Designing the Lean Enterprise Performance Measurement System

by

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Submitted to the Engineering Systems Division in partial fulfillment of the requirements for the degree of

Master of Science in Engineering Systems
at the
Massachusetts Institute of Technology

September 2005

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Abstract

The research contained in this thesis explores design attributes of the enterprise performance measurement system required for the transformation to the lean enterprise and its management. Arguments are made from the literature that successful deployment of the lean practices, across three different stages of the evolution of lean thinking, requires a supporting performance measurement system. The increase in scope of lean practices at each stage of the evolution increases the complexity in achieving synchronization across the enterprise subsystems. The research presents various attributes of the performance measurement system required at each stage and further derives the three key attributes for the design of the lean enterprise performance measurement system. These three attributes are: enterprise level stakeholder value measures, the causal relationships across performance measures at each level, and Uniform and consistent set of performance measures.

A detailed case study of an aerospace and defense business of a multi-industry corporation which has embarked on a journey towards creating a lean enterprise is presented. It highlights several challenges in the transformation from the perspective of performance measurement. The key challenges identified are: First, disconnect between the performance measurement for the lean practices and regular business practices hinder the adoption of lean practices. This disconnect exists due to the existence of both legacy performance measures and the new measures. Second, lack of understanding of the cause-effect relationship between performance measures across different enterprise levels poses difficulty evaluating the impact of lean related efforts. Third, use of non-uniform performance measures across various enterprise subsystems leads to non-lean behavior.

The theory underlying performance measurement is reviewed including the widely-accepted performance measurement frameworks suggested for the design of enterprise performance measurement system. Analysis of these frameworks reveals that none of the existing frameworks completely capture the desired attributes for the lean enterprise performance measurement system.

To design the lean enterprise performance measurement system, this research suggests a conceptual design that explicates the use of various tools and techniques to address the critical attributes. To identify stakeholder value measures this design demonstrates the use of stakeholder value analysis. Use of system dynamics modeling and structural equation modeling is suggested to establish, validate and evolve the cause-effect relationships between performance measures. And, to maintain the uniform set of measures the creation of measures dictionary is explained. Further, research is needed to empirically validate the model as a means for successful transformation and management of the lean enterprise.

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Acknowledgements

Completing this work has been a profound learning experience for me. Many people directly or indirectly contributed to my learning and helped me steer through my journey at MIT. I would like to take this opportunity to thank them.

First I would like to thank Professor Deborah Nightingale who believed in me and gave me an opportunity to be part of the research team at the Lean Aerospace Initiative (LAI). Working closely with her during classes as well on this research project gave me the opportunity to know this sharp intellectual and wonderful person. She provided nothing but praise and always instilled confidence and excitement in the project. I am privileged to have her as my advisor not only for this thesis but also for future endeavors in life.

I thank my mentor, Dr. Ajit Kambil, without whom I would have not attended MIT. Words are not enough to praise this gentleman. He has always provided me with incredible guidance and support. I hope for a chance in this lifetime to do something in return for him.

I appreciate LAI's generous support towards my research and education at MIT. I thank all my colleagues and fellow students at LAI for making it a wonderful workplace. I am especially indebted to my teacher and my friend at LAI, Jaykanth (JK) Shrinivasan. JK and I spent numerous hours together crafting this project, arguing over my crazy ideas and discussing life. Thank you, JK. In addition, I would like to thank Noel Nightingale for contributing his experience and great insights to this project. Along those lines, I would like to thank an MIT research affiliate, Geoff Bentley without whom this research would not have been possible. Dr. Kirk Bozdogan, you taught me a lot of things sir. Thank you for your words of wisdom. I would also like to thank Dr. George Roth for his expert counsel on this project. Geoff Groesbeck has been of incredible help for providing his editorial expertise.

Of course, there are countless other students I have met and made friends with along the way. I believe it is the incredibly high caliber of the MIT student that makes MIT the singular experience it is. And, there are countless MIT staff members whose help in hundreds of small ways I could not have done without.

But most of all, I would like to offer my thanks to my family. I am grateful to God for blessing me with such a wonderful family. It is my father and my mother - and the rich set of values that they inculcated in me - that make me the person who I am today. I cannot thank them enough for the strength they provide, the sacrifice they made and for being the best parents in this world. I am grateful to my brother who has been always there for me. My wife 'Kunjan' fills my thoughts and there is no other person with whom I would haved wish to share this incredible adventure called life. Our relationship brings a great source of energy, enthusiasm and resilience to me. There is no compensation sufficient for the sacrifices she has made and the burdens she has carried as a result of my decision to pursue this degree. In return, I can only say "thank you".

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Chapter 1

Introduction

1.1 Evolving enterprise scope and complexity

Enterprises today are evolving from traditional, vertically integrated enterprises to dynamic, network-centric enterprises. This evolution has resulted in an increase in size, scope, and complexity. Traditional fields of study focus on the use of decomposition approaches to study enterprises through individual lenses such as strategy, organization design, and theory of the firm, to name a few. These approaches enable a deep understanding of specific aspects of the enterprise; however the resultant 'big picture' view of the enterprise is often lost in the analysis process. The engineering systems lens views the enterprise as 'a system of systems' that consists of multiple interconnected and interacting systems such as supply networks, manufacturing systems, human resource development, information systems, accounting, strategic planning, etc. This perspective provides a deeper understanding of the synergistic relationships across various systems within the enterprise, and provides insight into how value is delivered to constituent stakeholders.

Stakeholders with high expectations, the intense competitive environment fueled by the global economy, commoditization of products and services, increased information availability, and industry consolidation all have created a turbulent environment of change for enterprises. To adapt to such a dynamic environment and enhance overall performance, enterprises deploy a variety of system-change initiatives such as TQM, JIT, Six Sigma, process re-engineering, flexible manufacturing etc. These system-change initiatives extend across functional and organizational boundaries to include customers and suppliers, resulting in the transformation from a functional enterprise to a process enterprise. However, improper use of these system-change initiatives, either through a lack of understanding of process interdependencies or through focus on an individual stakeholder, results in optimization of performance at the subsystem level as opposed to optimization at the enterprise level. Enterprise-level performance improvement requires a radical rethinking of how we manage enterprises through the use of 'lean' principles and practices.

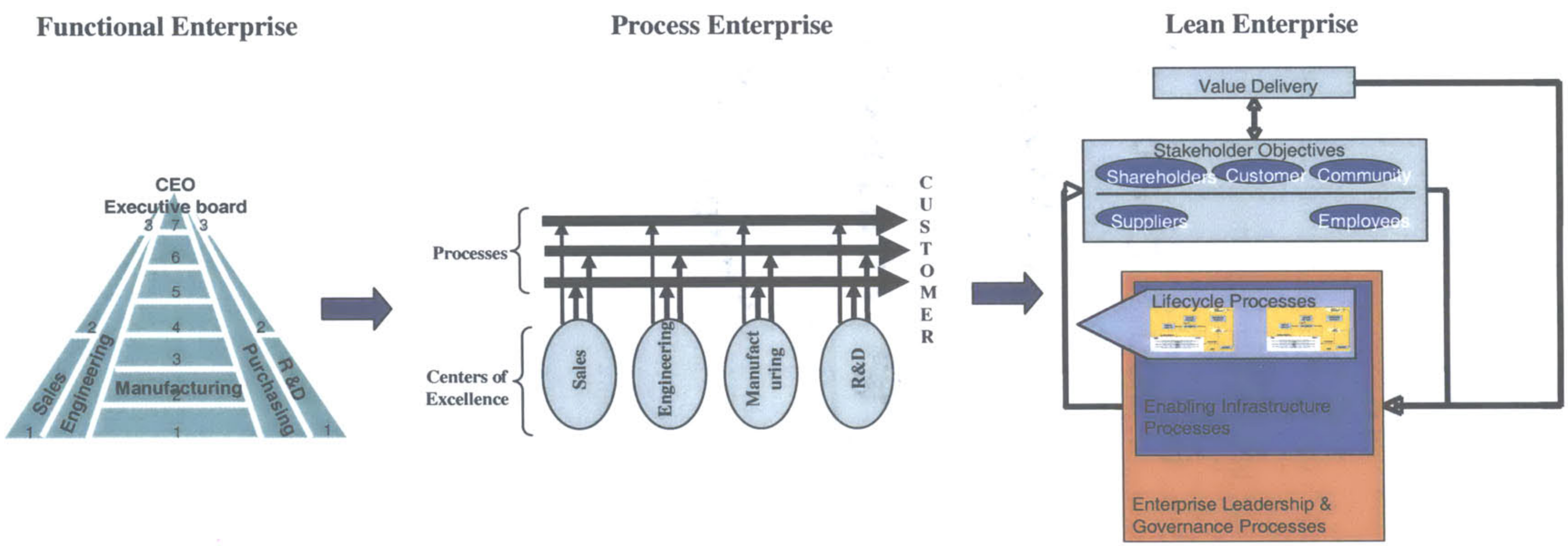
1.2 Lean as a management approach

In the last 15 years, the application of lean principles has evolved from the production cell level to the value stream level and finally to the lean enterprise perspective. Truly embracing lean principles and practices at the enterprise levels requires massive transformation. These transformation efforts include removing functional boundaries, process redesign, integrating across organizations, empowering people, involving all stakeholders in the value delivery process, etc. The evolution of enterprises is shown in **Figure 1.**

In most cases the impact of these lean transformation efforts are not reflected in terms of enterprise-level performance measures, and hence, many executives question the efficacy of transitioning to a lean enterprise.

Creating a lean enterprise is a means of managing the enterprise; it is not a performance enhancement technique (Nightingale, 2003). The transformation to a lean enterprise is a strategic approach that is intended to allow an enterprise to outperform its rival(s), based on the manner in which it plans, organizes and executes its activities. The objective of a lean enterprise is to deliver value to all its constituent stakeholders (Murman et al., 2002).

