
	7 Wastes	Identify the activities to remove from the system
	5S	Clean environment to avoid waste
	SPC	Avoid out of tolerance production
	Autonomation	Avoid producing defects
	Baka Yoke, Poka-Yoke	Avoid introducing production errors
	Use Good Equipment	Avoid introducing production defects
Just-in-time production		
	Kanban	Trigger mechanism for flow and pull
	Point of Use(POU) delivery	Introduces parts when and where needed, no overhead for receiving, handing, storage, etc.
	Andon	Warn of pending problems in the system
	SMED	Allows quick changeover for multiple products to be made on same machine and/or in same line
	Multi-machine operation	Distribute labor across multiple machines
	Workload leveling	Single piece flow
	Work standardization	Workload leveling, allows scientific improvement
	Right sized equipment	Single piece flow
	Mixed Production	Multiple products on same line
	Load Chart	Matches mixed production to mixed demand, reducing inventory, WIP build-up, and lead-time
	Supermarket	Fills in the gap where flow must stop
	Demand leveling	Eliminates large fluctuations in production demand
	TPM	Keeps the system operating normally
Continuous improvement in the right organizational environment		
	Kaizen	Structured improvement event
	Solve problems at lowest point in organization	Use all intelligence in organization, things get fixed faster, distributed decision making
	Employee Involvement	All brains are better than one, make employees feel more valuable, use their knowledge
	Teamwork	Working together solves problems
	Management by Ninjutsu	Employees coached by management
	Stand on shop floor	See how things actually work, change not dictated from an office
	Kaikaku	Radical improvement, a.k.a. breakthrough kaizen
	Cross-training	Employees have wider assortment of skills and daily activities, increase job satisfaction
	Scientific Improvement	All improvements must be run like an experiment with metrics for success established *a priori*
	5 Why's	Root cause analysis of problems

Table 2.2 Mapping of Ohno's lean philosophies to lean tools and techniques (Hallam 2003)

the production line a sign of waste. Other tools and techniques like *andon* and 5S also help problems to be detected. These signals activate continuous improvement and the repetition of this process makes employees more sensitive to continuous improvement and problem finding. Once the problem is defined, the problem-solving cycle begins from the production level. Workforces figure out root causes quickly, then create and evaluate improvement plans, and finally internalize these solutions in the organization.

What are the necessary conditions to implement the lean production system? There are five policies management should obey[1]:

Maintain long-term employment

Lean production eliminates waste and improves productivity, and as a result, creates surplus workforces. If management did not secure long-term employment for their workforces, continuous improvement would not happen at the production level. Long-term improvement also creates the environment and educational system to pursue continuous improvement.

Appoint a full-time transformation team

Lean production reveals hidden problems at first, and most of its principles and techniques are counterintuitive for workforces. Therefore, the failure of implementation is very likely. Temporary task forces cannot keep the momentum of lean transformation. A special team should be created to check the implementation regularly.

Management buy-in

Management should be the leader of lean transformation processes. They should create a shared vision that promotes this process.

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[1] Nikkei Business 2004.04.12

Being positive about failures

At the initial stage of lean transformation, there may be numerous failures. Although the lean production system's built-in alarms signal waste within production lines, the problem-solving cycle does not work well at first and, as a result, failures pile up. Therefore, management should remain patient until their workforce learns from experience and the problem-solving cycle starts to work well.

Evaluate the effort that is not connected directly with business performance

Lean transformation needs a culture in which every worker voluntarily suggests improvements. Near-term performance should not be overemphasized, so as to create a good environment for workforce. Trust-based relationships between management and labor should be established.

2.4 Benefits of lean production

After a successful lean transformation, factories typically achieve the following results (*LESAT Facilitator's Guide* 2000):

> *There is a dramatic improvement in responsiveness to customers. Shipments are rarely late; the number of defects reaching customers drop significantly, and overall customer satisfaction is much greater – thereby increasing market share.*
>
> *Most of the factory-floor chaos is eliminated. Rather than aisles clogged with batch production orders waiting for processing at banks of identical machines grouped together, individual parts and assemblies move smoothly within the Lean factory's synchronized manufacturing cells, never stopping until processing and inspection are completed. Production flow times are reduced by 80 percent to 90 percent. Workstations are well organized and neat; no idle parts or carts clutter the workspace. No expeditors*

are needed to push through late production orders by brute force. Storage racks for work-in-progress are largely eliminated. Material handling is simplified, often with manual methods replacing automation. Re-work stations are gone. Scrap is significantly reduced, and the factory floor is much cleaner. Labor productivity is double or triple that of the past. Production control systems and their associated information systems are greatly simplified.

Shipments from certified suppliers arrive shortly before needed, are organized in the correct sequence, and move directly to the point of use with no need for incoming inspection. Warehouse space for purchased parts and materials is reduced by 80 percent to 90 percent in many cases.

Completed orders are shipped immediately to customers upon completion of the last stage in the internal value chain, rather than accumulating in large warehouses. Orders are shipped to customers in small quantities (often single units) rather than in large lots. The total floor space needed in Lean factories is typically 55 percent to 65 percent of that needed in mass production factories for the same level of production.

Inventory levels at all stages (raw materials, in-process, and finished goods) are dramatically lower, often by greater than 90 percent.

Table 2.3 shows the simple rule of thumb, based on years of benchmarking and observation in organizations around the world, developed by Womack and Jones (1996). Initial conversion efforts dramatically reduce production throughput time and inventory level. Continuous improvement again doubles productivity and reduces other negative indicators by half within two to three years. Improvements can be expected to continue indefinitely, but at a declining rate.

	Initial lean conversion	Continuous improvement
Labor productivity	Double	Double again
Production throughput times	90% reduction	50% reduction
Inventories (Throughput)	90% reduction	50% reduction
Errors reaching customers	50% reduction	50% reduction
Scrap	50% reduction	50% reduction
Time to market, new product	50% reduction	50% reduction

Table 2.3 Benefits of Lean Production

2.5 Conclusion

The lean production system uses less of everything compared with mass production. The best Japanese auto companies developed a fundamentally different way of making things and these companies changed the dynamics of international competition. The lean production system continuously focuses to eliminate seven types of waste: overproduction, waiting, transportation, over-processing, excessive inventories, unnecessary motion, and defective products.

The lean production system is not know-how of the manufacturing techniques. Many companies failed to implement lean production in their factories because they just applied lean techniques without deeply understanding the underlying thought.

The essence of lean production is a fast-track improvement that is enabled by both the mechanism of specifying the problem and the production-line-based rapid problem-solving cycle. Management should keep the momentum for continuous improvement by motivating their workforces. Long-term personnel training and trust-based relationships between management and workforces are the basis of the lean production system.

Chapter 3. Lean Enterprise

3.1 Introduction

What is the Lean enterprise? Lean enterprise is a state of the company that applies the lean concept to their organizational activities and continuously eliminates waste from inside and creates value. This notion has evolved since the "discovery" of the lean production concept. Many manufacturing companies started to implement the lean production techniques in their factories, and realized amazing improvements in a specific activity in their shop floors. The core idea of the lean concept is eliminating waste and optimizing the flow of products, and it is applicable to the flow of business processes too. Many researchers and practitioners defined this possibility as a new organizational model, called lean enterprise, which enables dramatically higher level of performance as a whole. (Womack and Jones, 1994) This is the starting point of the lean enterprise concept.

An extended lean enterprise concept comes from the idea that the lean enterprise concept can be applied beyond one company. Some lean enterprises realized from their experiences that they could not reap a full benefit of this effort of being a lean enterprise if their customers and suppliers were not lean. For example, they operated their production system with lean-production techniques and dramatically improved their productivity. They also reorganized their business process within the company with the lean enterprise concept. However, if mass production

thinking dominates their supply chain, the supplier cannot provide raw materials as they need, and orders from customers are always in a batch-and-queue situation. This environment makes it hard to be a lean enterprise. Therefore, the second possibility mainly focuses on how different companies in a same value stream can make progress by eliminating wastes within their relationships.

In this thesis, to make the meanings clear, we distinguish two concepts of lean enterprise by calling the first concept lean enterprise and the second one extended lean enterprise depending on its scope of enterprise. In this chapter, two types of lean enterprise concepts will be explored and the methodology of transformation be addressed.

3.2 Lean Enterprise Concept

Lean enterprise consists of an operationally synchronized group of individuals and functions within a given organization and continuously eliminates waste from the inside of the organization to provide a value to the customer and all stakeholders. A single company usually has many functions for operating their business, and each function interacts with other functions. The value created by the company is definitely the result of this interaction. The lean enterprise concept reveals a detailed look of these interactions and eliminates waste from them, and creates the situation where less interaction makes more value. This is a core idea of the lean enterprise concept.

Compared to the lean production concept, the aim of the lean enterprise concept is clear, however, the way to lean enterprise is more abstract. The lean production concept has some techniques to achieve lean state, and we can measure the improvement of the product flow easily. The lean enterprise concept also needs this kind of methodology and Womack and Jones suggested five steps for this purpose.

Specify Value

The first step is specifying the value of ends user. This step is important because at the enterprise level functionalities have a relatively small portion of involvement in their services or products. By specifying the value at first, each of the employees can make a decision according to it and avoid suboptimization at each part. This value comes from specific products and services, with specific capabilities, offered at specific prices to specific customers. An important point is to ignore existing assets and technologies and to rethink firms on a product or service basis with strong, dedicated product teams.

Identify the Value Stream

A flow of value, a value stream, is an important idea in order to understand the lean enterprise. The value stream is the specific activities required to design, order, and provide a specific product, from concept to launch, order to delivery, and raw material into the hands of the customer. Lean enterprise focuses on a value stream, not just products or services. This change of focus to a value stream from products or services might be difficult for any organization at first, because traditional companies are not designed to optimize a value stream within their organization.

Value stream analysis distinguishes three types of activities: (1) activities which unambiguously create value, (2) activities which create no value but are unavoidable with current technologies and production assets, and (3) activities which create no value and can be eliminated immediately. Activity (3) should be eliminated, and activity (1) and (2) will be examined to improve the activity and to eliminate waste from them.

Make Value Flow Continuously

Once the wasteful activities are eliminated, the next step is to make the remaining value-creating steps 'flow.' This step seems too conceptual and hard to apply beyond the

manufacturing floor. Therefore, we need to look back at the counterpart of this concept to its origin. This 'flow' is identical to the idea of one-piece flow in Lean-production technique. What is the one-piece flow at the enterprise level? By identifying the value stream at the enterprise level, we can understand the route where the value should flow. This process make reorganizing work processes easier by integrating "Functions" and "Departments" in the company into product teams organized along the value stream.

Let Customers Pull Value

Continuous flow in value stream dramatically reduces the time required to go from concept to launch, sale to deliver, and raw material to the customer. It eventually makes possible the situation that the enterprise starts to make products or services when the customer needs them. It means that the company becomes more responsive to change in demand from the customer.

Pursue Perfection

As an organization begins to implement lean principles and practices, it finds that there is no end to the process of reducing effort, time, space, cost and mistakes while offering a product which is ever more nearly what the customer actually wants. By applying the previous four principles each time, the organization gains more and finds more wastes hidden. This reinforcing loop accelerates continuous process of improvement.

3.3 Extended Lean Enterprise Concept

Extended Lean Enterprise is a group of individuals, functions, and legally separate but operationally synchronized companies which continuously eliminate wastes from the inside of this alliance to provide a flow of value to the customer and all stakeholders. The scope of the extended lean enterprise will differ depending on the value they deliver. For example, in the case of personal computer hardware industry, a company provides a PC with customer's desired

functionality and competitive price by applying lean production-technique. This company's view of value is to deliver the product the customer needs as cheaply as possible, and the scope of enterprise will be completed within PC manufacturing company. Although a few customers admit PC's value as a product alone, most customers define the value of their PC by the benefit they can obtain from using their PC. Therefore, a PC manufacturing company becomes only the portion of the extended enterprise, and other participants which have relationships with the uses of PC like the internet service provider, computer Software Company, peripheral equipment maker, and so on join the enterprise. Personal computer hardware is one of the leading industries to apply lean-production techniques to their operation. However, from the extended lean enterprise view, they have more opportunity by reorganizing the relationships with other participants and create an industry-wide value stream. To achieve this goal, extended lean enterprise needs some kind of extra control system which will help optimizing the flow of value that runs through the various participants.

First, participants of an extended lean enterprise are legally separated companies, and there is no leader at first. Therefore, every extended lean enterprise needs a "team leader". The role of team leader is to orchestrate the decision to form an enterprise, to pull together the full complement of participants, and to lead the joint analysis of the total enterprise stream. (Womack and Jones, 1994)

Second, every participant is free to leave if other participants fail to improve their performance or refuse to reveal their real situation. In this sense, an extended lean enterprise is different from the Japanese traditional keiretsu system which usually depends on the cross-shareholding system to keep their relationships tight.

Finally, participants need to make agreements before they start work together as an enterprise to create a win-win situation, not a zero-sum game. Without these agreements,

participants may pass along their waste to other participants in the enterprise without creating any value. The extended lean enterprise should eliminate waste from each company and between each member company, thus creating additional value. These agreements include target costing, acceptable levels of process performance, rate of continuous improvement, consistent accounting systems to analyze costs, and formulas for splitting pain and gain.

Target costing

It is important to decide what price the customer will pay for a product and then working backward to determine how that product can be made so that it also delivers profit. This idea comes from the equation of "Cost = Price - Profit". This means that price is no longer the summation of cost and profit. Each participant is allocated a target cost to achieve the price the enterprise will offer to his or her customer.

Consistent accounting systems to analysis costs

Each participant usually uses a unique accounting system to analyze their costs. Even in the same company, different lines of business use different systems. To measure the activity of extend enterprise as a whole, every participant's accounting systems should be consistent to be on an equal footing. A standard accounting system also makes cost structure transparent to all participants. This transparency has a huge effect on avoiding suboptimization along the value stream.

Acceptable levels of process performance

As the enterprise takes the step to lean, their total performance is determined by their weakest link in the chain. Therefore, it is important that each participant complies with a minimum requirement for process performance measures, like inventory level, lead time, distance traveled etc, for their portion of the enterprise.

Rate of continuous improvement

Continuous improvement is the heart of a lean enterprise concept. To keep this momentum within the enterprise, a rate of continuous improvement is assigned to each participant. In other words, continuous cost reduction by way of continuous improvement is mandatory to participants.

Formulas for splitting pain and gain

In the extended enterprise, an upstream company's effort and investment might generate a downstream company's profit and vice versa. To make formulas for splitting profits and loss of the lean enterprise it is necessary to avoid pointless conflicts.

3.3.1 Stakeholder

Especially, for an extended lean enterprise, there is a long list of stakeholders from upstream to downstream of the value stream. From the lean production standpoint, companies ensured lower costs, higher quality, and better service & delivery solely to their customers by applying lean principles to their production level. However, we should be concerned about who their customers are. Most of the participants of the extended enterprise naturally have different visions and interests for their portion of the value stream, and they are more likely to pursuit their profit at the expense of the total performance of the enterprise. However, each value stream has profits and losses responsibility, and this should be prioritized to each company's interest. Therefore, the big challenge is that the value to all stakeholders should be optimized to maximize the performance as the extended enterprise.

Optimizing all stakeholders' value is the core idea of the extended lean enterprise. Murman et al (2002) defined nine types of key stakeholders for lean enterprise: customer/acquirer, end user/consumer, shareholder, employee/union, corporation, business partner, suppliers, and society.

Customer or *acquirer* is the one to whom the enterprise delivers its products or services. Lean manufacturers usually focus their needs. *End user* or *consumers* receive products or services from the enterprise's customer or acquirers, not directly from the enterprise. *Shareholder* provides capital for the enterprise in return for higher expectation of return on investment than debt holders do. An *Employee* consists of senior management and the workforce. They are fundamentals of value creation and support its activities. A union may represent some employees. A *Union* has a different internal governance structure; however, they need to support lean transformation in a given enterprise. A *Corporation* is the top management who lead the enterprise in the right direction. They need a strong commitment and leadership. A *Business partner* provides risk-sharing capital and intellectual property to improve the enterprise's products and services in return for a sustained portion of value created by the enterprise. *Suppliers* provide subassemblies, components, or services. In some enterprises, the number of suppliers goes to more than thousands. *Society* is an important stakeholder with an interest that the enterprise maintains the environment, provides job opportunities, supports the tax base, and serves as a positive force in the community, the country, and even the global economy. Elected officials, agencies, regulators, special interest groups, or individuals can represent society.

3.3.2 Value Stream Mapping

Within the defined scope of the lean enterprise, we need to make a current state of a value stream map. In this map, we write down all of the steps in the process as it currently operates. This process includes not only material flow but also information flow like a feedback from the customer. By using this map, every participant can see the whole value stream under discussion and agree on its current level of performance. The steps that do not create value should be

eliminated, while steps that are incapable, unavailable, inflexible, inadequate, and under- or overcapacitized should be perfected. (Womack and Jones, 2003) Then we can create a future state of the value stream map, and start effort to close the gap between the current and the future state of value stream map. This process will never end and continue to pursue for perfection.

3.4 Systematic transformation to the Lean Enterprise

A value stream mapping and an optimization of stakeholder's value are two key components to understand the concept of the lean enterprise. Some industries have applied a systematic transformation to the lean enterprise and developed some tools to transform and control the lean enterprise.

3.4.1 LAI's Approach

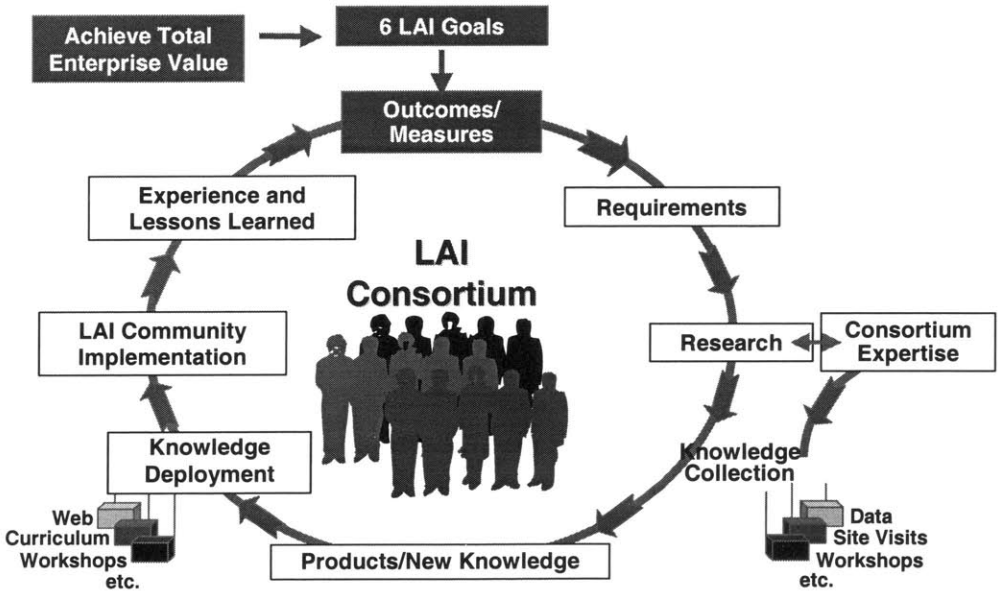
The consortium called Lean Aerospace Initiative (LAI) made a first step to go beyond the

	Company Name	$ in Million	Share %	LAI
1	Lockheed Martin Corp.	12,616	22.76%	○
2	Boeing Co.	9,116	16.45%	○
3	Northrop Grumman Corp.	4,908	8.86%	○
4	United Technologies Corp.	2,084	3.76%	○
5	Raytheon Co.	1,604	2.90%	○
6	Notrh American Airlines	1,194	2.16%	
7	Fedex Corp.	1,034	1.87%	
8	General Dynamics Corp.	954	1.72%	
9	L-3 Communications Corp.	924	1.67%	○
10	Computer Sciences Corp.	859	1.55%	

Source: Department of Defense

Table 3.1 US Air Force's procurement record in 2003

lean production around mid-1990s. LAI consists of key stakeholders from the US Aerospace Industry, government, organized labor, and MIT. Why the US Aerospace industry could have an enterprise level focus and pursue to transform the total aerospace industry to the lean enterprise? Some unique organizational structures are the key enabler of this movement. An important point is that this consortium includes the US Air Force as the member. In fiscal year 2003, the US Air force used $55 billion as a total for their procurement. Table 3.1 shows that there are strong relationships among LAI members. Among its prime contractors, LAI member companies dominated the top five. LAI member companies provide and share their data among their members, and in return, they can use LAI's tools and knowledge. This environment is good to create and develop better tools, because researchers have an access to test their tools in the real world and can get a feedback soon. This industrial-governmental-academia relationships works as the learning community and accelerate its knowledge cycle faster than if they do it independently.



Source: LAI

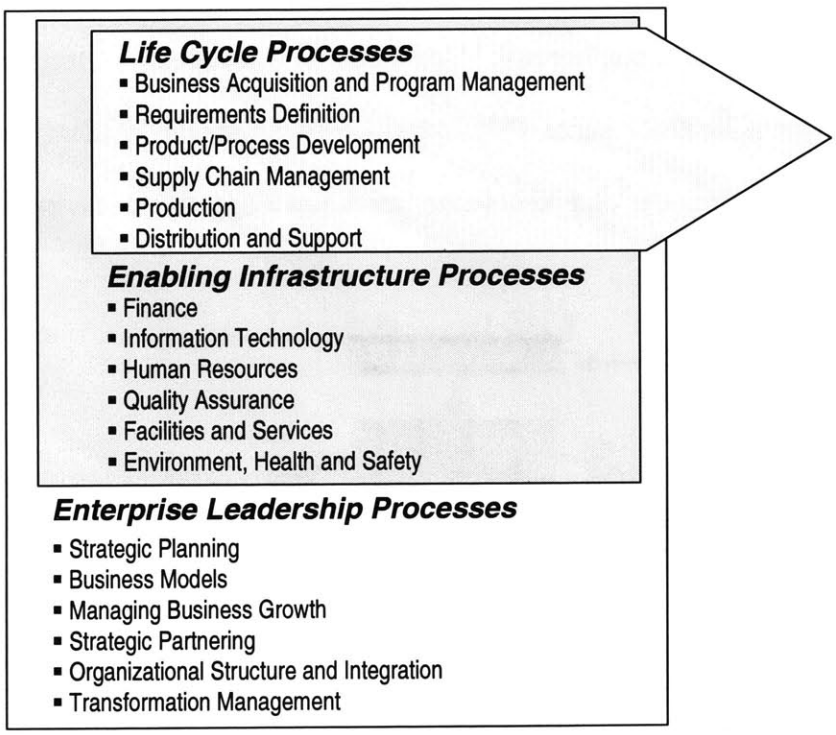
Figure 3.1 LAI's organizational learning

They started to think about a concept of 'lean enterprise' and learned that

"Understanding and creating value for stakeholders is a critical aspect of being a lean enterprise"

Before this step was made, most lean transformation focused on cost cutting and suboptimization of one part. LAI defined a 'lean enterprise' as follows

"A lean enterprise is an integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices." LAI also proposed the generic process architecture of enterprise (Figure 3.2) to make common language about 'enterprise' among the consortium members.



Source: LAI

Figure 3.2 Generic multi-program enterprise process architecture

This 'enterprise' architecture consists of 'Lifecycle Processes', 'Enabling Infrastructure Processes', and 'Enterprise Leadership Processes.' 'Lifecycle Processes' directly contribute to revenue generation by creating product, system, or services to their customers. Each function

seems to identical to traditional ones; however, key point is that they focus on an overall product

- Waste minimization
- Responsiveness to change
- Right thing at right place, at right time, and in right quantity
- Effective relationships within the value stream
- Continuous improvement
- Quality from the beginning

Source: LAI

Figure 3.3 Principles of a lean enterprise (Murman et al. 2003)

Human-oriented Practices	Process-oriented Practices
■ Promote lean leadership at all level	■ Assure seamless information flow
■ Relationships based on mutual trust and commitment	■ Implement integrated product and process development
■ Make decisions at lowest appropriate level	■ Ensure process capability and maturation
■ Optimize capability and utilization of people	■ Maintain challenges to existing processes
■ Continuous focus on the customer	■ Identify and optimize enterprise flow
■ Nurture a learning environment	■ Maintain stability in changing environment

Source: LAI

Figure 3.4 Overarching practices of a lean enterprise (Murman et al. 2003)

lifecycle and avoiding suboptimization within each operation. 'Enabling Infrastructure Processes' consists of traditional support functions. A difference in the lean enterprise context is that these support functions should support the 'Lifecycle Processes'. 'Enterprise Leadership Processes' does not show up in the traditional organizational chart, and set the direction for lean transformation of an enterprise.

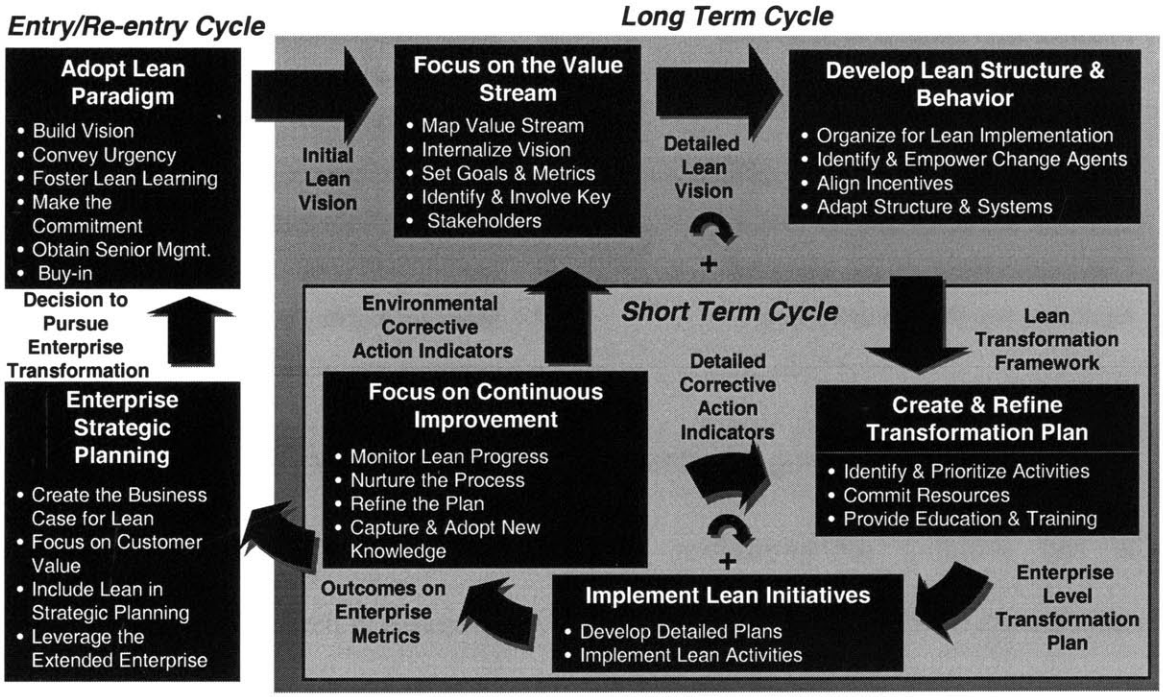
The next challenge of LAI was to find the principles and practices that will direct the lean enterprise. They expanded the knowledge of 'lean production' from the automobile industry to 'lean enterprise', and developed principles (Figure 3.3) and practices (Figure 3.4).

These principles eventually became the LAI's Lean Enterprise Model (LEM). The LEM

"has since become a standard reference for consortium members to developing lean enterprise strategies."