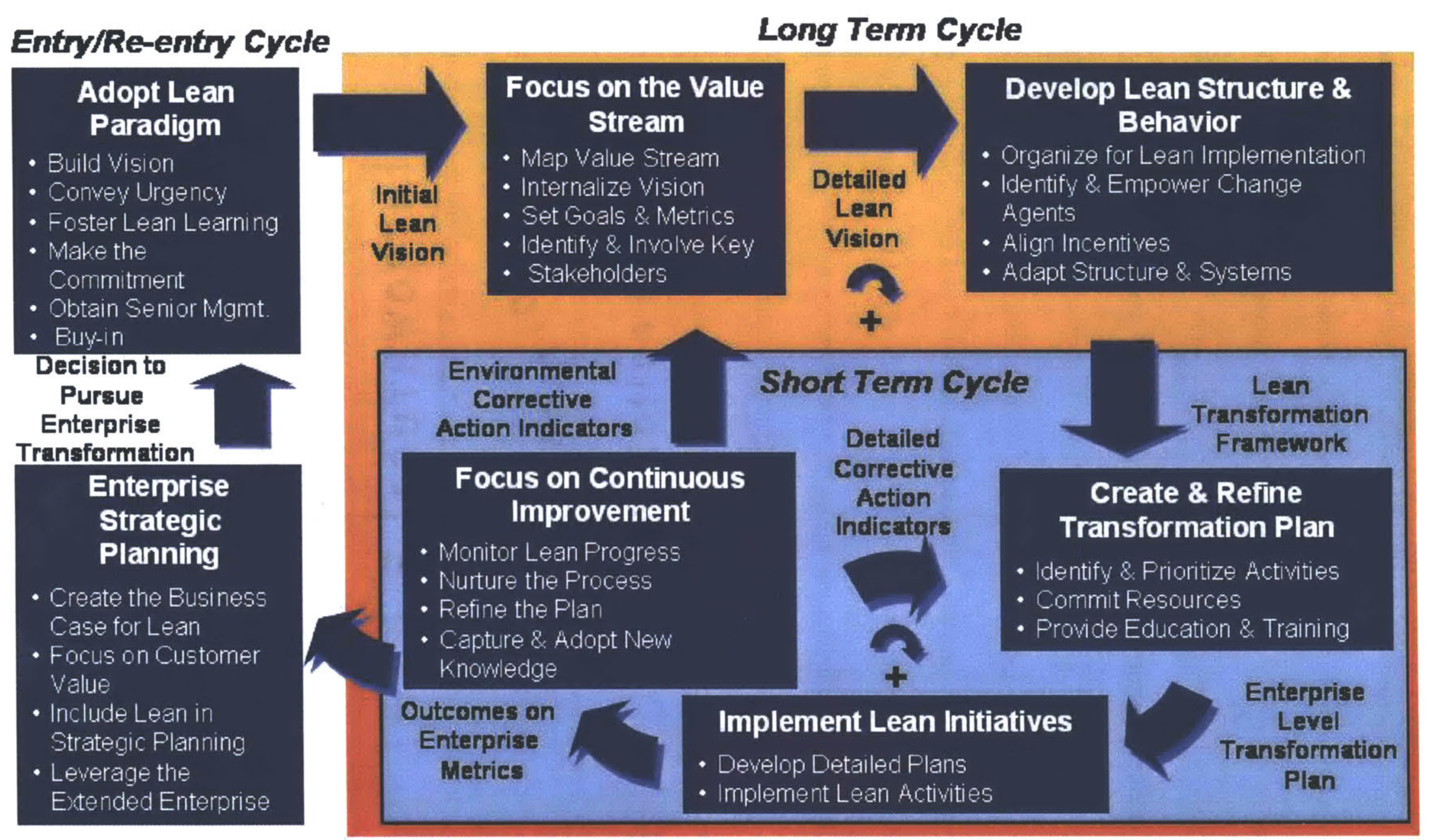
Figure 1.1: Evolution to the lean enterprise



Performance measurement provides the essential links between strategy, execution, and ultimate value creation and delivery. The lean enterprise perspective looks at multiple functions, processes, programs, and organizations in the extended enterprise as a *'system of systems'*. There are a myriad issues that arise as lean principles and practices promulgate throughout the enterprise, and they often highlight the need for systemic change in the enterprise. To incorporate requisite systemic changes while simultaneously managing strategy formulation, execution and ultimate value creation and delivery, changes in performance measures are needed, and corresponding support structures and processes have to be developed.

Successful deployment of the lean enterprise approach is not limited to the transformation of actions. However, corresponding change and systematic design of supporting performance measurement system is an imperative to synchronize those actions. Deployment of the lean enterprise approach is a journey of continuous learning and transformation. The approach constitutes three cycles, as described in LAI's Transition-To-Lean Roadmap (TTL), shown in **Figure 2**. In all three cycles, learning and transformation efforts are carried out at different levels of the enterprise. However, these cycles are tightly coupled and highly interdependent.

Figure 2.2: Transition to Lean Roadmap (Murman et al., 2002)



The entry/re-entry cycle focuses on strategy formulation and deployment of the lean philosophy at the enterprise level. Adoption of the lean paradigm at the enterprise level involves frequent improvements in the strategic plan. These improvements are carried out via learning and assessment of the external and internal environment, leading to the subsequent transformation of management policies, practices and, systems. Learning and assessment requires continuous performance feedback from the long-term and short-term cycles, as well as alignment of strategic goals and objectives with the performance measures used to assess stakeholder requirements, external environment, and enterprise performance. Transformation of management policies, practices and systems is carried out via the communication of the strategic plan across the enterprise, engaging leadership, allocating resources, and creating an environment to foster lean learning. Successful communication of the strategic plan requires alignment of performance measures between strategic objectives and activities across long-term and short-term cycles. Adequacy of resources, and impact of leadership and impact of lean learning at the enterprise level-performance require the understanding of causal relationships among transformation efforts, activities and measures.

The long-term cycle focuses on the execution of the strategic plan and development of the infrastructure needed to support lean practices. The execution process involves continuous improvement of enterprise-level processes across the value stream. Improvement targets are identified by comparing performance across the value stream against the strategic plan, desired stakeholder values and the impact of transformation efforts on the short-term cycle. Deployment of lean practices across the value stream includes change in employee behavior andmetrics and goals, as well as integration with stakeholders. Successful value stream transformation and adoption of lean practices requires a supporting infrastructure and performance measurement system. To motivate the adoption of lean practices and accelerate change in employee behavior, rewards and incentives, systems have to be aligned through changes in performance metrics. To assess the need for training and education, and its impact on goals and measures requires an understanding of causal relationships between education and training, and improvement targets. Integration of stakeholders requires communication of practices and performance measures to facilitate coordination across stakeholders as well as processes, across entry and short-term cycles.

The short-term cycle focuses on the activity-level improvements and continuous refinement of the transformation plan. Activity-level improvement is an experimentation and learning process. It includes implementation of lean activities and learning the impact of change in activities on performance across the value stream as well as at the enterprise level. To enable successful improvements, the outcomes of the lean activities need to be aligned with strategic goals and metrics, which require an understanding of linkages across activity-level metrics and with strategic goals and metrics. The continuous refinement process involves communicating the change in activities, and subsequent change in performance across the value stream, and capturing new knowledge. This new knowledge further leads to corrective actions in the transformation plan across the long-term and short-term cycle. Thus, the implementation and refinement process requires visibility of performance measures at the activity level, process level, and across the enterprise.

From the description of the three cycles within the TTL roadmap, a successful transformation depends not only on successfully identifying and implementing lean improvement initiatives, but also on the corresponding change in supporting measures and measurement systems. The change in performance measures should not be limited to only lean improvement activity, but also should include interconnected and interdependent systems and subsystems. For example, lean improvement activity in production process results in improved cycle time via a reduced number of machines in the operation line. The reduction in the number of machines also frees up significant amounts of space on the shop floor. But, unless the measures for accounting for the shop floor assets are changed, the impact of lean improvement activity on the enterprise level-asset utilization will not be realized. The performance measurement system should provide the glue that correlates the information gathered at various levels of the enterprise to synchronize the management of the enterprise while undergoing continuous transformation. However, in current practice, enterprises that embark on the transition-to lean journey make very limited or no changes to their current performance measurement system. Using existing performance measures and measurement systems in the changed environment fails to capture the impact of lean improvement activities. In some instances, traditional performance measurements lead to non-lean actions and behavior. For example, use of variance reports to assess the resource utilization of a business line encourage employee behavior to focus only on variance, ignoring continuous improvement efforts.

1.3 Research Objective

Therefore, the biggest research question is:

How do we design a performance measurement system to enable and sustain the transition to the lean enterprise?

To propose a limited answer to this question, the objective of this thesis is two-fold:

- To qualitatively explore current performance measurement systems used at the enterprise level and identify gaps in current performance measurement systems.
- To identify key attributes of the performance measurement system for the lean enterprise and propose a conceptual model for the lean enterprise performance measurement system.

1.4 Thesis Overview

Chapter 2 discusses the application of lean principles and practices at various levels of the enterprise. The timeline of evolution from lean production cells to the lean enterprise is discussed, followed by the implications of adopting lean principles and practices across the enterprise. These implications are presented from the perspective of performance measures and supporting systems. The chapter concludes by identifying the key elements of a performance measurement system for the lean enterprise.

Chapter 3 reviews the theory behind performance measurement. It discusses the evolution of performance measurement and supporting systems. Widely adopted performance measurement frameworks are presented, followed by a discussion of the limitations of these frameworks with respect to the lean enterprise.

Chapter 4 discusses a case study carried out at the aircraft and defense business facility, 'Gamma Tech', of a multi-industry conglomerate, 'Alpha Corporation'. Alpha has embarked on a journey of transforming from a holding company to a networked enterprise via adopting lean practices. This case study highlights 'Gamma Tech's use of multiple independent performance measurement systems, and its drawbacks in the context of enterprise-wide adoption of lean practices.

Chapter 5 describes a conceptual model of the performance measurement system for the lean enterprise. This model is proposed based on needs identified in Chapter 2, gaps identified from Chapters 3 and 4, as well as theoretical concepts and practical applications studied from the literature.

Chapter 6 presents the conclusions of the research and defines avenues of research that need to be explored further.

Chapter 2

From Lean Production to the Lean Enterprise: Implications on the Performance Measurement System

The adoption of 'lean' philosophy at different levels of the enterprise leads to change in practices and subsequent actions which in turn require change in the supporting performance measurement system. Deployment of lean practices at the production process level involves synchronization of the multiple tasks and activities. The operations across the production process are synchronized by the performance measurement system, such as Visual Management System, which incorporates the interdependencies and performance across the tasks and activities. As the application of lean practices evolves from the production process to the enterprise level, it requires interdependent subsystems across the enterprise, such as functions, processes, activities, to operate synchronously. With the increasing scope the interdependencies among the sub systems become more complex **(Figure 1)**. Thus the successful deployment of lean practices at the enterprise level requires a performance measurement system that incorporates performance measures to support the lean practices, facilitates the communication of performance across subsystems, and captures the interdependencies among the subsystems.

This chapter looks at the evolution of lean practices across three different stages: Lean production process, System change initiative and, The Lean enterprise. Development in the characteristics of performance measurement system for the successful implementation at each stage is presented based on a detailed literature review. A discussion on practices for creating the lean enterprise ensues, and the characteristics of the performance measurement system required to support the lean enterprise are identified.

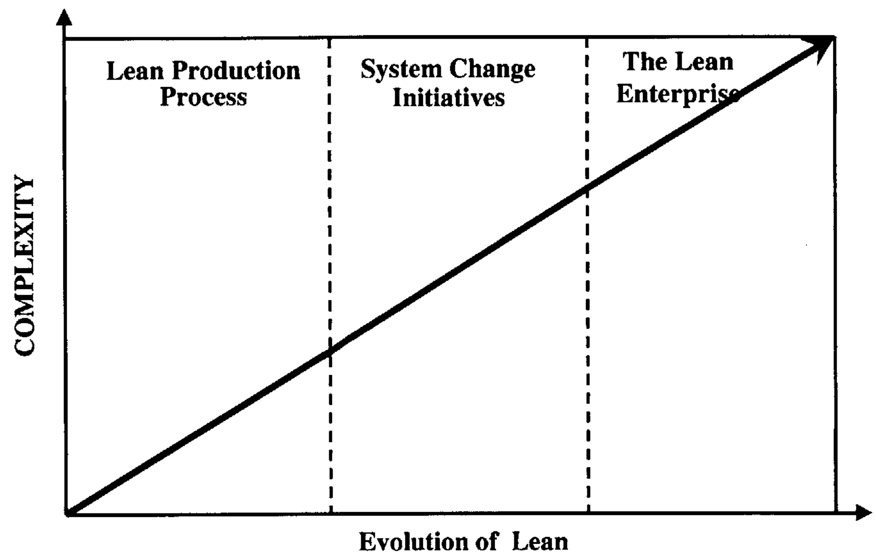


Figure 2.1: Evolution of the lean practices versus complexity at different level of the enterprise

2.1 Evolution of 'Lean' philosophy to the lean production process

The idea of "lean" originated in the context of the manufacturing environment from the work of Taiichi Ohno at Toyota. The application of lean principles first appeared in the domain of engine manufacturing, and quickly expanded to automotive manufacturing and, finally to the complete production process. Ohno defined three types of activities occurring in the production process: value added work, non-value added work and waste (Ohno, 1988). The way of managing the production process by continuously removing waste and non-value added work was largely defined as lean production process. Shingo and Ohno identified seven different types of manufacturing wastes: overproduction, waiting time, transport, inventory, motion defects and processing(Shingo, 1992). At Toyota, the identification and elimination of these wastes in the production process resulted in reduced cost of manufacturing as well as improved quality of products. The quest for continuous improvement and waste removal, while delivering the customer value at Toyota gave birth to the famous Toyota Production System (TPS). TPS is built on systemic principles and practices, such as Just in Time production and delivery (JIT) and, Autonomation (*jidoka*) and continuous improvement (*kaizen*).