3.4.1.2 Transition-to-Lean Roadmap

Compared to a manufacturing floor, an enterprise is hard to see as a whole. A value stream map shows a snap shot of the current state of the enterprise and the blue print of the desired state. However, transforming an enterprise to lean without a route map is difficult. Transition-to-Lean



Source: LAI

Figure 3.5 Transition-to-lean roadmap

Roadmap (Figure 3.5) was created by LAI to give an idea of what steps should we take to transform an enterprise by applying lean principles and practices. This roadmap tells what the key factors in implementing the lean enterprise concept are, and an ideal order in which transformation activities should be performed. This map also gives us an insight why do so many lean transformation initiatives fail.

3.4.1.3 Lean Enterprise Self Assessment Tool (LESAT)

A Lean Enterprise Self Assessment Tool (LESAT) is a capability maturity model developed by LAI to measure the 'leanness' of an organization and its readiness for change. LESAT consists of diagnostic questions for every item in the Transition-to-Lean Roadmap. For every question, five maturity statements were provided, ranging from least capable (Level 1) to world class (Level5). By measuring differences between the organizations' current and desired future states in a certain time period, we can measure the progress of the transformation to the lean enterprise. Although we can get a score after each assessment, the process itself is more valuable than score. Through the discussion with other members within the enterprise, the participants can obtain holistic view of their enterprise.

3.4.1.4 Summary

LAI established the systematic method to transform a company to the lean enterprise. They started from creating an organizational learning cycle among influential parties of the aerospace industry. Especially, extensive involvement of owner (the US Air Force) is the key of rapid growth of their methodologies. These methodologies consist of three parts: Best Practices, Implementation, and Assessment. These methodologies are directly applicable to other industries at the enterprise level.

3.5 Conclusion

Lean enterprise continuously eliminates wastes from the inside of this organization to provide a flow of value to the customer and all stakeholders. Various organizations can be a lean enterprise by applying lean techniques which has a root in lean-production techniques. These

techniques can be applied to a non-manufacturing areas of the company (the lean enterprise concept), and to a group of companies sharing the same value stream (the extended lean enterprise concept).

Two key parts of the lean enterprise concept are the value stream and the optimization of stakeholder's value. A lean Enterprise exists along a given value stream and is continuously improves through the five steps: Specify Value, Identify the Value Stream, Make Value Flow Continuously, Let Customers Pull Value, Pursue Perfection. Through these processes, a value to all stakeholders should be optimized to achieve the best result of the enterprise as a whole.

Lean tools are helpful to be the lean enterprise. A Value Stream Mapping gives a snap shot of the current state and the blue print of the future state to all stakeholders. The Transition-to-Lean Roadmap gives an idea of how to be a lean enterprise. LESAT shows where we are on the lean journey. Those tools are developed by LAI and adopted to the aerospace and other industries.

Chapter 4.
Applicability to Japanese Construction Firms

4.1 Introduction

Over the past ten years, the Japanese construction industry has been shrinking. Figure 4.1 shows the change in Japanese investments within this industry over a twenty year span.

Following the collapse of the speculation bubble, private companies cut their domestic construction investment by nearly half. The Japanese government used to make up for a decline in private construction investments by increasing investments in the public sector. However, the government cannot continue to afford this type of policy, and so began decreasing investment in the public sector to improve fiscal balances. Although these investments in the public sector (5% of GDP in FY2002) are still at a high level compared to other developed countries (2-3% of GDP), this trend of declining investment in the public sector seems to be unavoidable. Therefore, Japanese construction firms will be confronted by cut throat competition if they do not take a step in the right direction. There are two directions: one is to pursue new and promising business areas, and another is to stay with conventional domestic business and make reforms within the industry.

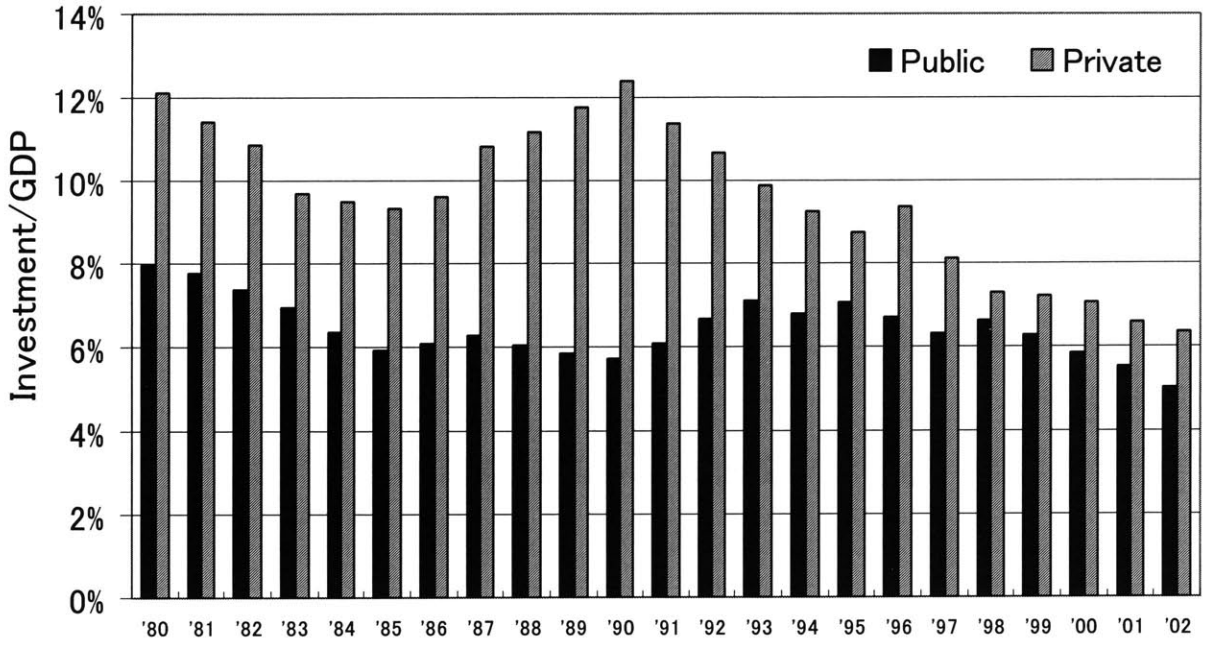


Figure 4.1 Construction investments in Japan

In the first direction, renewal, urban redevelopment, overseas construction, PFI, engineering, and environmental market could help make up for the shrinkage in the Japanese construction market. Most Japanese construction firms set out on a journey in this direction as shown below.

> *"With regard to securing orders, we will concentrate our efforts on such fields as urban revitalization, environment and engineering, renewal, and overseas businesses, while pursuing marketing activities that are responsive to the changing marketplace (Taisei Corp[2]).*"
>
> *"Looking ahead, we intend to secure orders and enhance profitability by practicing "Concurrent Engineering" in every project we undertake and by thoroughly implementing quality control and reducing costs at construction sites, while aggressively marketing in the fields of renewal, environment, urban revitalization, and large-scale overseas projects. We will strive to develop a new profit base by promoting*

[2] Taisei Corp, To Our Shareholders; http://www.taisei.co.jp/english/ir/share.html

PFI (Private Finance Initiative) and engineering businesses while further solidifying our financial position by reducing management costs and emphasizing cash flow (Obayashi Corp[3])."

"*The conclusion is clear. Shimizu is well positioned with its superior technology, proven reliability and long history of construction results to be a major beneficiary of expected growth in demand in such key market sectors as urban redevelopment, private finance initiatives, and environmental services and protection (Shimizu Corp[4]).*"

However, there are many new comers for these attractive markets, and not all the construction firms are capable of following this direction because they often have little knowledge of them. Competitiveness in these areas is not determined by price, but by the type of technologies available and by planning capability, and construction/management experience.

In the second direction, however, there is no clear path right now. The market is shrinking and competitors do not exit the market. Japanese construction firms need new business models to meet the changes in the construction industry environment, but this industry is naturally resistant to the influence of other industries, insisting its own production peculiarities. However, this needs to change.

Previously, the lean production concept shows some techniques that make other industries' manufacturing facilities more efficient and responsive to change. The lean production concept expands into the lean enterprise concept, and the lean enterprise concept shows two possibilities for new organizational models, the lean enterprise, and the extended lean enterprise.

In this chapter, we will explore the applicability of these three concepts for Japanese construction firms for each standpoint, the production, the enterprise, and the extended enterprise

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[3] Obayashi Corp, Annual Report 2003; http://www.obayashi.co.jp/english/ir/annual/pdf/ar_03.pdf
[4] Shimizu Corp, Annual Report 2003; http://www.shimz.co.jp/english/pdf/ar_2003_04.pdf

levels.

Before going further into this analysis, the word "Japanese construction firms" should be defined. There are 552,000 of registered construction firms in Japan, as of March 2003. Among these construction firms, we focus on general contractors with the capability of planning, design, and research and development because these capabilities are similar to that of manufacturing companies, which apply lean methodologies in their organization.

4.2 Production level

4.2.1 Production in the Japanese Construction Industry

At the production level, Figure 4.1 shows the construction value stream. Most of activities take place on the construction site, and construction firm, subcontractors, and suppliers are the main players there. Construction firms only play a leadership role and organize construction sites by selecting subcontractors and suppliers under unique conditions. Pre-construction phases such as planning and design are usually beyond the control of construction site. After the bidding process, construction firms create detailed plans for each task and manage the on-site production process. Each subcontractor executes tasks under the direction of project management team from construction firms. Suppliers deliver needed materials in a timely manner. In this fashion, each participant adds value to the construction product with each task. Currently, relationships among the participants of the construction process are influenced by a number of production characteristics.

4.2.1.1 Lack of production capacity

Although construction firms contract for projects, they do not have their own production

team within the organization. They procure optimal production teams for every project because every product in the industry needs a one-of-a-kind production system that responds to changes in the construction market. To do this, construction firms need to focus on developing expertise in the selection of appropriate subcontractors and learn how to manage the on-site production team. Once construction firms contract with subcontractors and suppliers, they focus on mainly the schedules. This may lead to the firm's lack of the knowledge about "true" construction costs.

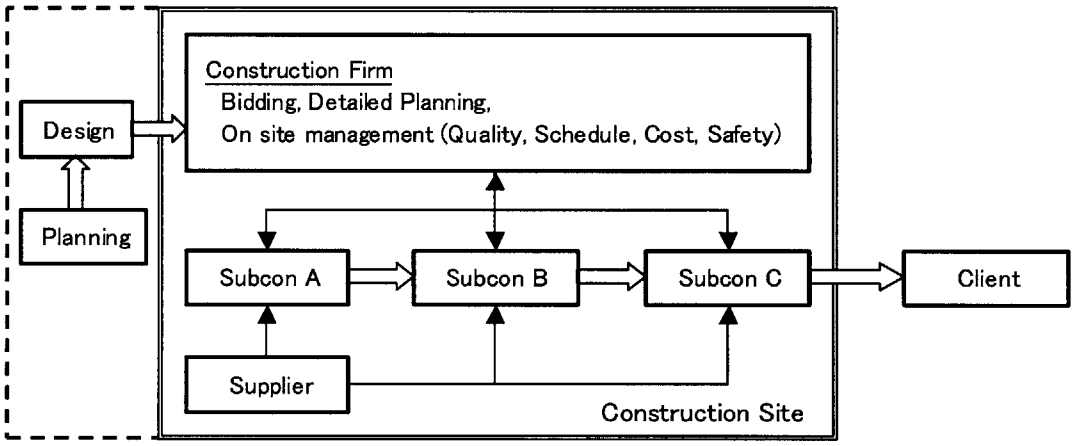


Figure 4.2 Construction value stream at the production level

Figure 4.3 shows a simple model of the relationships between the contracted price and the actual cost of similar tasks in hypothetical projects. Construction firms do not change their

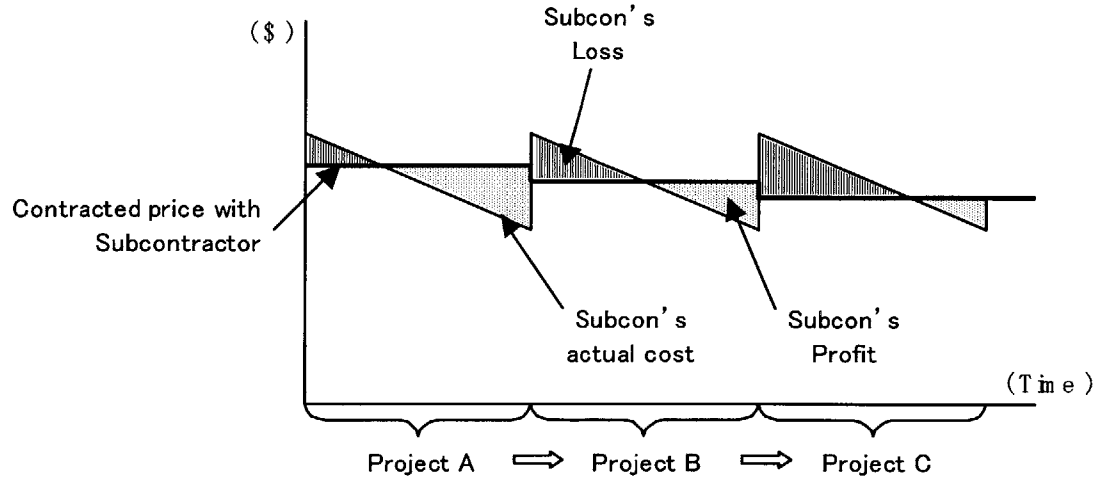


Figure 4.3 Contracted price - cost model (current state)

contracted-price during a project. Subcontractors reduce their costs during the project A and make a profit because they improve their productivity by the repetition of the tasks and reduce the input of their workforce as the project proceeds. An important point here is that this kind of productivity improvement is not systematic within the construction industry. It relies heavily on subcontractors' efforts. For the subsequent projects, construction firms have information from the previous projects, which might force them to reduce the contracted price even with different sub-contractors. But, if the new subcontractors do not have experience in this task, they have to start from the scratch and need a greater effort to achieve the productivity levels expected by the construction firm. The repetition of this kind of business practice leads to the adversarial relationships between construction firms and subcontractors, and creates a vicious cycle of profit loss by subcontractors, which in turn creates further tension.

4.2.1.2 Build-to-order production

Construction firms do not start production until they receive the order from the client, because they cannot predict client's specific needs and given conditions like budget and regulations. Construction firms make a contract for each project with the specific price and the construction schedule, or the lead time, with the client. It is important to realize that this build-to-order style production system in the construction industry is not the result of a desperate effort to reduce the lead time as in a manufacturing company. It is simply the result of consensus about the current construction technologies. For both clients and construction firms, it is hard to imagine constructing a building only a few days after making a contract while reducing the cost dramatically. However, this is what is happening in the manufacturing industry. The reason that some manufacturing companies are trying to achieve a build-to-order production system is to eliminate their inventory and improve their cash flows. Cash flow management is not common at

the construction site level, and the notion of inventory is traditionally rare in the construction industry. Is there inventory in the construction industry? We can say that the tasks already finished but not yet paid for by the client are the construction inventory. Compared to the effort of managing schedules of construction processes, construction firms usually readily accept the condition of payments as clients suggest which do not match actual progress. Therefore, a production point of view will make some changes in this area.

4.2.1.3 On-site production

In the construction industry, production takes place at the construction site. Of course, there is no production facility there at the beginning. The condition of each site determines the whole construction process, and construction firms apply an appropriate construction method to execute the project. Weather adds uncertainty to the construction schedule and also safety issues.

Creating good relationships with subcontractors and suppliers from scratch is difficult when a new construction project is done in an area unfamiliar to a construction firm. Continuous improvement in construction productivity is also difficult under this condition. This is a serious issue for Japanese construction firms because this peculiarity creates the barrier to entry into the international market in this industry.

In addition, we need to see another aspect of the effect of on-site production. In the manufacturing industries, commercial jets and luxury liners are as expensive as construction projects. However, clients always have an option to refuse receiving the product when its quality does not meet their requirements. This is not the case with the construction industry. Once the construction process begins, it is unrealistic to return the product because of quality problems because construction products cannot move from the construction site and removal is very costly. Therefore, clients traditionally care about semi-finished product quality as well as the finished

product.

4.2.1.4 Quality by inspection

At the production level, there are two main activities to deliver the required quality to the client: incorporating the quality during the construction process, and checking the quality by inspection. Construction firms also offer a defect liability period to their clients.

At the beginning of the project, construction firms establish the rule of managing the construction processes to achieve the required quality, and keep the rule during the project. Before the hand-off to the next process, construction firms inspect whether the quality satisfies the required level. Even when the construction processes are managed well by following the established rule, quality should be inspected.

Project managers are very careful about quality and their goal is usually zero defects. The construction product is hard to replace and the effect of delaying the schedule is tremendous. Therefore, construction firms usually take preventive actions for quality control to avoid future disasters. Although construction firms previously check quality, the client's engineer also inspects before the handover of the project.

4.2.1.5 Task-focused production

Construction firms usually break down the project and assign separate tasks to subcontractors. Each task has the its due date and contracted price. This is a basic project management technique: dividing the project to understandable levels and monitoring the progress of each. Some subcontractors subcontract their tasks again to sub-subcontractors. This kind of multi-level subcontracting is a common practice in the Japanese construction industry and runs the risk of losing customer focus at the production level. These multi-layered

subcontractors cannot see the whole project and optimize their behavior to meet their tasks. This task-level optimization sometimes sacrifices benefits for the total project.

4.2.2 Position of construction site as a production system

As we discussed in Chapter 2, there are three types of production system: Craft system, Mass production, and lean production. We looked at the construction industry from the production point of view in the previous section, and Table 4.1 shows the position of construction site as a production system.

Construction firms do not have a production capacity and this keeps them flexible and adaptable to changes in the construction market. This business strategy perfectly complies with the lean production concept. However, for other practices, the craft and mass production systems seem to dominate this industry.

	Craft	Mass Production	Lean Thinking
Focus	Task	Product	Customer
Operations	Single items	Batch and queue	Synchronized flow and pull
Overall Aim	Mastery of craft	Reduce cost and increase efficiency	Eliminate waste and add value
Quality	Integration (part of the craft)	Inspection (a second stage, after production)	Prevention (built in by design and methods)
Business Strategy	Customization	Economies of scale and automation	Flexibility and adaptability
Improvement	Master-driven continuous improvement	Expert-driven periodic improvement	Workforce-driven continuous improvement

Table 4.1 Production systems at construction site

First, the craft system aspect comes from the task-oriented nature of this industry. Construction firms divide their projects, and subcontractors deal with the production parts of the

project. Each subcontractor focuses on carrying out the contract they made with the construction firm (focus on task). Subcontractors seldom receive the same contract and need adjustment for each job (single item operations). Under this contractual structure, construction firms have little incentive to improve subcontractors' productivity. Only Subcontractors have the incentive to drive improvement within their organization.

Second, a mass production mentality also exists in this industry. For the construction site, a majority of project managers believe that the basic strategy to be profitable is to reduce the cost and increase the efficiency of each task. Therefore, they feel nervous when they see machines and workforces idle at their construction site, due to this basic view (overall aim is reducing cost and increasing efficiency). In addition, inspection is required both internally and externally. Internally, construction firms need to assure the quality of finished tasks executed by subcontractors. Externally, the client's inspector again checks the quality of the product (quality checked by inspection).

4.2.3 Applicability of Lean Production Concept to the Construction Site

The lean production concept is a methodology for transforming the mass production system to the lean production system. However, the previous section reveals that the production peculiarities of the construction industry determine the behavior at the construction site as a mixture of mass production, craft system, and lean production. This is a result of the long history of suboptimization at the production level and hard to change just by applying the lean production concept.

However, some elements of the lean production concept can be applied to the relationships between construction firms and subcontractors. For example, what will happen if subcontractors receive their orders from construction firms not on a single project basis, but with a long-term

contract for a stable level of work per year? This is the relationship between lean manufacturers and their suppliers. They make an agreement about continuous improvement, and use the target costing technique we discussed in chapter 3. Figure 4.4 is the case where a momentum for continuous improvement exists. Construction firms make long-term contracts with subcontractors with agreements that: (1) the contracted price will be reduced as the tasks are repeated, and (2) construction firms will invest for subcontractors' productivity improvements. As a result, the customer receives benefit in the form of a price reduction, and construction firms receive profits in return for their investment for subcontractors' improvement. Subcontractors do not lose money as long as they keep the momentum of their continuous improvement.

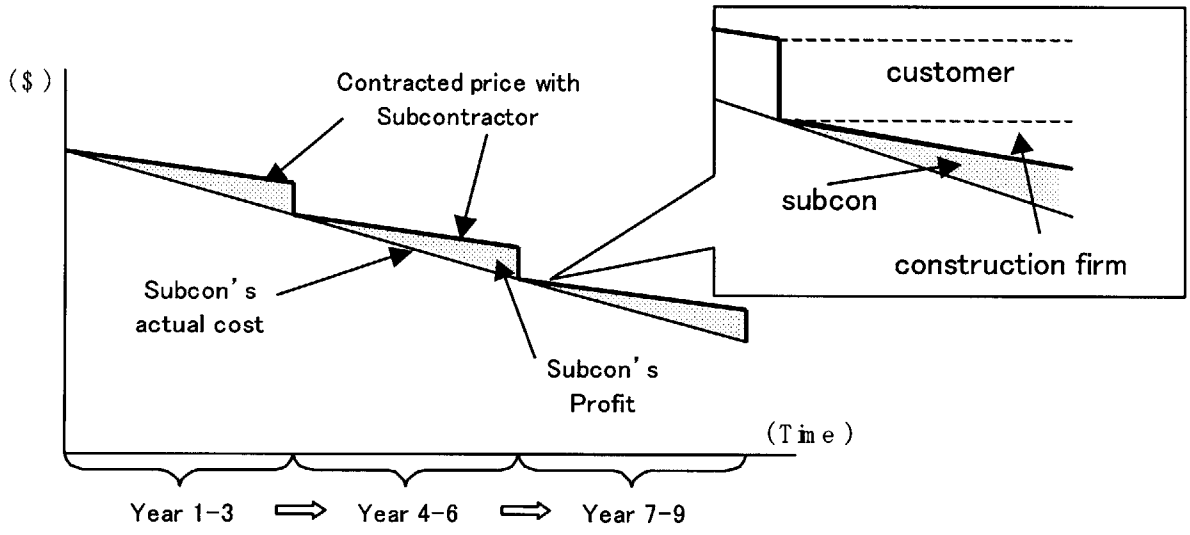


Figure 4.4 Contracted price - cost model (future state)

As we discussed in Chapter 2, continuous improvement at the production level needs trust-based relationships between management and workforces. In the construction industry, this relationship is very weak. Production is basically separated from construction firms, and construction firms and subcontractors only have project-based contracts and do not have a long-term employment agreement. Therefore, we can apply the lean concept to the construction production only if the relationships between construction firms and subcontractors change from

the current situation. This is beyond the control of the individual construction site level, and we can conclude that the lean production concept itself is difficult to apply to the construction industry at the production level under the current industrial business structure.

4.3 Enterprise level

4.3.1 Enterprise in the Japanese Construction Industry

At the enterprise level, construction firms have various lines of businesses other than

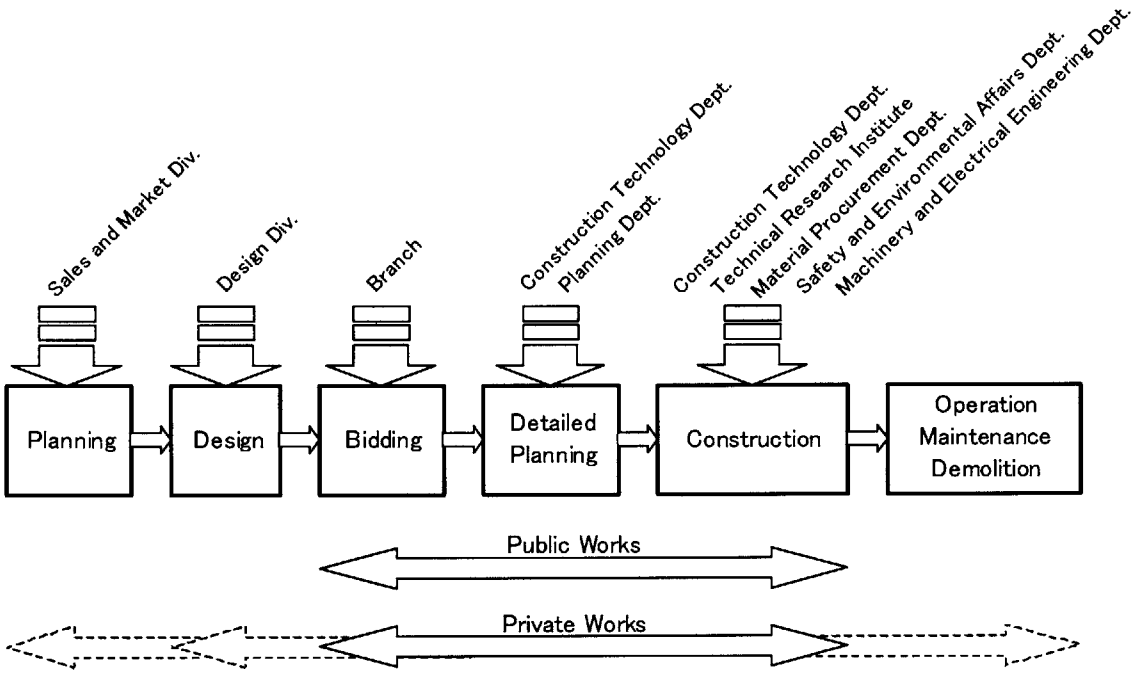


Figure 4.5 Japanese construction firm traditional business processes

construction site management. Figure 4.5 shows the traditional business process of the Japanese construction industry and associated functions Japanese construction firms usually have. However, their scope of business depends on the types of clients and contracts.

First, they have two types of clients: public organizations and private organizations. For the public works, the Japanese construction law defines that the same construction firm cannot

execute both the design and construction phases in a single project. Therefore, construction firms mainly focus on the construction work despite their planning and design capabilities. In this case, clients contract the planning and the design work to design firms, engineering firms, and consulting firms, and construction firms receive the drawings and the specifications before the bidding on the project. Each local branch of construction firms has a responsibility for profits and losses of their projects and for preparing for tendering. After this pre-construction phase is finished, local branches allocate appropriate managers to each construction site. These managers take over the responsibility for the project, and construction firms focus on supporting them.

For the private work, there is no limitation on the scope of the business which construction firms can offer to their clients, and construction firms have more presence in the construction business process. In addition to the scope of business in the public works, the sales and market division can support the client's planning phase and the design division can make the changes as the client's needs take shape.

Second, the type of the project delivery method also defines the scope of business of

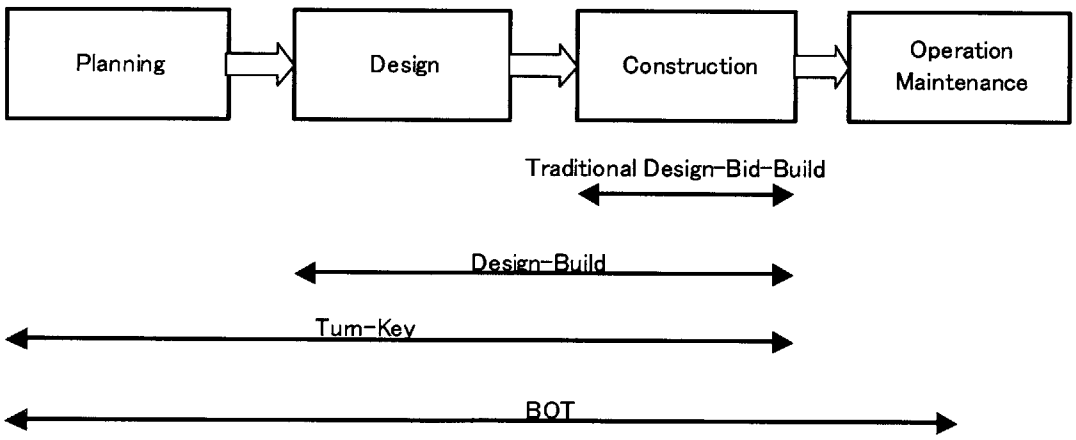


Figure 4.6 Scope of business by the type of the contract

construction firms. Figure 4.6 shows the scope of business by the type of the contract. Construction firms have charge of the construction phase for the traditional design-bid-build

contract. For the design-build contract, construction firms do the design and construction phases. For a turn-key contract, they do planning through construction work, and also provide a test run of facilities. For a build-operate-transfer (BOT) contract, construction firms design and construct facilities with their own financing and provide operation and maintenance.