The findings of the International Motor Vehicle Program (IMVP) at MIT showed that lean production combines the best features of both mass production and craft production: the ability to reduce costs per unit and dramatically improve quality while at the same time providing an ever wider range of products and more challenging work (Womack et al., 1991). These findings, along with the dynamic competitive environment in the 1980's, stimulated interest in emulating the TPS beyond the technical contingencies of automotive manufacturing across various industries and geographies.

A number of western companies began programs to emulate Toyota production systems. However, while there were successful implementations the number was limited. Many companies equated the TPS to sophisticated operational tools and techniques. Rather than implementing the complete system or philosophy, they attempted to implement only particular elements of lean production (McLachlin, 1997). Although the appearance of the TPS in North America and Europe stimulated some changes, manufacturing practices was transient, superficial and insubstantial (Shingo, 1992). Based on the comprehensive survey of lean production literature, (Shah and Ward, 2003) suggested that a successful lean production process requires lean practices and supporting structures, which includes performance measurement and rewards aligned with lean practices.

2.1.1 The Lean Production Process

The objective of the lean production process is to continuously reduce the waste in human effort, inventory, time to market and manufacturing space to become highly responsive to customer demand while producing world-class quality products (Phillips, 2000). In the past several years, scholarly journals have published a plethora of successful lean production practices. The boundary of the lean production process is limited to the production line, with close coordination or overlapping the supplier and customer activities and a distant relationship with other functions of the enterprise **(Figure 2)**. Seven common lean production practices have been identified from the literature. (Shingo, 1992 Koufteros, et al., 1998;White et al., 1999; (Pavnaskar, et al., 2003; Carreira, 2005; Shah and Ward, 2003; and Maskell and Baggaley, 2004.)

- Shop-floor employee involvement
- Re-engineering set-ups
- Cellular manufacturing
- Quality circles
- Preventive maintenance
- Dependable suppliers
- Pull production

These practices are interdependent and are implemented across multiple tasks and activities within the production process. Increased interdependence among the tasks requires improved visibility of performance across the production process to successfully deploy lean practices. For instance, managing the pull production in a work cell depends on the performance of the preceding activity and the customer takt time. The continuous improvement efforts are carried out via involving shop-floor employees in problem identification, problem solving and decision making. To empower employees in decision making requires more open communication and better understanding of the cause-effect relationships across the tasks/actions. In addition, to support the shop-floor employees in problem solving and to encourage the use of lean practices, supervisors need access to the shop-floor performance information. The performance measures and the supporting system facilitate the communication and coordination, besides monitoring and control, required for the deployment of lean practices

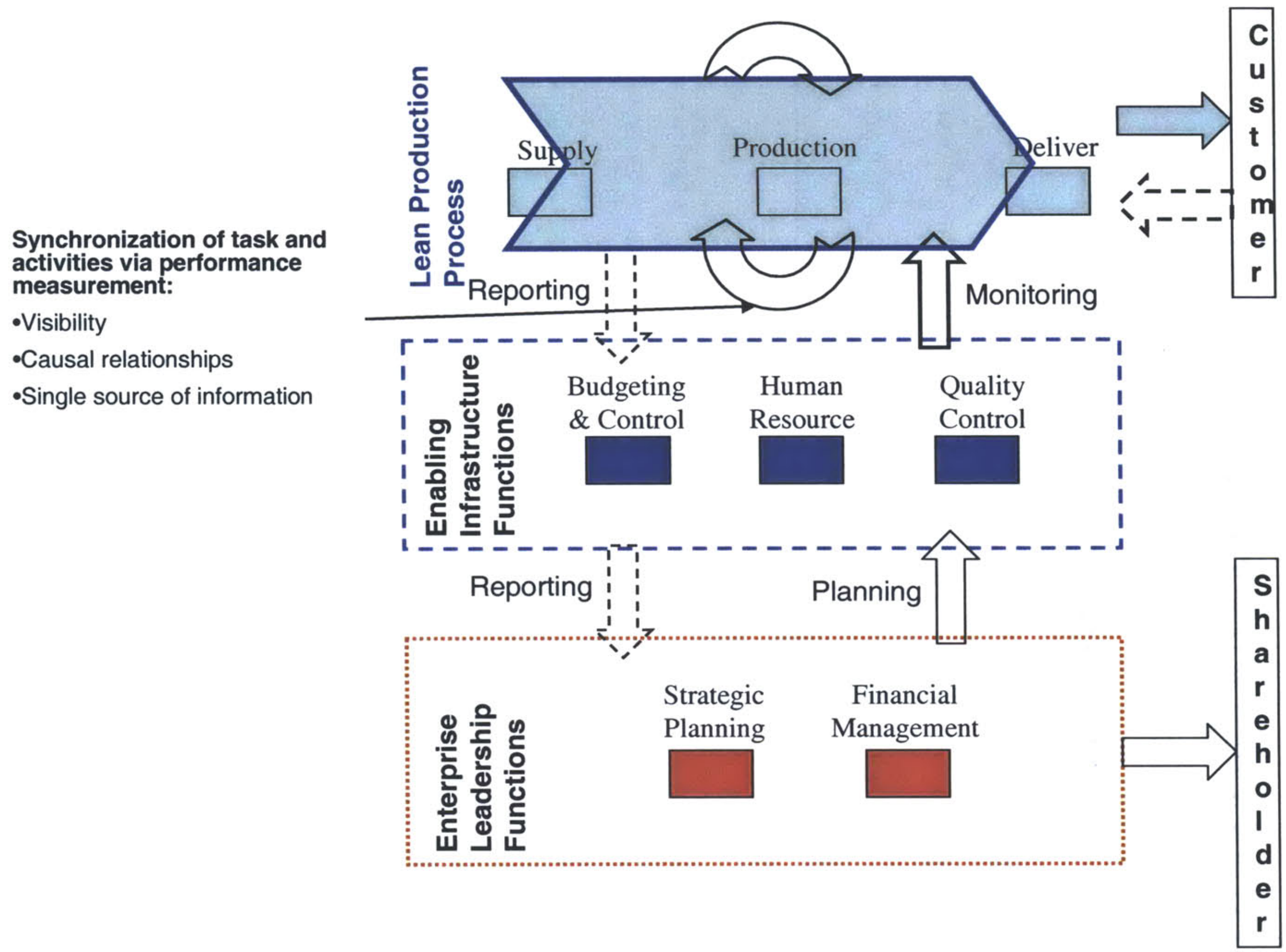


Figure 2.2: Lean production process in a functional enterprise and the corresponding performance measurement system

2.1.2 Performance measurement: Lean Production Process

Successful deployment and management of the lean production process involves different set of performance measures and a supporting system. Maskell and Bagelly (2004) argue that the lean production focuses primarily on the process level performance measures such as customer takt time, flow rate and, stability of the pull system instead of the traditional measures such as machine level utilization, overhead absorption etc. The performance goals around these measures are managed by providing visibility into the individual and task level performance via visual management system. In addition, the impact of interdependent activities on the overall performance is not always logical, and hence the causal relationship between the tasks and activities is captured via combination of visual management, integrated measures and frequent analysis of the individual and task level measures. To enable the coherent decision making, horizontally across the process and vertically among the managers and employees, the uniform sets of measures are used and the measurement information is collected into single information source.

2.1.2.1 Visibility

A lean production process has a strong focus on direct reporting of measurements at the source, which in turn provides real-time visibility across the production process. It is common - and preferred - to see whiteboards located at production cells, measuring production rates and performance to schedule, and customer service level, such as on-time delivery, quality performance, safety performance, and set-up time trends Carreira, 2005). Richey (1996) observed that winners of the 1996 Shingo prize for manufacturing excellence primarily used a visual performance management system on the shop floor. Real-time visibility of performance measures across the production line enables operators to stay focused on their target, helps them understand how their work relates to the larger goals of the production line, and provides instant feedback for problems to be fixed quickly. For example, consider pull production practices described by Maskell and Baggely (2004). Pull production is driven by customer demand, i.e., a production process manufacture only to meet precisely timed customer requirements. By allowing only a small amount of work-in-progress inventory to flow at any time, a pull system shortens the time that parts stay in the system by eliminating or greatly reducing waiting time. Thus, a visual presentation of the takt time - the rate at which a customer demands the product - along with the actual production rate, keeps operators focused across the production process, enabling them to meet customer demand When actual production quantity falls below a certain level, operators raise the alarm by reporting the problem visually on the display or by turning on the *andon* light. This visual presentation of these measures helps operators up and down the production line moderate manufacturing tasks accordingly, and alerts managers and engineers on the shop floor to solve the problem quickly. Thus, the performance measurement system provides visibility across the lean production process, enabling it to meet customer demand with minimal waste of actions, time and material.

2.1.2.2 Causal relationships

The successful implementation of a lean production process also depends on the causal relationships between actions and performance measures captured in the performance measurement system. For example, shop floor employee involvement means first-level employees participate in activities to define and solve problems. It can be antecedental to all other lean practices. Enhanced shop floor employee problem solving skills facilitate re-engineering of set ups, establishment of quality improvement efforts, and initiation of effective preventive maintenance programs (Koufteros et al., 1998). However, lack of employee involvement is very difficult to measure directly. Thus, the identification of root cause is determined via causal relationships established in the measurement system.

At the shop floor, production performance measures are gathered for each cell very frequently (e.g., hourly) and presented visually on the shop floor (Richey, 1996; Maskell and Baggaley, 2004; Carreira, 2005). This performance measurement information serves two purposes. One is to provide real-time feedback to the operators and the other is to analyze the data for identifying consistent problems. If production measures fall short of the target consistently and problems are not reported by shop floor employees, it is an indicator of insufficient employee involvement, in which case further action is taken to educate employees or enhance their morale to increase shop floor employee involvement. The causal relationship between employee education, morale and outcome is captured in performance measurement system. Similarly, equipment that has not been properly maintained may cause unplanned downtime that increases waiting time and induces firms to compensate for poor equipment reliability by adding inventory. Inventory extends throughput time by clogging the factory floor (Koufteros et al., 1998; Cua et al., 2001). These casual relationships are captured in the performance measurement system by measuring operational equipment effectiveness, which is a function of down time, production rate, and first time throughput (Jeong and Phillips, 2001).

2.1.2.3 Single source of information

In a lean production process, engineers, managers, accountants, production and inventory planners, and floor supervisors use the information from single performance measurement system, . Use of a single performance measurement system allows coherent decision making and keeps activities focused towards the goals.