Regardless of their types of clients and contracts, we can say that construction firms' scope of business always includes the construction phase. Their basic business strategy is to provide services-whatever brings them construction contracts-and then make a profit. Figure 4.7 shows the construction value stream at the enterprise level. At first, the client's needs flow into construction firms, then construction firms add value, and finally value flows to the client

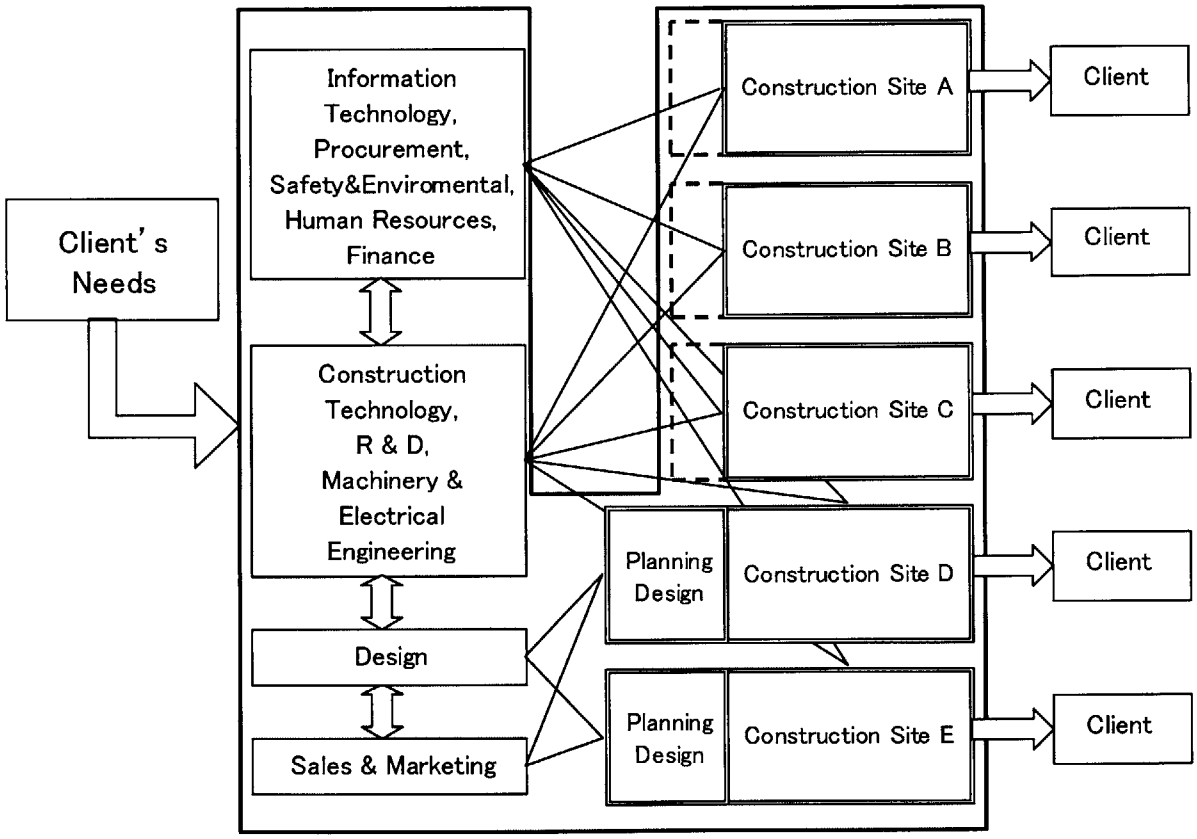


Figure 4.7 Construction value stream at the enterprise level

through the construction product. The right-hand-side of the value stream is where the construction process is actually going on. Each construction site has a structure as shown in

Figure 4.2. Their scope of business depends on the customer and contract types, and it is not a permanent organization. The role of the left-hand-side of the value system is to keep the right-hand-side working well, and this role consists of two parts: supporting the-right-hand side business processes and supporting the enterprise itself. These business processes between each construction site and supporting functions, or among supporting functions, are repeatable regardless of production characteristics in the construction industry.

4.3.2 Applicability of Lean Enterprise Concept to Construction Firms

At the enterprise level, the construction value stream in the previous section gives a quick view of how the value flows to clients. However, this value stream view has little relation with the construction firms' current organization. Construction sites belong to local branches depending on their locations. Each branch separates their construction sites to the building section and the civil section, and creates two different line of management systems. This separation also takes place at the headquarters level. They have two design sections and construction technology sections. Support functions belong to headquarters or local branches. Among these functionalities, there are many business transactions which are repeatable and have a possibility to improve. We examine the applicability of the lean enterprise concept for construction firms by following the five steps we discussed in the previous chapter.

Specify customer's value

Customer's value is a product's or service's capability provided to them at the right time, at an appropriate price, as defined in each case by them. Some clients may put emphasis on the on-time delivery of the building facility and pay a premium for early completion because they need it immediately in order to be responsive to the market. However, due to the construction

environmental change and severe competition, most clients would like just to obtain exactly the construction products they need as quickly as possible at the lowest possible price. Currently, a construction firm's basic strategy is to increase the number of orders received by leveraging its various functionalities while increasing the profitability at each construction site to improve its bottom line. There is a dilemma here: complying with client's value without any change of business process may increase the number of orders received but hurts the profitability at the construction site in the long run. Keeping the contracted price high to be profitable at the construction site decreases the client's value and subsequently reduces the number of orders received.

The construction firm as an enterprise should address this dilemma by focusing on providing required products as quickly as possible at the lowest possible price through the value-adding activities of its organization. This means that construction firms should comply with the change in clients' values by improving internal business processes. Business models of construction firms should be optimized to achieve this goal.

Identify the Value Stream

Clients' values are delivered through the value stream. Value stream is the specific activities required to plan, design, and provide a specific service, from concept to design, detailed design to construction, and maintenance to demolition. Although construction firms' involvement for the value stream is limited depending on its contract with the client, all the steps of the internal business process should be written down to the value stream map. This map gives an idea of what their business processes beyond the production level are. Then, all participants discuss "which processes are critical for their enterprise" and "what are the interactions among their process". Through the analysis, they can distinguish (1) activity which unambiguously create value, (2) activities which create no value but are unavoidable with current technologies and

regulations, and (3) activities which create no value and can be eliminated immediately. Activity (3) should be removed to eliminate waste from the enterprise.

This process might be quite a challenge for the most construction firms in Japan. Their organizational structure are large and complex, and also have more than thousands of construction sites, which create a complexity for capturing the value stream. Therefore, it is good to start from a small unit for this step. For example, local branches have both building and civil management section and also have profit and loss responsibilities for the construction site in their region. Although there are some interactions between construction sites and headquarters, local branches fit well for the starting point to identify the value stream.

Make Value Flow Continuously

Through the way of the identification of the value stream, the construction firm only has (1) activities which unambiguously create value, and (2) activities which create no value but are unavoidable with current technologies and regulations. Next step is to reorganize these remaining processes to make value flow. Construction works move in single-process-flow manner at the production level. However, administrative and managerial work often moves in batches through sequential operations that are organized along functional/departmental lines. The large number of paperwork and approvals results in numerous errors, delays, and reworks. Miscommunications with client, designer, supplier, etc results in many poor decisions. Impediments to smooth flow throughout the firm degrade overall performance. Functions and departments in the firm are checked up at this step and integrated to the team which minimizes "batch-and-queue" mentality.

Let Customers Pull Value

Construction firms' business flow is basically a pull system. Construction firms do not start construction processes until they receive orders from clients. However, in the construction processes, each task is in a sequential order and cannot be executed simultaneously. This makes

difficult to apply a "pull" concept to construction processes. On the other hand, planning and design processes have great possibilities to apply the "pull" concept in order to shorten the lead-time from planning to pre-construction phases and to deliver value to the customer within a short time period after their order.

Pursue Perfection

If construction firms achieve perfection, waste is completely eliminated so that all activities along the value stream create a value. Along the way to perfection, tools and methods like TTL-roadmap and LESAT will be helpful. Organizational structures might be changed and work processes should be refined.

These five steps suggest reorganizing construction firms' business processes from customers' values standpoints. By eliminating waste form the business transactions among their functions and departments, each construction site could be offered appropriate supports at the right time. Feedbacks from construction sites also pull more refinement at supporting functions.

However, fundamental problem arises here again. Due to their limited participation to the whole construction life cycle, perfection within construction firms might not bring the optimal solution to their customer and other stakeholders. Without optimizing all stakeholders' value, construction firms cannot obtain a long-term success.

4.4 Extended enterprise

4.4.1 Extended enterprise in the Japanese Construction Industry

As we discussed in previous sections, clients' needs in the construction industry cannot be satisfied by a single entity because the construction value stream is shared by many participants.

This might be results of long history of the industry and construction production peculiarities. The lack of holistic view of the construction value stream creates the current situation where each participant tries to maximize their profit and allocate their risks to other participants.

We need to seek the enterprise level integration of construction value stream to have a holistic view. By integrating to the extended enterprise, construction firms and other participant can offer service as if there is no boundary between planning, design, and production processes. Figure 4.8 shows the hypothetical extended enterprise. A client plans new business and need to

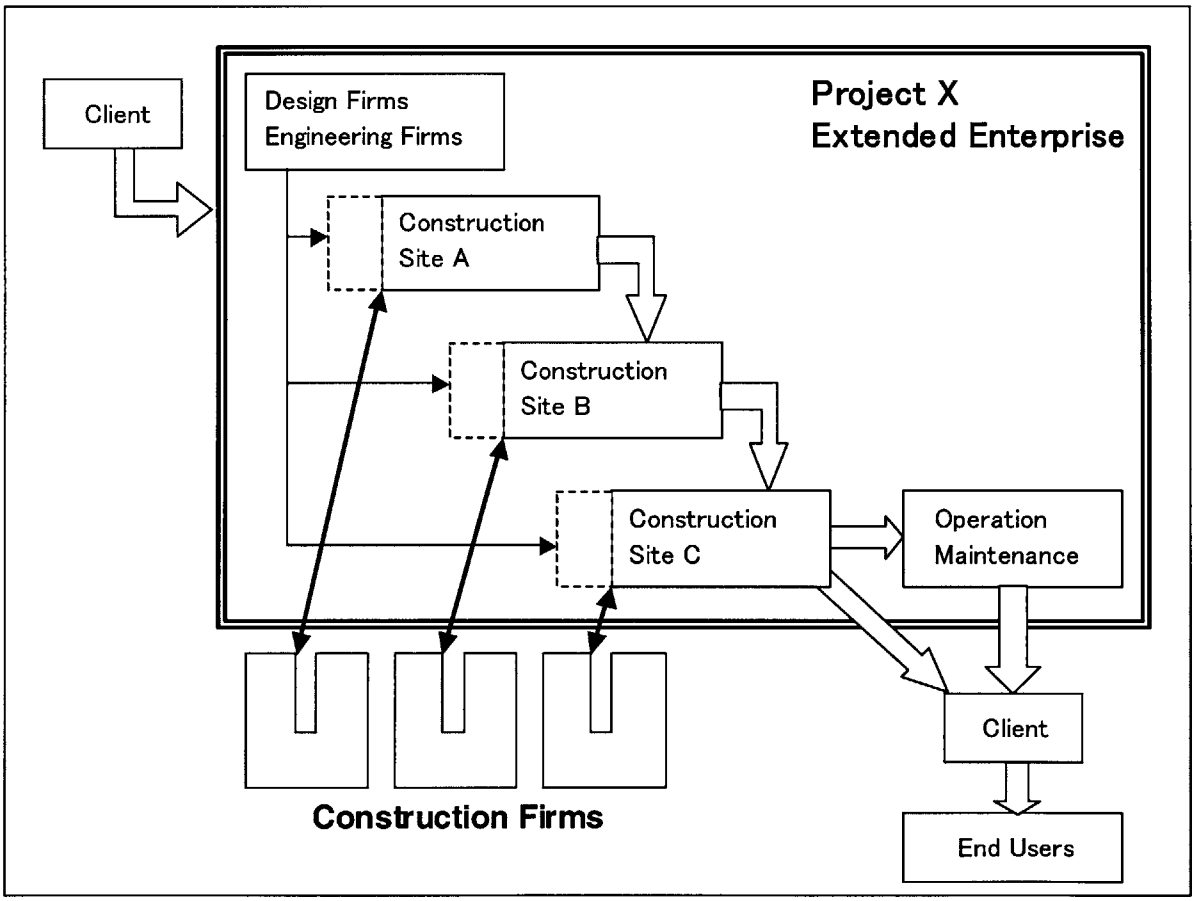


Figure 4.8 Construction Value Stream at the extended enterprise level

construct some facilities. The extended enterprise for this project includes the design phases, the construction phases, and the operation and maintenance phases. Each participant for this extended enterprise is legally separated but operationally synchronized companies. The goal of

this extended enterprise is eliminating wastes continuously from the inside of the extended enterprises in order to provide a flow of value to the customer and all stakeholders. The client does not need to deal with each company because the extended enterprise optimizes their transactions within them and deliver the maximized value to the client.

This holistic approach of waste elimination is not common practice in the Japanese construction industry. There are many reasons for that.

First, not every participant can see the whole picture of extended enterprise. Most of them are only able to optimize their behavior within their contracts, and have no flexibility to see others. Even though Japanese construction firms do well taking this role as a contractor in the construction process, they have no access to improve processes among other participants like clients and designer, and clients and maintenance companies.