In contrast, traditional reporting logic usually yields a report only after a week or more has elapsed after the fact. Further, it is all too often delivered in a sufficiently complex format such that fairly complicated analyses are required to translate the information to render it viable, let alone relevant. In sum, traditional reporting logic essentially delivers for the most part "old news". To avoid the time lag between reporting and action, managers and supervisors responsible for the production process instead should use a visual management system in real-time by walking down the production line.

The successful deployment of the lean practices across the production process incorporates a systematic performance measurement and support system. In order to synchronize the tasks and activities with in the limited focus of the production process, the performance measurement system encompassed all three attributes described above **(Table 1)**. Although a systematic and structured approach is adopted to deploy lean practices and the corresponding performance measurement system, the impact of lean practices on the overall enterprise performance remains limited due to the restricted focus on the production process. Realizing the limitations of the lean production process, researches and practitioners further developed the lean philosophy into broader approaches called system change initiatives.

	Lean Production Process
Focus	Production line (task, activities and cells)
Lean Practices	Cellular Manufacturing, Quality Circles, Dependable supplier, Pull Production, Re-engineering set-ups
Performance Measures	Take time, On Time Delivery, First time through, Safety Performance, Production Rate
Performance Measurement System	• Visibility - Real Time Reporting, • Causal Relationships (production tasks and activities), • Use of Single source of Information

Table 2.1: Characteristics of the lean production process and corresponding performance measurement system

2.2 Beyond the lean production process - The system change initiatives

In the late 1980s, lean thinking further matured into operations management and system-change initiatives, extending the scope and complexity of deploying and managing lean practices. The most widely accepted system-change initiatives are Total Quality Management (TQM), Just in Time (JIT), Six Sigma, and Business Process Reengineering **(Table 2)** (Bozdogan, 2004). The scope of system-change initiatives extends beyond the production line, moving across functional boundaries and organizations to include suppliers and customers **(Figure 3)**. System change initiatives are deployed across multiple subsystems of the enterprise to achieve one or more of the following strategic objectives: improve quality, improve speed, reduce cost, and increase flexibility. Each initiative includes several different approaches to achieve these objectives.

These approaches share some common characteristics, namely, customer focus, continuous flow, waste reduction, continuous or breakthrough improvement, and human management.

2.2.1 Just In Time (JIT)

The overarching objective of JIT is to continuously improve operations, with a goal of achieving lower production costs, higher rates of productivity, better quality and reliability of products, improved delivery times and improvement of working relationships with suppliers and customers (Kazazi, 1994). JIT initiatives primarily focus on eliminating all forms of waste by implementing a series of approaches: improving facility layout, product design, production planning and scheduling, material flow, supply chain and human management aspects. These approaches span business units and functions, such as planning, procurement, production and delivery. Performance of JIT initiatives is measured by inventory turnover, cycle time, lead time, and delivery.

2.2.2 Total Quality Management (TQM)

TQM is aimed at continuously improving and sustaining quality of products and processes by capitalizing on the involvement of management, the workforce, suppliers, and customers themselves to meet or exceed customer expectations. TQM practices include cross-functional product design, process management by statistical process control, supplier quality management, customer involvement, performance information and feedback, committed leadership, strategic planning, cross-functional training, and employee involvement (Flynn and Sakakibara, 1995; Cua et al., 2001). Practices are the approaches used by managers and workers with the goal of achieving a certain type or level of performance (Flynn and Sakakibara, 1995; Cua et al., 2001).

	Just in Time	Total Quality Management	Six Sigma	Business Process Reengineering
Goal	Lower production cost, higher rate of productivity, improved delivery times	Improve quality,	Reduce variability, reduce waste in the process, and improve profits.	Improve value delivery to the customer
Approach	Improving facility layout, product design, production planning and scheduling, material flow, supply chain and human management aspects	Cross functional product design, process management: SPC, Supplier quality management, customer involvement, performance information and feedback, committed leadership, strategic planning, cross-functional training, and employee involvement.	Statistical tools and techniques (mistake proofing, root cause analysis and failure modes and effects analysis)	Process redesign
Scope	Business units and functions	Management, workforce, supplier and customer	Activities and processes	Processes, enterprise
Performance measures	Inventory Turns, Cycle time, Lead time, delivery performance	Customers' perception of quality, defects in parts per million and percentage of units that pass final inspection without requiring rework	Defects parts per million, profitability	Critical to the enterprise

Table 2.2: Comparison of system change initiative

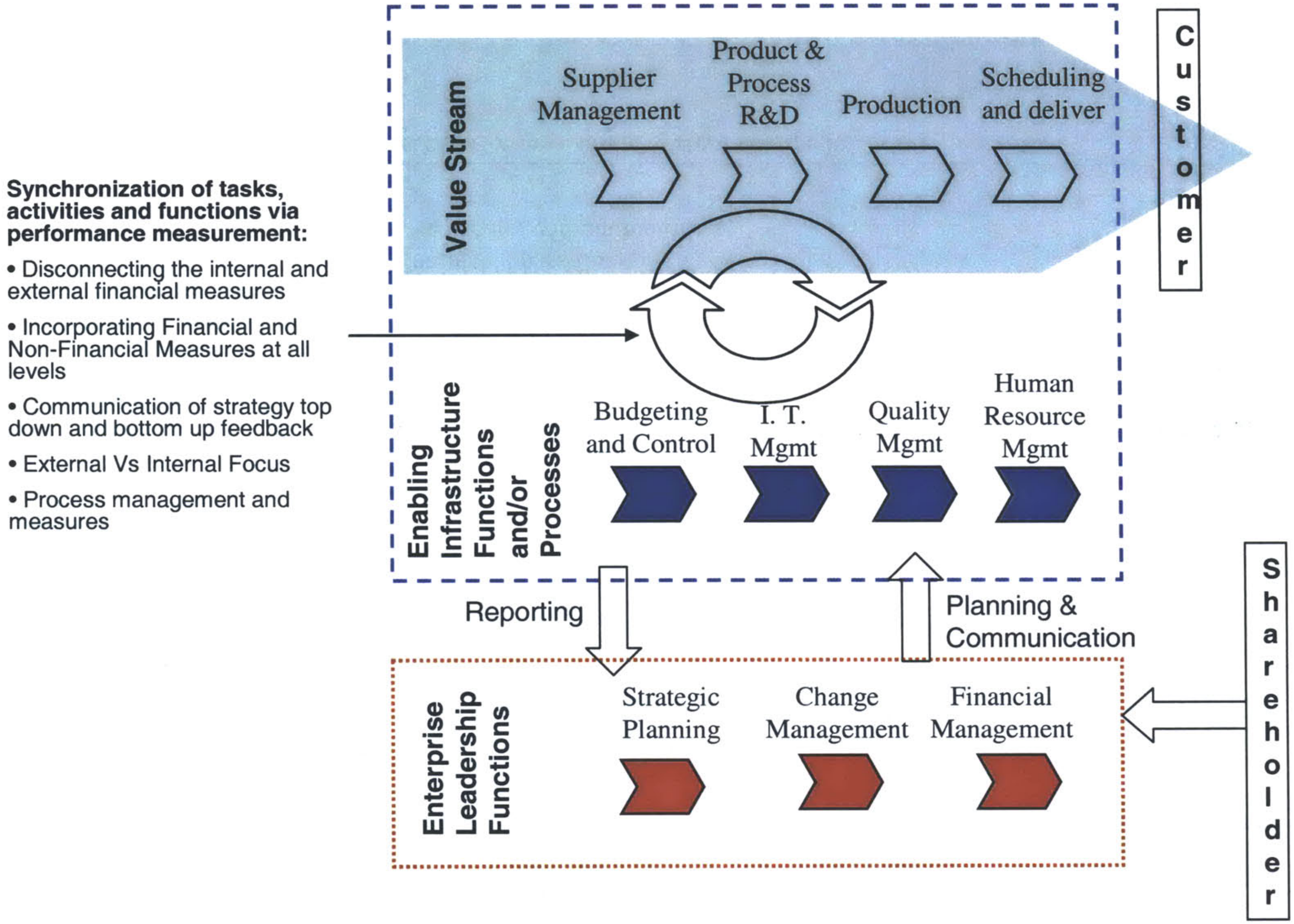


Figure 2.3: Enterprise structure for system change initiatives and elements of a performance measurement system

.TQM performance measures include customers' perceptions of quality, defects in parts per million, and the percentage of units that pass final inspection without requiring rework

2.2.3 Six Sigma

Six Sigma is focused on driving out variability and reducing waste in processes, by using powerful statistical tools and techniques. Its basic premise is that product or process defects are an undesirable expense and therefore consume potential profits. TQM proposes an incremental continuous improvement in individual operations, while Six Sigma sets out to transform an entire process with a focus on quantifiable elimination of defects. This transformation can be incremental as well as radical. The primary Six Sigma measure is defects parts per million in products or processes.

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2.2.4 Business process reengineering

Reengineering, as defined by (Hammer and Champy, 1993) is the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements. Process re-engineering includes a focus on customer and outcomes, seeing work on an end-to-end basis, following a process, collaboration with others, aligning all employees with a common objective, and continuous improvement. Process redesign, discipline and alignment lead to improved process performance, which leads to improved enterprise performance. The performance metrics a business wants to dramatically improve using reengineering may vary, although the basic objective remains the enhancement of value provided to the customers.

Successful deployment of a system change initiative requires alignment and synchronization, vertically across multiple levels and horizontally across functions and organizations. In the late 1980s and early 1990s, heightened global competition compelled manufacturing companies to adopt customer-oriented, flexible, responsive execution strategies. Several companies deployed system change initiatives to align their business operations with their strategies. The implementation of system change initiatives extends from activity-level change to organization-level transformation. System change initiatives emphasize a high level of interaction with and interdependence across activities and functions as well as among employees, and between employees and leadership **(Figure 3).** For instance, TQM is focused on improving ultimate product quality delivered to the customer, through a series of actions from supplier quality through product delivery. Change in actions at the supplier's end directly affects the production performance. Hence, cross-functional communication is encouraged to improve overall performance. Similarly, JIT's objective of waste removal and maintaining continuous flow leads to the removal of wasteful interactions and encourages functions to work closely to establish the continuous flow.

To align actions at the operational level with strategic objectives requires supporting performance measures **(Figure 4)** (Nanni, Jr. and Robb Dixon, 1992). Hence, successful implementation of system change initiatives requires corresponding change in performance measures and a supporting system to align activity-level performance with desired strategic objectives.

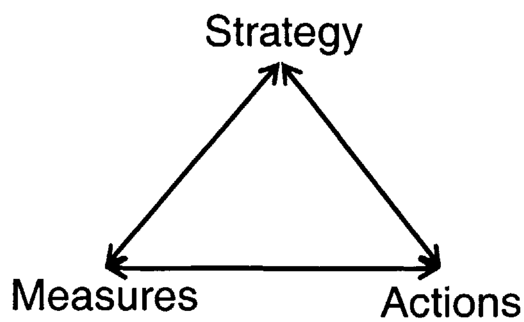

Figure 2.4: Alignment of strategy, actions and measures (adapted from (Nanni Jr and Robb Dixon, 1992)

2.2.5 Performance Measurement: System change initiatives

Appropriate performance measurement and a supporting system is imperative to the successful implementation and execution of system change initiatives (David and Mohamed, 1995a). The interdisciplinary view required by strategic management highlights the need for wider frame of reference than the traditional notion of control or performance evaluation. It encompasses a set of organizational policies, systems and, practices that coordinate actions and transfer information in support of the entire business management cycle. Performance needs to be assessed in several dimensions: in determining the adequacy of strategies for achieving organizational objectives, in revising strategies, in communicating them, and in development of tactical objectives as well as in its traditional role of control feed-back (Nanni Jr and Robb Dixon, 1992; Lockamy Iii and Cox Iii, 1995). Adoption of lean practices under system change initiatives led many companies to change traditional performance measures and the supporting system from strategic-level to activity-level as well as across functions and organizations to synchronize their operations **(Figure 3).** The change in performance measures and supporting systems include the following key aspects:

- Disconnecting internal and external financial measures

- Incorporating financial and non-financial measures at all levels
- Communication of strategic objectives top-down and bottom-up feedback
- External *vs.* internal focus
- Process management and measures

2.2.5.1 Disconnecting internal and external financial measures

New customer requirements and associated system change approaches clearly reveal the limitations of traditional performance measures. The system change approaches focus on overall cost effectiveness rather than department cost effectiveness, cost reduction rather than cost control, and cost as an *ex ante* design issue rather than cost as an *ex post* evaluation issue. Traditional performance measures are based on traditional accounting systems. Return on investment (ROI), return on assets (ROA), return on sales (ROS), purchase price variances, sales per employee, profit per unit production, and productivity are examples of these traditional performance measures (Ghalayini et al., 1996). However, such performance measures have many limitations. The most significant limitation of traditional performance measures is that they fail to provide accurate costs. Researchers have found that traditional product-costing techniques overstate the cost of high-volume products, while understating the cost of low-volume products (Sinclair and Zairi, 2000).

Several new product-costing techniques have been developed recently. These new techniques are intended to provide more accurate cost information, primarily by cutting the link between internal management reporting and the demands of external regulations ((Nanni Jr and Robb Dixon, 1992)). The product-costing technique that has gained most support, however, is activity-based costing (ABC). ABC attempts to identify the underlying activities that cause costs (Sinclair and Zairi, 2000) .This change in costing techniques leads to more accurate product costing, identification of areas for improvement in performance, and improved information for strategic planning. However, it is not an entirely sufficient solution for implementing the system-change initiatives.

2.2.5.2 Incorporating financial and non-financial Measures at all levels

When formulating their firms' strategies, managers define goals based on customers' requirements, competitors' capabilities and internal organizational capabilities. Customer requirements go beyond cost measures, to encompass quality, speed, and flexibility. To meet customer expectations, managers define strategic goals and objectives not only on the basis of financial measures, but also non-financial ones. Use of non-financial measures enables managers to incorporate customer needs directly into strategic objectives. Also, these measures help managers evaluate organizational capabilities against customer satisfaction, instead of only in dollar terms. Thus, while deploying the system change initiatives, organizations also deploy a balanced set of performance measures at the enterprise level, which include efficiency and effectiveness measures such as cost, quality, speed and flexibility (Neely and Gregory, 1995a). Use of a balanced set of measures reduces waste by avoiding disconnects between customer expectations, a firm's strategy and its actions.

Organizations that deploy system-change approaches aim to constantly adapt to changing external and internal environments through effective learning and continuous improvement efforts carried out at the activity level. This learning requires experimentation, problem solving, and, in one sense, testing of hypotheses across various activities. These hypotheses need to be designed and tested such that they are relevant to achieving strategic objectives. The performance of activities and learning from experimentation are measured in non-financial terms. Hence, instead of using financial measures, such as cost variance reports, to understand the impact of experimentation and learning at the organizational level, it is imperative to use an equal balance between financial and non-financial measure. Use of non-financial measures at the strategy level reveals the direct relationship between activity and strategy and enables problem solving by helping to determine if poor results are attributable to the failure of a strategy or of its execution.

2.2.5.3 Communication of strategic objectives top-down and bottom-up feedback

System change initiatives extend across functional groups in an organization as well as across organization boundaries. To avoid non-lean behavior while fostering the change through continuous improvement and waste removal activities, it is necessary to align activity outcomes with strategic goals and performance measures across functions. This requires communication of goals, objectives and performance vertically, from strategy level to tactical level. Organizations communicate strategic goals across business units and functions via strategy and goal deployment processes (David and Mohamed, 1995b), during which activity-specific measures in each functional unit are tied to strategic performance measures such as quality, speed, flexibility, and cost.

2.2.5.4 External vs internal focus

System change initiatives extend across functional groups in an organization as well as across organization boundaries. To avoid non-lean behavior while fostering the change through continuous improvement and waste removal activities, it is necessary to align activity outcomes with strategic goals and performance measures across functions. This requires communication of goals, objectives and performance vertically, from strategy level to tactical level. Organizations communicate strategic goals across business units and functions via strategy and goal deployment processes (David and Mohamed, 1995b), during which activity-specific measures in each functional unit are tied to strategic performance measures such as quality, speed, flexibility, and cost.

2.2.5.5 Process management and measures

Change in activities in one function may affect the performance of activities in other interdependent function. Also, a decision pertaining to performance improvement in one performance demission may involve trade-offs with other performance measures. For example, product design improvement that involves reducing total cost is subject to quality criteria and customer-perceived values. This in turn requires knowledge of parts, processes and activities and their impact on cost, quality and customer satisfaction. Thus, for successful change initiatives, it is critical to capture and coordinate the knowledge of relationships between product characteristics and among corresponding activities and functions. A need for integration and coordination of activities to achieve overall enterprise-level performance enables management of the enterprise by process (Toni and Tonchia, 1994). Performance improvements techniques, such as statistical process control and Six Sigma, are implemented across processes and require performance measures across processes.

The focus of lean practices under the system-change initiative is much broader than the lean production process. To support these practices the performance measurement system includes the relevant measure and broader performance measurement techniques reflecting all the above-mentioned aspects **(Table 3)**. In the past decade, researchers and practitioners have suggested a variety of frameworks to incorporate these aspects into a performance measurement system. Some of these widely accepted frameworks are reviewed in chapter 3.

To improve overall performance, a large number of western companies have adopted lean practices from lean production processes and/or system change initiatives. However, implementing tools and techniques is important in improving performance but not sufficient. In 1996, Womack and Jones translated the lean principles from the TPS into five key steps to guide the directional mindset for the adaptation of lean practices. These five guiding steps are:

- Define customer value by product
- Identify the value stream and remove waste
- Organize around flow
- Let the customer pull value from the producer
- Pursue perfection

	Lean production process	System change initiative
Focus	Production line (task, activities and cells)	Single Organization (departments, processes, suppliers and customers)
Practices	Cellular Manufacturing, Quality Circles, Dependable supplier, Pull Production, Re-engineering set-ups	TQM, JIT, Six Sigma, Process Re-engineering
Measures	Take time, On Time Delivery, First time through, Safety Performance, Production Rate	Quality, Delivery, Process Time, Cost, Flexibility, Customer Satisfaction
Performance Measurement System	• Visibility - Real Time Reporting, • Causal Relationships (production tasks and activities), • Use of Single source of Information	• Balanced set of strategic metrics (Financial-Non financial), • New methods of cost accounting (ABC, Target Costing), • Top down-bottom communication, • Internal Vs External Focus (Benchmarking and Self Assessment), • Process Management and Measures (value delivery)

Table 2.3: Comparison of the characteristics of the lean production process and the system change initiatives with respective performance measurement systems

As lean philosophy was born in a manufacturing environment, these five guiding principles are very process centric. They extend beyond the boundary of production system by involving value delivery to the customer. However, their definition of value is limited to the customer and to the characteristics of the physical product, reflecting a narrow manufacturing perspective. Deming and (Juran, 1992) work presents the causal relationship between product-quality improvement and customer satisfaction. But quality is just one aspect of customer satisfaction, and customer satisfaction itself is just one aspect of enterprise-level values. In addition, value stream mapping helps to understand and streamline the enterprise processes with value delivery. Michael Hammer, a proponent of process re-engineering, defines process as a way of getting work done.

Thus, limiting the implementation of lean practices to the streamlined process of getting work done and delivering value to the customer does not *ipso facto* lead to overall enterprise-level performance improvement (Womack and Jones, 1996; Murman et al., 2002). Lean practices and principles should be adopted and implemented across a larger enterprise system, involving all processes and stakeholders that drive the value stream, which is called the lean enterprise.

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2.3 The Lean Enterprise

Womack and Jones (1996) define the lean enterprise as one in which all organizations along the value stream work jointly, to define and deliver value to the end customer while maximizing the overall return of the value stream. These organizations work together to adopt lean practices through identifying waste and cooperating with each other to improve overall performance, in particular target cost and target return on investment for each organization. Once these targets are met, organizations will set new targets by continuously working together to identify remaining waste and eliminate it.

The Lean Aerospace Initiative (LAI) at MIT defines the lean enterprise as an integrated entity that efficiently creates value for its multiple stakeholders by employing lean principles and practices (Murman et al., 2002). An enterprise may consist of one or more value streams, one program or multiple programs. The generic process architecture of a lean enterprise consists of three broad process categories: lifecycle process, enabling processes, and leadership processes **(Figure 5)** (Murman et al., 2002). The components of these processes, such as organizations, functions, tasks and people, work together in a synchronized fashion to eliminate waste with the goal of creating value for all stakeholders.

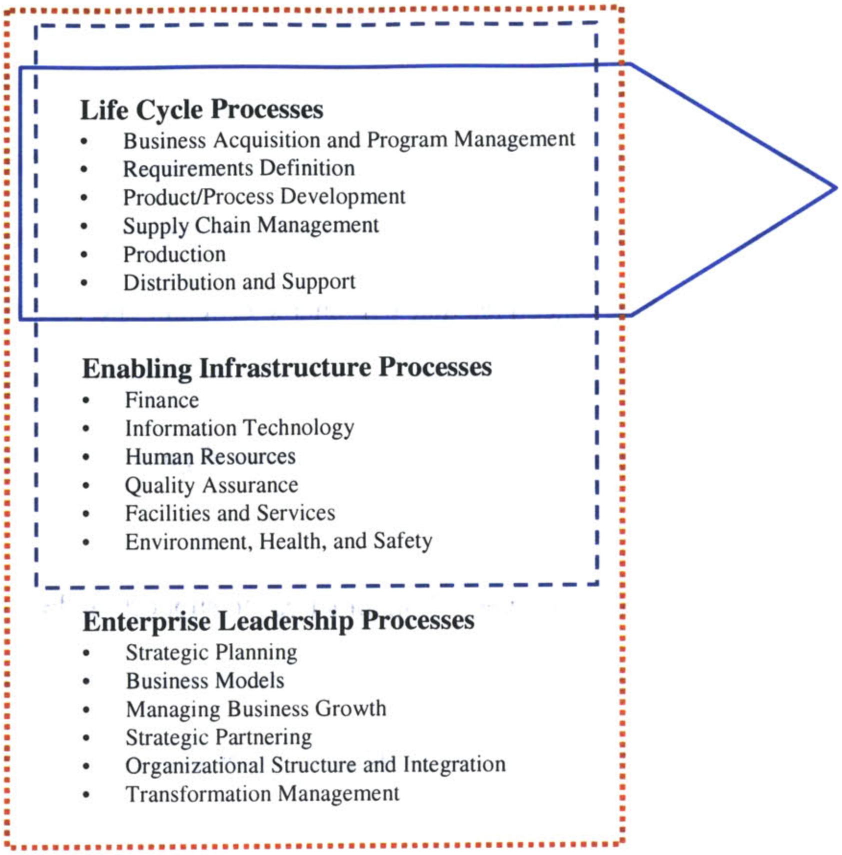


Figure 2.5: Enterprise Process Architecture (Murman et al., 2002)

The organizing principles for a lean enterprise, identified by the LAI are:

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

Transformation to a lean enterprise increases the traditional scope of lean and other system change initiatives from a few processes and functions to multiple value streams. An increase in scope expands the strategic objectives of the enterprise and the complexity of managing it. The strategic objectives of a lean enterprise are not limited to value delivery to the customer and shareholder alone, but also include objectives that will enable efficient and effective value creation and value delivery to all stakeholders **(Figure 6)**. Change in strategic objectives, in turn, requires transformation of supporting practices to create actions aligned with the strategy.