Second, in the construction industry, each project has different condition and participants will never be the same without special consideration. Therefore, each participant would not spend time to make suggestions for others who may not work together again. They usually eliminate waste within themselves and throw it to other participants, not outside of extended enterprise. This behavior only creates a zero-sum game, not a win-win situation.

4.4.2 Applicability of Extended Lean Enterprise Concept to the Japanese Construction Industry

Can this type of relationship be built in the Japanese construction industry? Japanese construction firms may have more chance of success than other countries' construction firms.

First, they have the possibility to expand their position downward in the construction value stream by integrating production functions. Japanese construction firms traditionally have an exclusive subcontractors group who serves mainly for a single construction firm in return for

receiving a priority to get a job. From the construction firm's standpoint, this system worked well to retain good subcontractors in the booming Japanese construction market. However, systematic way of continuous improvement does not exist in this group of subcontractors, because just being the group guaranteed them stable level of job from the construction firm. As a result, some of them are no longer competitive compared to independent subcontractors. Construction firms should reorganize their relationships with subcontractors in order to create the base of continuous improvement at the production level.

Second, construction firms have the possibility to expand their position upward in the construction value stream because they already have the capability in the planning and the design phases. However, the separation of design and construction phases in the Japanese construction industry has a long history and is deeply rooted, and construction firms have already optimized their organization to deal with it. Currently construction firms do not use different business models regardless of whether their project is designed by their design department or other companies. Even in the design-build project ordered by the private sector, the design phase of the construction value stream is managed solely by their design department. This is due to the suboptimization in the construction firm.

How these opportunities can be actualized by applying the extended enterprise concept? The construction industry should follow five steps for lean transformation and also assure three things to create the extended lean enterprise with other participants.

First, they should make a team leader who coordinates every participant in the right direction. Although this role is typical for a final assembling company in the manufacturing industry, it is not the case in the construction industry. Final assembler in the construction industry is a construction firm, and they are good at organizing construction processes. Here, we

need to address who is the actual customer of the extended enterprise. Clients might be the customer for some projects like office buildings and factories. For other projects, end user is the customer of the extended enterprise. For example, clients plan to build new office building for renting business. In the traditional view, clients are the customer for construction firms in this case. Although the extended enterprise delivers the value to the client, this might not optimized to the end users' value. This is because the relationship between construction firms and end users is not so tight in current contracting business environment. Therefore, clients might be the best team leader for the extended enterprise in this sense.

Second, they should make agreements before they operate as the extended enterprise. Among these agreements, target costing may have huge effect and will confront huge resistance at first. This process will clarify the reason why each participant needs improvement by understanding big picture of how to deliver value which end user wants. To drive the improvement as the extended enterprise, they need to standardize their performance measurements. Desirable and acceptable improvement rate among the enterprise would be good criteria for this purpose. They also need to adopt consistent managerial accounting systems to analyze their costs precisely among different companies. Benefits from the transformation to the lean enterprise might not be the same among participants. The right direction is of course to optimize as a whole, therefore, they need to make formulas for splitting pains and gains to avoid later dispute.

Finally, each participant has to make a commitment to improve communication and keep their performance level higher than expected and information should not be hidden from other participants among the extended enterprise. They also have a right to leave from the extended enterprise. The extended enterprise should expect to engage in a never-ending process of continual refinement and improvement in every aspect of its operation and management.

What is the most difficult part to achieve these future states? First, it is very difficult to make a long-term agreement with subcontractors because of uncertainty in the future work volume in the current construction industry environment. The work volume of subcontractors completely depends on number of orders construction firms received. However, as they optimize relationships within the extended enterprise, elimination of waste will proceed and waste like adversarial bidding process might be gone.

Second, this new future state also requires open book relationships between construction firms and subcontractors even with the clients. They have to make the agreement for the profit level in proportion to their added value to the construction value stream. This kind of analysis does not take place in the negotiation because 1) between construction firms and subcontractors, construction firms are always in a high ground and subcontractors are forced to abide by them, 2) between clients and construction firms, construction firms never reveal their cost structure for clients because this practice will hurt future profit of construction firms. Therefore, the extended enterprise needs to establish mutual-trust relationships.

4.5 Conclusion

The Japanese construction market is shrinking and this trend seems to be continued. Construction firms in Japan need to change the way of business to meet this environmental change. There are few growing sectors around conventional construction markets, and most construction firms find their way into these market. However, they are struggling with improving profitability of their core contracting business.

Three concepts, the lean production concept, the lean enterprise concept, and the extended lean enterprise concept are borrowed from the manufacturing industry and examined its

applicability to Japanese construction firms.

At the production level, a construction process in Japan is the mixture of three transitional models of production systems: craft, mass production, and lean production. Peculiarities in the construction industry drive each construction site to optimize at the production level. Therefore, just applying the lean production technique at the production level is not appropriate.

At the enterprise level, construction firms manage and support its production level. Although they have functions and departments to address the whole processes of the construction value stream, they do not fully participate in planning and design phases and do not have the capability of construction process within their organization. This might limits an effect of implementation of the lean enterprise concept at the enterprise level. They can apply the lean tools for their organization and might optimize the value stream; however, it does not reap the full benefit of lean transformation.

At the extended enterprise level, construction firms have to seek a new type of business organization as a whole. Lacks of the capability in the construction process within their organization should be addressed by implementing trust-based relationships with subcontractors and suppliers. Lacks of full participation in planning and design phases should be achieved by optimizing a value among stakeholders. This new organization needs a strong leadership that optimizes relationships among different companies. Depend on the type of customer, the leader of the extended enterprise should be decided. If end users are the actual customer, clients might be appropriate to organize the extended enterprise to optimize value to the customer. If the client is the consumer/customer, construction firms can be the leader to optimize the value among stakeholders by leveraging their capability to the whole construction value stream. There are many barriers to achieve the extended lean enterprise: however, drastic changes have to be implemented at this level to survive the changing construction industry environment.

Chapter 5. Case study

5.1 Introduction

We derived three lean concepts from the manufacturing industry in previous chapters, and assumed that the extended lean enterprise concept can be applied to the Japanese construction industry. This is because most of the production and the enterprise levels waste in the industry cannot be removed without optimizing the extended enterprise level value flow. In this chapter, we will explore the Central Japan International Airport project through the extended lean enterprise concept point of view, and will see the validity of the extended enterprise concept in the large and complex construction project.

5.2 Project Overview

The Central Japan International Airport is being built as the third largest international airport in Japan. This new airport is located on Ise Bay, about 170 miles southwest of Tokyo. The airport is scheduled to open by March 2005 in time for a World Exposition to be held in around Nagoya. It will serve a major population center of about 10 million people and also a major industrial area, particularly automobile producers, and is expected to handle a significant quantity of the commercial cargo from the area.

The new airport is being constructed on an artificial offshore island created by land reclamation. It is designed to allow initially one large runway with dimensions of 3,500m x 60m,

and will occupy an area of 4.3km x 1.9km. Since the Central Japan International Airport will be an offshore airport, only water areas will be affected by aircraft noise, thus enabling aircraft to land and take-off 24 hours a day without time constraints.

The passenger terminal building will consist of a main terminal building with a central pier extending towards the runway and two 'wings' extending out to the sides. This pier will measure 500m in an east-west direction while the 'wings' will measure 1,030m running in a north-south direction. The total floor area for the passenger terminal will be about 220,000m^2.

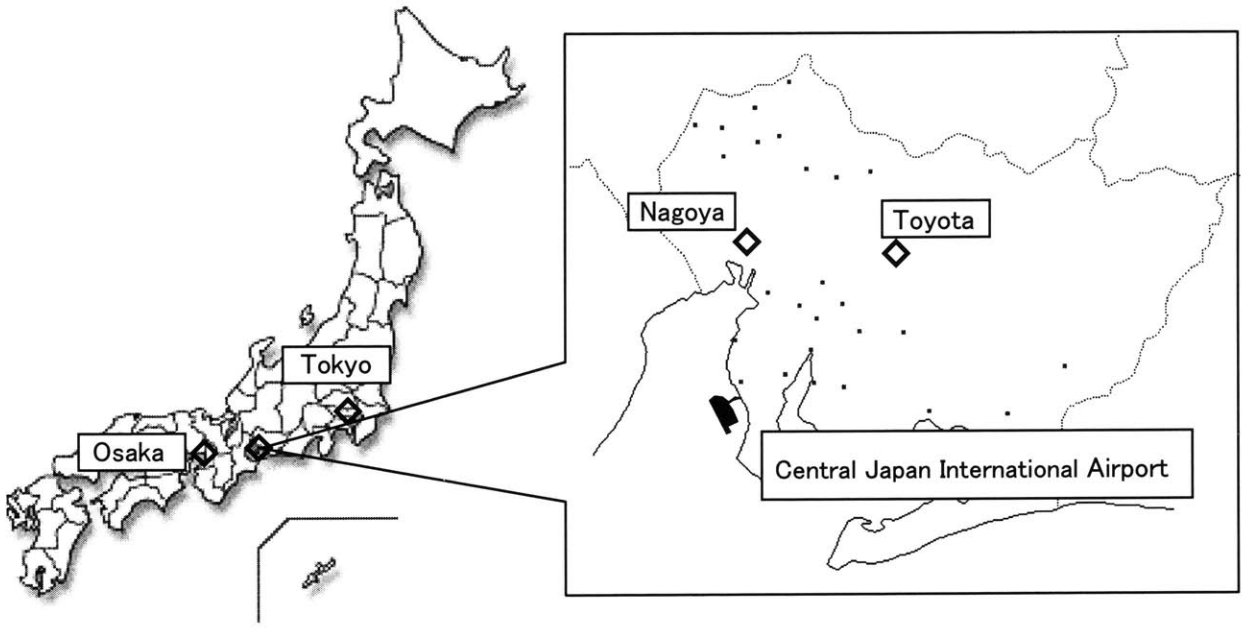


Figure 5.1 Map of the Central Japan International Airport

The terminal building will be constructed of two self-contained levels to allow easier flight connections for travelers. It will have abundant commercial space for shops and malls and an observation deck to allow views of the airplane takeoffs and landings.

Central Japan International Airport Company Limited (CJIAC) is the operating body of this airport and is designated to construct and manage the airport efficiently and established as the private sector in 1998 by the national government. The main shareholders are the national government, prefectural governments, municipal governments, and private companies that have

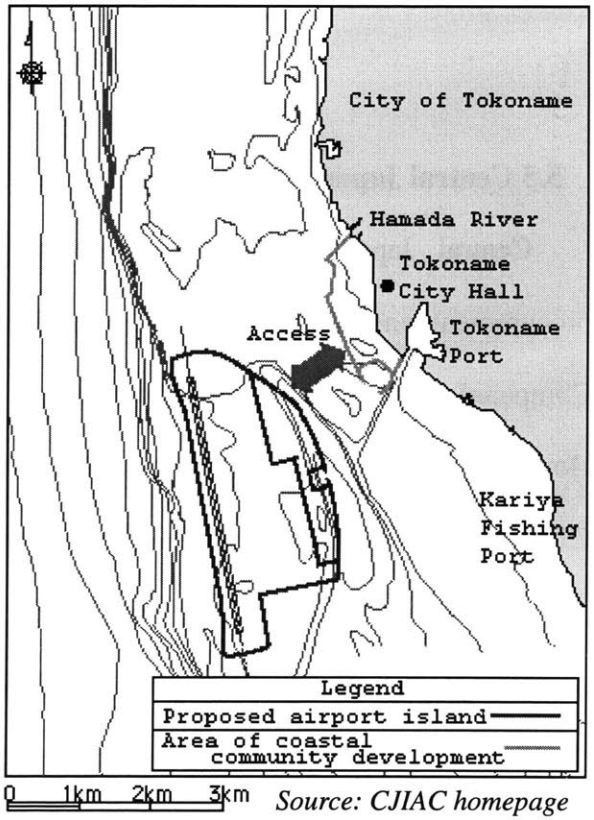
their headquarters around Nagoya as shown in table 5.1.

Share Holders	Share holding ratio (%)
National government	39.99
Aichi Prefectural Government	5.89
Toyota Motor Corporation	2.84
Central Japan Railway Company	2.84
CHUBU Electric Power Co., Inc.	2.84
Nagoya Railroad Co., Ltd	2.84
UFJ Bank Limited	2.84
Nagoya Municipal Government	2.83

Table 5.1 Main Shareholders of CJIAC

Management executives of CJIAC come from the main shareholders. The CEO of CJIAC is, in particular, the former board member of Toyota Motor Corporation. This is a result of the request from political and business establishments to activate the private sector as much as

Source: CKAC homepage



Source: CJIAC homepage

Figure 5.2 Surrounding Area of Central Japan International Airport

possible by applying Toyota's lean management system to the airport project.

CJIAC estimates total project cost as ¥768 billion and finances expenditure through the combination of equity, interest-free loan, and interest-bearing debt as shown in Figure 5.3. Private companies hold half of CJIAC's equity as a whole, which highlights the difference in organizational structure from other large-scale projects in Japan.

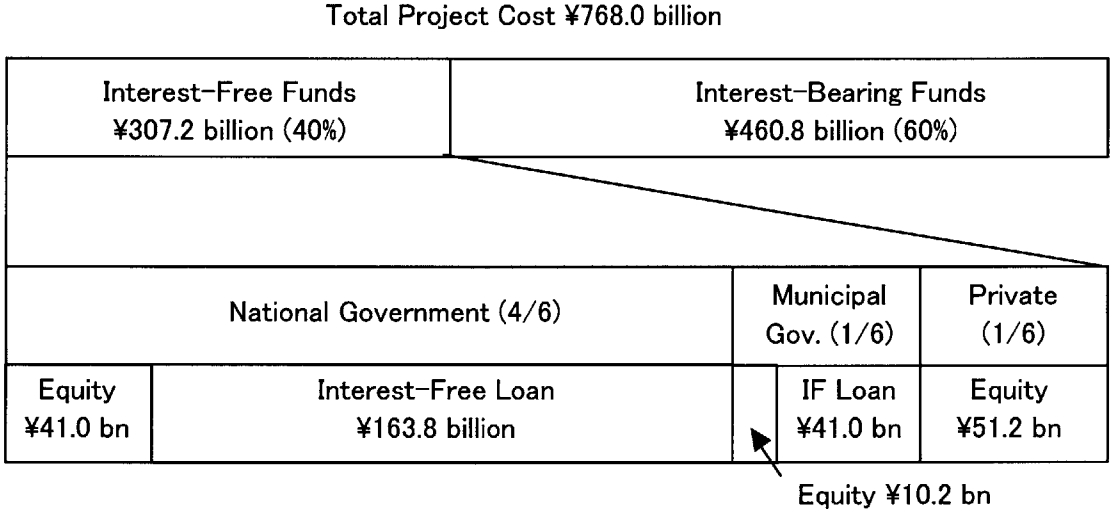


Figure 5.3 Sources of Funds of CJIAC

5.3 Central Japan International Airport as an extended enterprise

Central Japan International Airport goes through the process of planning, design, procurement, and construction, and then starts its operation and creates value to its stakeholders. Compared to its long operation period, the design and construction phase is a short period. However, quality of design and construction has a huge effect on the entire project life. Therefore, CJIAC should manage well all the participants of this project to avoid a future disaster.