LAI researchers have proposed a set of overarching practices to support the lean enterprise **(Figure 7)**. Transformation in the lean enterprise involves change in human-oriented as well as process-oriented practices while deploying lean principles. These practices are implemented at all levels of the enterprise and across all stakeholders. Human-oriented practices include empowering employees in decision making at all levels, building optimal capability through training, and nurturing a learning environment. This also includes aligning and involving stakeholders towards a unified enterprise vision, strengthening relationships across stakeholders, and building capability to adapt to change in internal and external environments. The process-oriented practices focus on synchronization of flow across all stakeholders by ensuring seamless and timely information across the value stream. They also emphasize the use of quantitative measurement for continuous improvement and optimizing the flow across the enterprise.

'The enterprise becomes what it measures" (Hauser and Katz, 2002). To align the actions with the desired strategic objectives and support the lean enterprise practices requires supporting performance measures and a system.

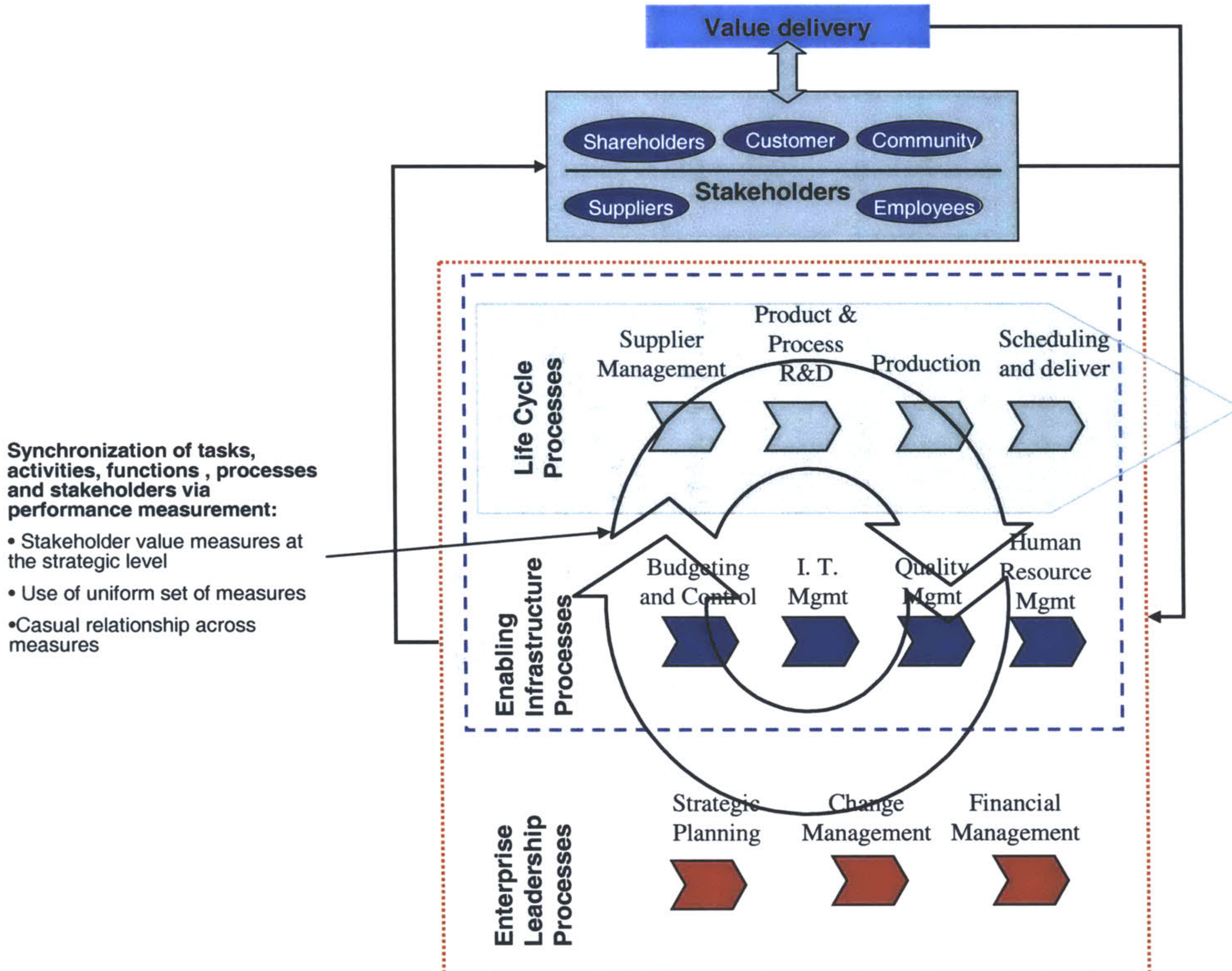


Figure 2.6: The lean enterprise and performance measurement perspective

2.3.1 Performance measurement: the Lean Enterprise

The elements of performance measurement and the supporting system identified while implementing the system change initiatives are necessary but not sufficient for managing the lean enterprise. One of the primary reasons for this is the scope of the lean enterprise which calls for synchronization of all the tasks, activities, processes as well as stakeholders **(Figure 6)**. Transformation to the lean enterprise changes the strategic frame of reference from customers and shareholders to multiple stakeholders. Thus, to align the actions across different processes at multiple levels with all stakeholder values it is an imperative to understand and measure the stakeholder values and incorporate them at the strategic level.

Human oriented

- Promote lean leadership at all levels: Align and involve all stakeholders to achieve the enterprise's lean vision.
- Relationships based on mutual trust and commitment: Establish stable and ongoing relationships within the extended enterprise encompassing both the customers and suppliers.
- Make decision at lowest appropriate level: Design the organizational structure and management systems to accelerate and enhance decision making at the point of knowledge, application and need.
- Optimize capability and utilization of people: ensure that properly trained people are available when needed
- Continuous focus on the customer: proactively understand and respond to the need of internal and external customer
- Nurture a learning environment: provide for development and growth of both the organizations' and individuals' support for attaining the lean enterprise goals.

Process oriented

- Assure seamless information flow and timely transfer of, access to, pertinent information
- Implement integrated product and process development
- Ensure process capability and maturations
- Maintain challenges to existing processes: ensure a culture and systems quantitative measurement and analysis to improve process continuously.
- Identify and optimize the enterprise flow
- Maintain stability in changing environment: Establish strategies to maintain program stability in the changing, customer driven environment.

Figure 2.7: Overarching principles of the lean enterprise (Murman et al., 2002)

Integration and synchronization of all the subsystems across an enterprise's value stream/s requires a unified understanding of the actions, outcomes of these actions, and corresponding measures **(Figure 8)**. To enable a unified understanding and subsequently make decisions toward improving overall enterprise level performance it is necessary to use a clearly defined uniform set of metrics.

The goal of lean enterprise practices is to achieve optimal performance at the enterprise level. As described above, a lean enterprise is a complex system with numerous interdependencies among actions across organizations and at all levels of an enterprise. Hence, to achieve optimal performance across an enterprise it is critical to capture the impact of interdependent actions through developing an understanding of causal relationships among performance measures.

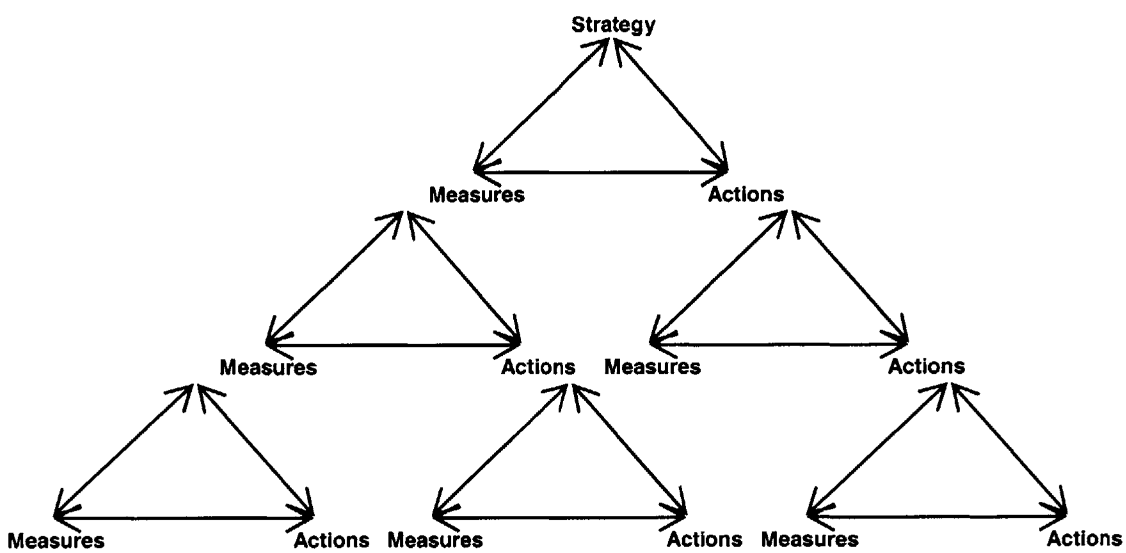


Figure 2.8: Synchronizing actions and measure at all levels of the enterprise

2.3.1.1 Stakeholder value measures at the strategic level

Traditionally the strategic objective of the organizations has been successful value delivery to the customers and shareholders. Thus the performance measures used at the strategic level have been limited to financial and some non-financial measures such as quality, cost and delivery. The increase in scope of the lean enterprise encompasses all the stakeholders. Indeed, customer focus is one of lean enterprise principles. However, a lean enterprise engages multiple stakeholders in the value creation and value delivery process. Hence to involve and align the stakeholders' actions towards creating a lean enterprise, it is critical to include measures of all the stakeholder value at the strategic level of the enterprise. It will enable the decision makers to align the actions towards achieving the stakeholder values at the same time enabling them to understand the tradeoffs with other stakeholder values and its impact on the strategic objectives **(Figure 9)**

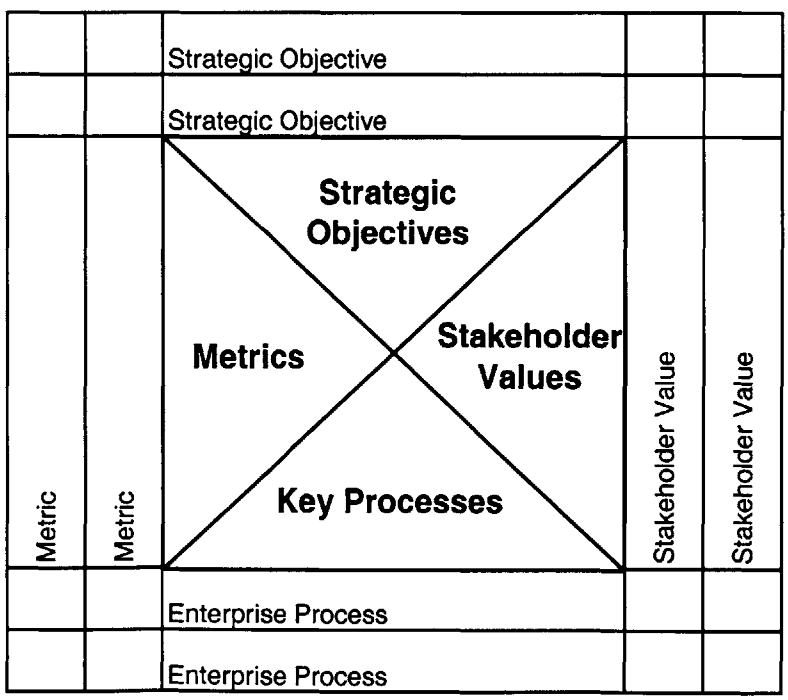


Figure 2.9: Aligning strategic objectives, stakeholder value, key process and measures (adapted from Nightingale, 2003)

2.3.1.2 Use of uniform measures

The objective of a lean enterprise is to continuously improve system-level performance while adapting to the change in external environment. System-level improvement is achieved through practices such as synchronizing flow at different levels and across various stakeholders, involving employees in decision making at all levels, and use of quantitative measurement and analysis for continuous improvement (Spear and Bowen, 1999). **(Figure 10)** determined that in a lean system, actions and performance outcomes of individual activities are thoroughly understood and highly specified. Also, improvements need be carried forward based on scientific methods, which requires clean, uniform measurement information. Synchronizing each organization across the enterprise to achieve system-level performance improvement requires a seamless and unified set of performance information, which in turn requires a unified set of performance measures. Similarly, to empower employees to make decisions aligned towards system-level performance improvement, performance measures used at all levels and across all stakeholders should have uniform definitions.

DNA of Toyota Production System: The Four Rules

1. All work shall be highly specified as to content, sequence, timing and outcome.
2. Every customer-supplier connection must be direct, and there must be an unambiguous yes-or-no way to send requests and receive responses.
3. The Pathway of every product and service must be simple and direct.
4. Any improvement must be made in accordance with scientific method, under the guidance of a teacher at the lowest possible level in the organization.

Source: Steven Spear and H. Kent Bowen, 1999

Figure 2.10: DNA of Toyota Production System

2.3.1.3 Causal relationships

The goal of lean enterprise is to achieve the optimal performance at the enterprise level via deploying human related and process related practices. These practices are deployed across different subsystems such as individual, activity, processes or organizations. The impact each subsystem on the other subsystem or the impact of practices on the enterprise level performance is not always logical, that is one plus one equals two. Moreover, a lean system should consist of simple and clearly defined interdependencies between system components and communication between those components should be clearly specified **(Figure 10)** (Spear and Bowen, 1999). Also, the lean system should be integrated with minimum and simple interconnections that will enable direct value delivery (Spear and Bowen, 1999). Thus, variance in performance among the activities and underlying causal relationships should be captured in the performance measures and the supporting system of the lean enterprise.

From the previous discussion, it is evident that the scope of lean enterprise is much wider than that of system change initiative and the lean production process **(Table 4).** The deployment of lean practice across the enterprise with the objective of optimal value delivery to all the stakeholders makes the decision making even more complex. Hence it is essential to make design of performance measurement system as integral part of the lean enterprise transformation process. Along with the various aspects of the performance measurement system identified for the lean production process and the system change initiative, it is critical to incorporate the three aspects described above. It will enable the successful adoption and management of the lean enterprise practices.

	Lean Production Process	System Change Initiative	The Lean Enterprise
Focus	Production line (task, activities and cells)	Single Organization (departments, processes, suppliers and customers)	Extended enterprise (value streams and all stakeholders)
Practices	Cellular Manufacturing, Quality Circles, Dependable supplier, Pull Production, Re-engineering set-ups	TQM, JIT, Six Sigma, Process Re-engineering	Seamless information flow, Integrated product and process development, Process capability and Maturation, Identify and Optimize enterprise flow, maintain stability in changing environment, Align and involve all stakeholders to achieve lean vision, Relationship based on mutual trust and commitment across the extended enterprise, make decisions at the lowest levels, optimize capability and utilization of people, focus on external and internal environment, Nurture a learning environment
Metrics	Take time, On Time Delivery, First time through, Safety Performance, Production Rate	Quality, Delivery, Process Time, Cost, Flexibility, Customer Satisfaction	Stakeholder value (effectiveness), Overall efficiency, System availability, System level Flexibility
Performance Measurement System	• Visibility - Real Time Reporting, • Causal Relationships (production tasks and activities), • Use of Single source of Information	• Balanced set of strategic metrics (Financial-Non financial), • New methods of cost accounting (ABC, Target Costing), • Top down-bottom communication, • Internal Vs External Focus (Benchmarking and Self Assessment), • Process Management and Measures (value delivery)	• Stakeholder value measures • Uniform set of measures • Causal relationships between measures across all levels.

Table 2.4: Comparison of the characteristics of the lean production process, the system change initiatives and the lean enterprise with respective performance measurement systems

2.4 Conclusion

The study of the evolution of lean practices, from the production process to the system change initiatives to the lean enterprise, underscores the increasing complexity of the truly lean system. The importance of performance measurement in the transformation through the adoption of a lean philosophy at each stage of this evolutionary process has been highlighted. Various attributes of performance measurement and the supporting system important for the adoption of lean practices across different stages were described as well. Successful deployment of lean practices across a system requires synchronization of its subsystems. To synchronize the subsystems of a lean enterprise, three important attributes of performance measurement systems have been identified:

- Stakeholder value at the strategic level
- Use of a uniform set of measures
- Explicit understanding of the causal relationships across subsystems

With the identification of these attributes, in the next chapter various performance measurement literature will be reviewed. In addition, a number of suggested frameworks to design a performance measurement system will be evaluated against attributes required to design a lean enterprise performance measurement system.

Chapter 3

Enterprise Performance Measurement – A literature review

Introduction

"You are what you measure" (Hauser and Katz, 2002). The central role of performance measurement in managing an organization to achieve its desired performance goals has long been recognized from the days of management accounting. The changing landscape of the competitive environment in last two decades has compelled organizations to excel beyond mere financial performance, looking for improvements also in quality, speed, flexibility, etc. Consequently, the ways and means of accurately measuring performance became an increasingly important field of research for both organizations and academia. Extensive efforts have been carried out to define and further enhance performance measurement practices across various components of the organization and then integrate them across the organization in a performance measurement system. This chapter provides a detailed understanding of the various aspects of performance measurement as well as a review of select performance measurement frameworks that have been widely adopted to facilitate the design of a performance measurement system. It concludes with discussion on some limitations of these performance measurement frameworks.

3.1 Performance measurement

Performance measurement is the process of measuring efficiency, effectiveness and capability, of an action or a process or a system, against given norm or target (Fortuin and Korsten, 1988; Neely and Gregory, 1995b). Performance can be measured quantitatively or qualitatively. Effectiveness is a measure of doing the right job (Drucker, 1987), which in the context of an action, or process or a system means the extent to which stakeholder requirements are met. Efficiency is a measure of doing the job right (Drucker, 1987), which in the context of an action, or process or a system means how economically the resources are utilized when providing a given level of stakeholder satisfaction. And capability is a measure of ability required to do both the job right and right job, in the short term as well as the long term **(Figure 1)** (Sink and Tuttle, 1989). This can be tangible, such as, resources, technology, or intangible, such as a corporate culture.

Effective performance measurement process requires various considerations around the design of two key aspects: performance measures and performance measurement system. The body of literature on performance measurement has evolved primarily around performance measures and performance measurement frameworks that facilitate the design of performance measurement system. The role of performance measurement guides the design of these two aspects by defining the purpose and the context.

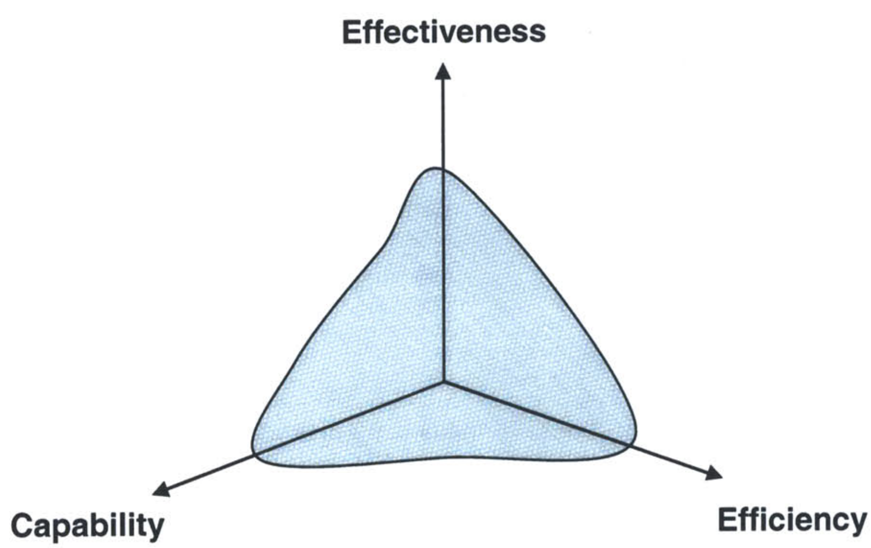


Figure 3.1: Three dimensions of measurement (Sink and Tuttle, 1989)

3.2 Role of performance measurement

The measurement of internal performance for planning and control purposes can be traced to the development of the first large companies (Kaplan, 1984). Performance measurement enables managers and employees to monitor and control resources and actions to achieve predefined targets. Figure 1 illustrates this idea by taking a process control perspective on the organization. At the operational level, measures for resources (input), actions, and process performance (output) are monitored and compared with the desired target. Comparison between actual performance and target performance identify gaps (if any) that can point to the need for intervention and improvement. The size and direction of the gap (positive or negative) provide information and feedback at the tactical level that can be used to identify productive process adjustments or other actions. In addition, an appropriate set of measures and timely gap identification by employees supports their involvement in the continuous improvement efforts.

Measures facilitate coordination among the multiple processes by communicating performance to workers and managers across processes. Coordination across processes results in timely and accurate actions, minimizing waste and improving overall performance. Measures communicate performance not only to internal workers and managers for the purpose of control and coordination, but also to external stakeholders. Many times stakeholders and users of measures do not understand the workings and processes of an organization or operation, nor do they need to. Well-designed and communicated measures provide the user with a sense of knowing what needs to be done without necessarily requiring him/her to understand the intricacies of related processes.

Poorly developed or implemented metrics can lead to frustration, conflict, and confusion (Maskell, 1991; Melnyk et al., 2004).

Miller et al. (1990) argued that performance measurement should facilitates decision making to align actions with strategic objectives and provide feedback on operational performance and internal capabilities to the strategic level **(Figure 2)**. The decision making process involves the selection of appropriate performance measures and targets that will align the behavior of employees to achieve desired actions and strategic objectives. A company achieves its objectives when a performance culture and strategy reinforce each other (Kerr, 2003). H. Mintzberg (1979, *The Structure of Organizations*) stated "Performance control systems can serve two purposes, to measure and to motivate." Mohamed and David (1995), in their literature review identified that performance measurement can profoundly affect the motivation of individuals. They also identified that the impact of performance measurement on behavior depends on the organizational context of the measurement, the use made of measurements, the degree of agreement between measurements and organizational objectives, and the individual's motivational response to measurement. In addition, comprehensive performance measurement allows managers to make decisions from a long-term perspective.