The extended enterprise concept is a good framework to deal with this kind of large and complex project. By considering Central Japan International Airport as the extended enterprise, the goal of this enterprise will be clear: continuously eliminating waste from the inside of this enterprise to provide a flow of value to the customer and all stakeholders.

Only CJIAC interacts directly with most of stakeholders at this level, therefore it should be a team leader and make advance agreements with participants to keep this enterprise stable.

5.4 Specifying Customer's Value

Specifying a customer's value is the first step in transforming the organization to a lean state. Who is the customer for Central Japan International Airport? Travelers, airlines, freight companies, and tenants in the terminal building could all be considered the customer. Airport revenue might indicate actual customers. Sources of revenue consist of aeronautical revenues, non-aeronautical revenues, and tax revenue. Aeronautical revenues are: (1) landing fees and (2) terminal rentals from passenger and cargo airlines. Non-aeronautic revenues are: (1) concession fees from commercial activities like shops, restaurants, duty-free, etc, in the airport; (2) concession fees for aviation fuel and oil; (3) automobile parking and rental fees. Tax revenues come from passenger facility charge. These sources of revenue are interdependent and can be understood well by a simple causal diagram. Figure 5.4 shows that all causal loops go through "Landing fees per flight", which means that landing fees per flights have an effect on all the revenue sources of the airport. Therefore, it is safe to say that keeping landing fees per flight low creates value to the enterprise from the revenue source point of view.

However, we should be careful that, although most causal loops are reinforcing feedbacks, revenue from landing fee is negative feedback loop. It means that lowering landing fees per flight hurts revenue from landing fees even though it increases other revenues. This kind of problem among stakeholders should be addressed by applying the lean enterprise concept to maximize the value of entire enterprise.

Focus on landing fee at the operation phase as the extended enterprise's target is not common practice for most of the airport construction in Japan. The public sector usually tries to cleverly use up its annually allocated budgets, and landing fee is determined by the accumulated cost. For example, Kansai International Airport was built on an artificial island on Osaka Bay. Its

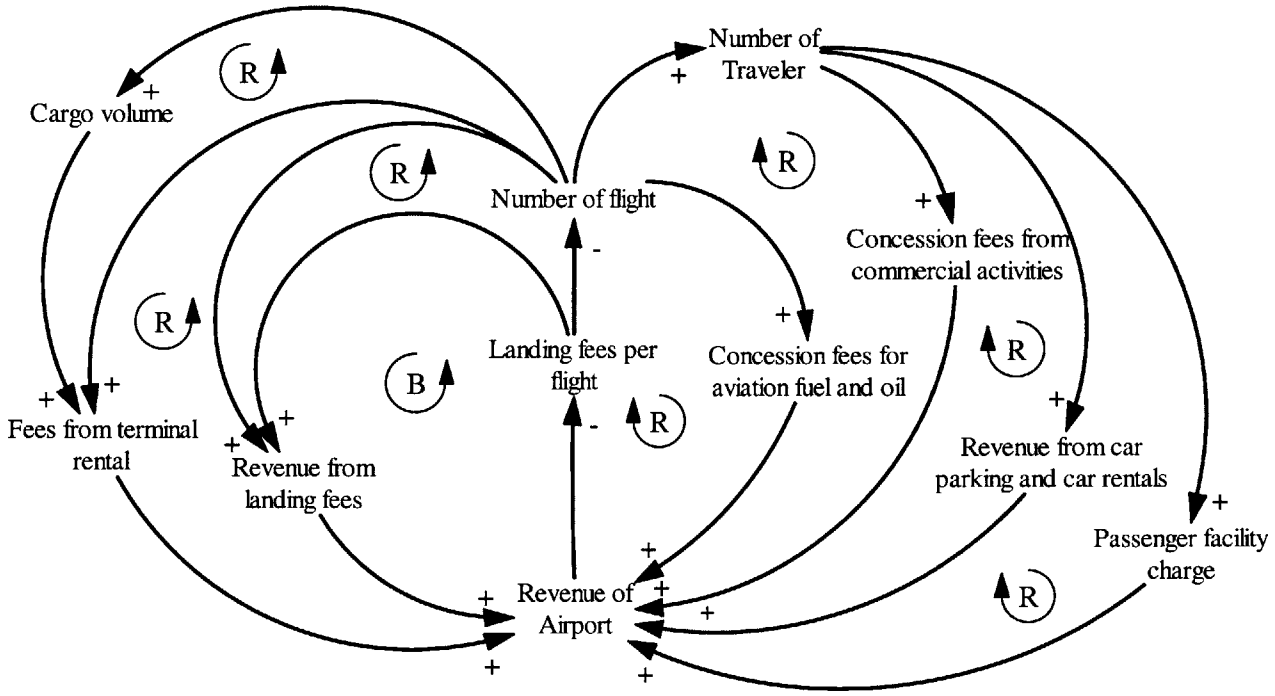


Figure 5.4 Causal diagram of airport revenue

original project cost was estimated at ¥1,068 billion; however, total project costs rose to ¥1,458 billion, or 1.4 times higher than the original estimate. As Table 5.2[5] shows, their landing fee is the second highest in the world and is more than double that of the rival airport around Southeast Asia. Kansai International Airport realized that its landing fee was not competitive and recently reduced its fee 9%. On the other hand, CJIAC plans to offer a lower landing fee than Kansai International Airport from the beginning of the project.

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[5] Yomiuri Online 04.02.11 (modified): http://chubu.yomiuri.co.jp/news_air/air040211_1.html

Landing Fee of Major Airports 2003.12	
Tokyo (Narita)	US$8,700
Kansai	7,600
New York (JFK)	4,800
Hong Kong	3,500
Paris (Charles de Gaulle)	3,300
Seoul	2,600
Singapore	1,700
London (Heathrow)	900

For jumbo jet (395t)

Table 5.2 Landing fee of Major Airports

5.5 Value Stream Map of the Central Japan International Airport

Value stream of the Central Japan International airport might be a large and complex one if we try to pick up every detail of business transaction among project participants. Therefore, we only focus on the big picture of this value stream at first and then look into detail for some

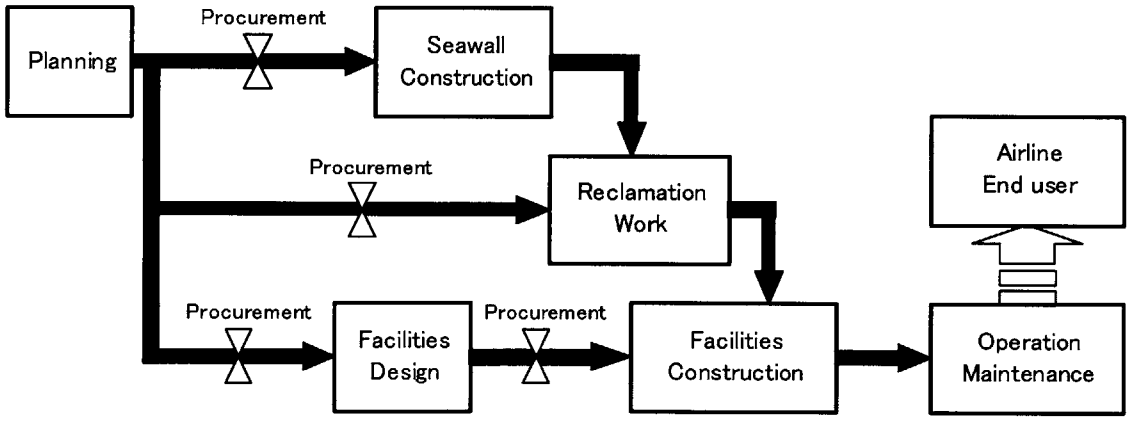


Figure 5.5 Value Stream Map of the Central Japan International Airport

important points.

Figure 5.5 shows an outline of the Central Japan International Airport value stream. By regarding airlines and end users as actual customers, CJIAC is better to be the part of extended enterprise as we discussed in the previous chapter. Lowering the landing fee clearly create value for these customers and this should be the goal for the extended enterprise.

CJIAC is the private sector and has all the responsibility from planning to operation. Total cost is estimated at ¥768 billion, and among their projects, three contracts are the largest: Seawall construction of the airport island (¥71.3 billion); Reclamation work for the airport island (¥71.2 billion); Construction of passenger terminal building (¥76.8 billion).

Seawall construction 3 JV 15 Firms	Part I	Toyo Construction, Sato Kogyo, Mitsui Real Estate Construction, Tekken Corp, Nitto Daito JV
	Part II	Wakachiku Construction, Fujita Corp, Rinkai Construction, Meiko Construction, Japan Industrial Land Development JV
	Part III	Penta-Ocean Construction, Maeda Corp, Saeki Kensetsu Kogyo, Tokyu Construction, Ohmoto Gumi JV
Reclamation Work 3 JV 15 Firms	Part I	Toa Corp, Kumagai Gumi, Nishimatsu Construction, Mitsui Construction, Tokura Construction JV
	Part II	Kajima Corp, Toda Construction, Okumura Corp, Honma Gumi, Nippon Doken JV
	Part III	Taisei Corp, Hazama Corp, Penta-Ocean Construction, Dai Nippon Construction, Yahagi Construction JV
Terminal Building 2 JV 16 Firms	Part I	Taisei Corp, Kajima Corp, Obayashi Corp, Tokyu Construction, Toda Construction, Overseas Bechtel, Sato Kogyo, Yahagi Construction JV
	Part II	Takenaka Corp, Shimizu Corp, Konoike Corp, Tobishima Corp, Fujita Corp, Lotte Construction, Meiko Construction, Tokura Construction JV

Figure 5.6 Member of each joint venture

CJIAC awarded these contracts to Joint Venture (JV) of the construction firms. Each of them consists of a complex enterprise structure. Figure 5.6 shows that each task is executed by several joint ventures. Each joint venture also consists of several construction firms and organizes their subcontractors and suppliers.

5.6 Control the extended enterprise

5.6.1 Cost Management

How does CJIAC manage this complex organization? It applied the Cost Management concept, which is similar to the target costing method.

The Cost Management concept is shown in Figure 5.7 and is well understood by comparing it with the traditional business process of the public work. For projects of both types, there is the originally allocated budget. For the public work, the original budget is allocated to each facility without being evaluated. However, CJIAC evaluated the profitability of the project in order to come up with a new and more reasonable budget for the project. In this process, evaluation should strictly comply with basic project schemes such as making a profit within one year and paying off the debt by the targeted year. It also adjusted the budget balance planning through the flexible revisions of business conditions such as demand, interest rates, tax rates, etc. Therefore, targeted costs were also reviewed occasionally. The Investment Planning Committee was established and met once every three months to update the project profitability and targeted costs. CJIAC also hired outside consulting firms to adjust their costs to the latest market prices. This concept is completely different from the public work, because if the situation changes for the public work, the extra budget will be made up in the next fiscal year.

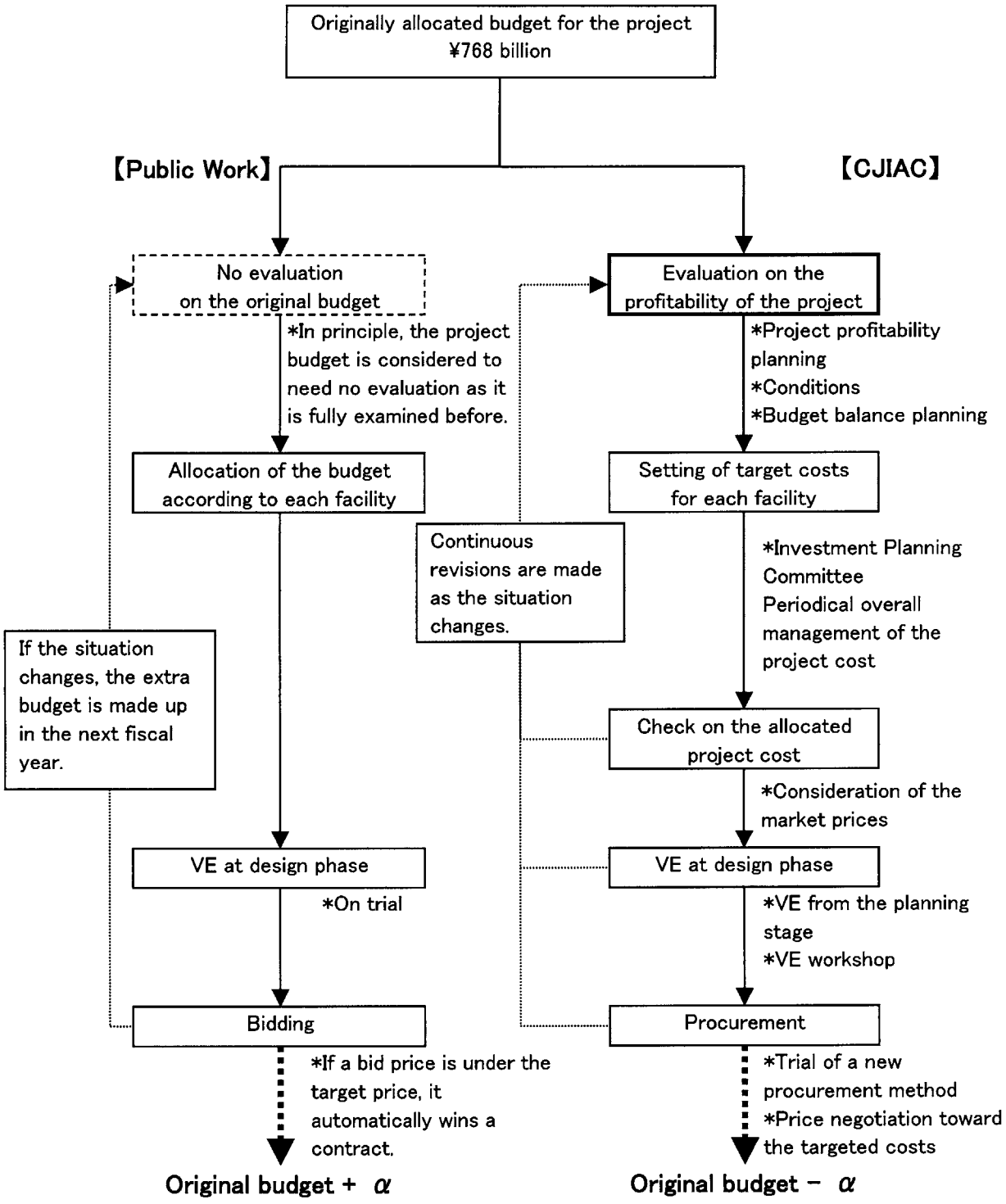
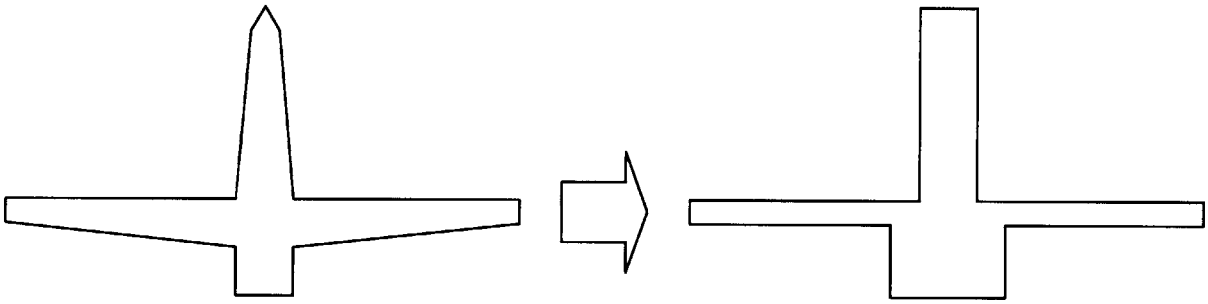


Figure 5.7 Flow chart of cost management (Bito 2003)

5.6.2 Value Engineering

CJIAC's extensive use of Value Engineering method (VE) is also an important point of Cost Management.

At the planning phase, it created a VE workshop to consider alternative plans. This workshop consisted of domestic and overseas experts other than actual designers in charge. They tried hard to eliminate waste from the original plan. For example, the original plan of the Passenger Terminal Building had a symbolic shape inspired by the Japanese traditional paper craft and its roof has a complex curved shape. The VE workshop suggested changing the plan as shown in Figure 5.8 and making the roof simpler, and this change would reduce ¥41 million of the construction cost[6]. The design team resisted this change at first, but the CEO of CJIAC pointed out, "Your design is great, but from where can end users appreciate the design?", and every member was convinced to change the design. Through various improvements, the VE workshop finally reduced more than 17% of the cost for the four main building facilities.



Original Plan

Modified Plan

Source: Nikkei Architecture 2003.08.13

Figure 5.8 Change in the plan of the Passenger Terminal Building

At the bidding phase, CJIAC also applied the VE method. For the public work, a contractor automatically wins a contract if his bid price is lowest and under the target price of the client. However, CJIAC uses bidding just to select the candidate for the contract. For the Passenger Terminal Building[7], prime contractors' bidding price was 10% higher than the targeted cost by CJIAC. So, after the bidding, they met with the contractor 25 times until they agreed about the contract. During the long negotiation, the contractor suggested 200 improvements to achieve the targeted cost of CJIAC. One of the examples is shown in Figure 5.9. As we discussed earlier, the three parts of the project are : Seawall Construction, Reclamation Work, and Terminal Building.

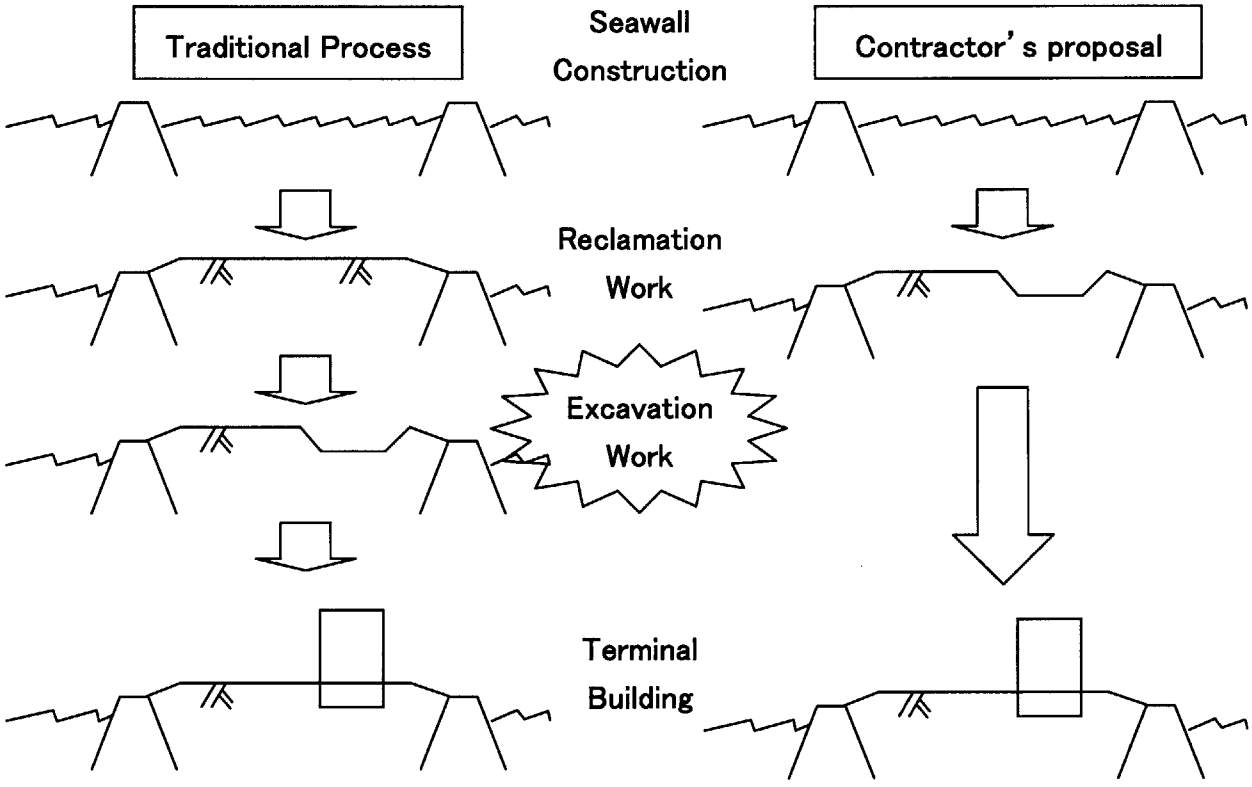


Figure 5.9 Waste elimination by the contractor's proposal

Each contract was assigned to different joint ventures and there wasn't much interaction among them. In the traditional processes, joint ventures for reclamation work purchase soil and deposit

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[6] Nikkei Business 2003.05.05
[7] Nikkei Business 2003.05.05

it in seawater, and finally they finish their job by making the surface even. Terminal building contractors then excavate the surface to build the basement and discard soil. The contractor suggested to CJIAC not make the surface even before the reclamation work's contactors handed over the site to the building contractor because this change would save money and time. This is waste elimination at the extended enterprise level.

At the construction phase, CJIAC encouraged contractors to suggest ideas for waste elimination in return for a 50% refund of reduced cost as an incentive. This system worked well because CJIAC announced its target costs and specified its target levels in advance to give contractors more chance to leverage their construction management capabilities.

5.6.3 Strong leadership

CJIAC has successfully implemented the extended enterprise concept by empowering their designers and contractors. Strong leadership also has enabled a drastic waste elimination from construction processes.

The construction of facility building on the artificial island usually begins after the full completion of the reclamation work because the Public Water Body Reclamation Law requires the approval of completion from the prefectural government which issued the construction license for the project. In this project, CJIAC separated its reclamation work area to 19 blocks, and received approval sequentially as each block was completed. By adopting this method, they could finish reclamation work for the Passenger Terminal Building area first. Although, at that time, the reclamation work finished only 40% of the total area, CJIAC could start the time-consuming construction work.

Now we can say that the normal construction process for reclamation work is clearly dominated by batch and queue mentality. Partially completed but not approved areas of

reclamation work are undoubtedly the inventories in the construction industry context. Actually, this partial approval method needed extra efforts from both contractors and the prefectural government. However, CJIAC leads stakeholders well under the strong leadership of its CEO who committed to finish this project on time under the budget for the successful operation of the airport.

5.7 Benefits of lean

CJIAC applied the lean concept to a large and complex construction project for the first time in Japan. What is the result so far? Table 5.3 shows the result of various large construction projects completed in this decade in Japan. Most comparable projects cost more than initially estimated and need extra time. Akashi Kaikyo Bridge was an exception because this project finished on time.

	Actual cost/ Initially Estimated cost	Actual construction period/ Initially Estimated period
Central Japan International Airport[8]	87% (estimated)	98% (estimated)
Akashi Kaikyo Bridge[9]	125%	100%
Trans-Tokyo Bay Highway[8]	126%	125%
Kansai International Airport[8]	136%	136%
Toei subway Oedo-line[8]	143%	156%

Table 5.3 Comparison of large project's costs and schedules in Japan

Although there are many reasons for cost overrun and the extension of the construction period, it is sure that CJIAC managed their project well by applying the lean concept. Compared to these previous projects, Central Japan International Airport might achieve big success because it may shorten the schedule a little while reducing the cost more than 10% from its initial estimation.

5.8 Conclusion

The Central Japan International Airport Company manages its airport project in a different way from the traditional construction project by the public sector. CJIAC applied the lean concept to this large and complex construction project and eliminated waste in a way that is not typical for the construction industry. It has a consistent policy that has something in common with the extended lean enterprise concept we discussed in the previous chapter. It specified the customer's value as providing a competitive landing fee for airlines, and it derived target costs for the construction processes by calculating the profitability at the operation phase of the airport. It also applied the cost management concept that makes their cost structure responsive to the environmental change. The value engineering method was used extensively to eliminate waste from the construction value stream. CJIAC used the VE method not only for the planning and design phases but also for the construction phase. CJIAC has updated its target costs periodically by applying its cost management concept, which made the negotiation during the VE method more productive. CJIAC leads this extended enterprise with the strong leadership. For this airport project, CJIAC is not an actual customer, but airlines and travelers are. Therefore, it was a good decision for them to take a leadership role in this extended enterprise. Finally, compared with other large projects in Japan, CJIAC will achieve a big success by reducing costs and time as benefits of implementing the lean concept.

Chapter 6. Conclusion

This thesis derived lean concepts from the manufacturing industry and examined the applicability of lean concepts for construction firms in Japan. For this purpose, this thesis explored the business processes of the Japanese construction industry from three perspectives: the production level, the enterprise level, and the extended enterprise level.

At the production level, this thesis examined the applicability of the lean production concept. This concept changed the dynamics of international competition in the manufacturing industries, notably in the automobile industry, by transforming the mass production system to the lean production system. The lean production system uses less of everything compared with the mass production system and continuously focuses on eliminating waste. However, the lean production concept cannot be applied to the construction industry because the production system of the construction industry is not simply mass production. Due to the peculiarity of construction, the production system of the construction industry is the mixture of three transitional models of production systems: craft, mass production, and lean production. Although the lean production system itself is not applicable to the construction industry, its underlying concept can be applied beyond the production level. The essence of the lean production system is a fast-track improvement that is enabled by both the mechanism of specifying the problem and the

production-line-based rapid problem-solving cycle, and a momentum for continuous improvement that is enabled by long-term personal training and trust-based relationships between management and workforces.

At the enterprise level, this thesis examined the applicability of the lean enterprise concept. The lean enterprise concept derived from the lean production concept and can be applied to non-manufacturing companies. A lean enterprise continuously eliminates waste from the inside of the company to provide a flow of value to the customer and all stakeholders. The U.S. aerospace industry created useful tools and methodologies to implement the lean enterprise concept for their industry. However, company level optimization does not create the value fully for the construction industry because construction firms do not participate in the whole construction value stream and cannot reap the full benefit of lean transformation.

At the extended enterprise level, this thesis examined the applicability of the extended lean enterprise concept. An extended lean enterprise is a group of individuals, functions, and legally separate but operationally synchronized companies which continuously eliminates waste from the inside of this alliance to provide a flow of value to the customer and all stakeholders. This new organization needs a strong leadership that optimizes the relationships among different companies. The Central Japan International Airport project was explored to verify the applicability of the extended lean enterprise concept. The Central Japan International Company is a private sector company and manages its project in a different way from the public sector. This thesis revealed that it has a consistent policy, which complies with the extended lean enterprise concept, and it is on the way to accomplish their project without any cost overrun and delay, which is quite usual for the large and complex project in Japan.

Each construction process focuses on doing the job right and add value to some extent. Construction firms in Japan seem to be stuck doing the job more and more right. However, these efforts can create more value if instead, they are doing the right job. No one knows what the right job is at first. Although lean concepts are not directly applicable to construction firms in Japan, these concepts definitely help to find the answer by continuously eliminating wastes from their business processes.

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