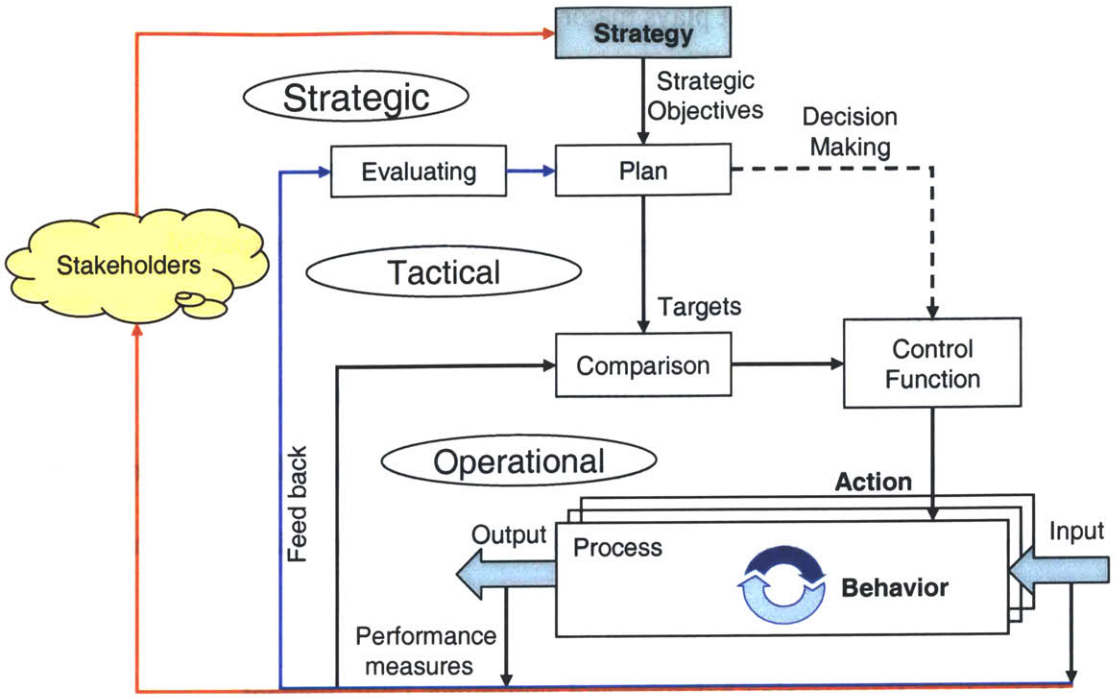


Figure 3.2: Process control perspective on an organization (adapted from Lohman et al., 2004)

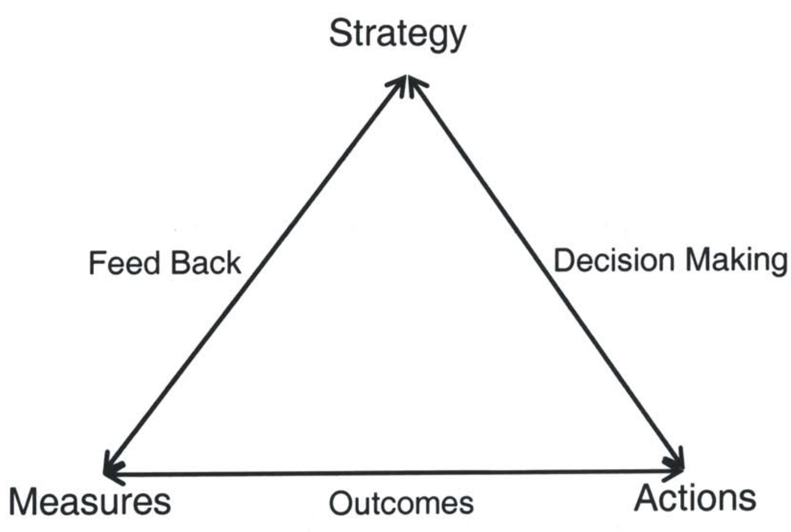


Figure 3.3: Role of measures to align strategy and actions (adapted from Nanni, Jr. and Robb Dixon, 1992)

In sum, performance measurement plays major role in an organization along five dimensions:

- Monitoring: Measuring and recording actual performance.
- Control: Identifying and attempting to close the gap between expected performance and actual performance.
- Improvement: Identifying critical improvement opportunities.
- Coordination: Providing information for decision making and enabling internal communication across processes as well as external communication with stakeholders.
- Motivation: Encouraging behavior and continuous improvement.

To carry out effective performance measurement it is imperative to carefully design performance measures at each level in the organization that will support all of the above roles.

3.3 Performance measure

A performance measure is a verifiable variable that is expressed in either quantitative or qualitative terms. Neely and Gregory (1995a) define performance measure as a variable used to quantify the efficiency and effectiveness of an action. Daum (2004) extends the definition of performance measure to include qualitative aspect because different stakeholders put different value on the same outcome, which cannot be quantified. Also, intangible measures to a large extent cannot be quantified, and thus require qualitative measures (Lev, 2001). Performance measures capture characteristics or outcomes in a numerical or a nominal form (Ghalayini et al., 1997).

A performance measure should be based on an agreed upon set of data and a well understood and well documented process for converting that data into the measure. Given the data and process, independent sources should be able to arrive at the same measure value (Melnyk et al., 2004). To interpret meaning from a measure, however, it must be compared to a target.

Targets should be clearly stated for each performance measure and should provide a challenge to employees to achieve high performance levels. (Box and White, 1993) have suggested using statistically derived performance targets, while Spendolini(1992) suggests using standardized benchmark performance targets. Sinclair and Zairi (2000) have noted that the target is designed to be a path of improvement rather than comparing performance with a static target. Several authors, notably Miller et al. (1990) and Maskell (1991) suggest graphing performance against improvement targets, both to highlight historical trends and to foster awareness for continuous improvement. Schneiderman (1988) suggested plotting targets using the 'half life' concept, to keep continuous improvement process on track.

Performance measures also should be designed considering the action(s) and behaviors that they will drive. Eccles and Pyburn (1992) identified in their research that the impact of performance measure of one activity may not be limited to just that activity. Also, performance measures have behavioral impact, especially in systems involving humans who respond to performance measures (Neely et al., 1997). People modify their behavior and actions to ensure positive performance even if this means inappropriate course of action (Kerr, 2003).

A performance measure will lead to an effective performance measurement and ultimately performance improvement if it is systematically designed to address all the elements. Nelly et al. (1997) note the following:

> *a plant where the performance of a plant manager was assessed on the basis of return on investment; the performance of a product group manager was assessed on the basis of whether or not product was delivered on time and performance of the shop-floor supervisor or operator was assessed on the basis of production output versus standard. The measures induced dysfunctional behavior in the system.*
>
> *In a lean manufacturing environment there are several ways in which production output can be increased. One option is to reduce cycle times, either through product or process innovation. Another is to eliminate the causes of unproductive time, perhaps through the introduction of a preventive maintenance program, which reduces the risk of machine breakdowns. A third is to seek to eliminate the time wasted in producing poor quality product possibly through the introduction of fail safe, or Poka Yoke devices. In this particular plant the shop floor supervisors and operators decided to try and reduce unproductive time by decreasing the amount of time spent on set-ups. Rather than implementing a set-up time reduction program, however, they decided simply to eliminate the need to set-up machines as frequently by increasing batch sizes. Thus they could meet the desired standard output. Increased batch sizes led them to produce more of non-required product leaving product managers without necessary product to fulfill the particular orders. They responded sanctioning overtimes, which once again adversely affected return on investment. Thus, the design of a performance measure should involve various elements that can improve the quality of metrics, communicate appropriate information and lead the behavior and action towards overall goal.*

Hence the design of performance measures should be comprehensive enough to capture all the attributes that will enable the performance measurement process to successfully carry out the desired roles. A comprehensive design of the performance measure requires an understanding of all the elements that can affect performance measurement, as well as potential subsequent actions, including the dimensions and levels of measurement.

3.3.1 Elements of performance measures

Various authors have discussed one or more elements of design of performance measures in the organizational context. Neely et al. (1997), through their comprehensive literature review and study of these elements, have proposed a template for a detailed design of the performance measures, which they call the "performance measure record sheet" **(Figure 4).** It includes ten different elements that contribute to the design of a robust performance measure. In addition, others have attempted to include the process and world-class manufacturing views in designing performance measures. To manage performance by processes, it is measured across the process as well at the individual task level (Toni and Tonchia, 1994). Thus, the scope of performance measure should play a part in the design of performance measures. Also, the performance measure should be owned by the responsible individual task or process owner ((Hammer and Champy, 1993). C. Lohman et al. (2004) modified the performance record sheet to involve the process elements to design the measures across the supply chain process **(Figure 5).**

Title	Customer service – adherence to customer schedule
Purpose	To enable us to monitor factory completion performance
Relates to	Business objectives – "meet quality standards", "delivery on time" and "no customer complaints"
Target	100 per cent schedule completion on time at least by end of 1996
Formula	Percentage of pieces to arrive at the customer's location when promised
Frequency	Weekly
Who measures?	Dispatch manager
Source of data	Delivery receipts
Who acts on the data?	Production manager
What do they do?	Investigate reasons for late delivery, set up problem-solving teams to eliminate root causes
Notes and comments	Early deliveries are not on time

Figure 3.4: The performance measurement record sheet with an illustration

Element 1 – Title: The title of the measure should be clear. A good title is one that explains what the measure is and why it is important. It should be self-explanatory and not include functionally specific jargon.

Element 2 – Purpose: If a measure has no purpose then one can question whether it should be introduced. Hence the rationale underlying the measure has to be specified.

Element 3 – Relates to: The business objectives to which the measure relates should be identified.

Element 4 – Target: The objectives of any business are a function of the requirements of its stakeholders. An appropriate target for each measure should therefore be recorded based on the trade offs between the stakeholder requirements.

Element 5 – Formula: It is the way performance is measured and affects how people behave.

Element 6 – Frequency: The frequency with which performance should be recorded and reported is a function of the importance of the measure and the volume of data available.
Element 7 – Who measures: The person who is to collect and report the data should be identified.

Element 8 – Source of data: The source of the raw data should be specified. The importance of this question lies in the fact that a consistent source of data is vital if performance is to be compared over time.

Element 9 – Who acts on the data: The person who is to act on the data should be identified.

Element 10 – What do they do: This is probably the most important element contained on the performance measure record sheet, not because it contains the most important information, but because it makes explicit the fact that unless the management loop is closed, there is no point in having the measure.

Metric Elements	**Explanation**
Title	Use exact names to avoid ambiguity
Objective/purpose	The relation of the metric with the organizational objectives must be clear
Scope	**States the areas of business or parts of the organization that are included**
Target	Benchmarks must be determined in order to monitor progress
Formula	The exact calculation of the metric must be known
Units of measure	What is/are the unit(s) used
Frequency	The frequency of recording and reporting of the metric
Data source	The exact data sources involved in calculating a metric value
Owner	**The responsible person for performance of that part of the organization, collecting data and reporting the metric**
Comments	Outstanding issues regarding the metric

Figure3. 5: The performance measurement record sheet (modified) (adapted from C. Lohman et al., 2004)

3.3.2 Dimensions of performance measures

While choosing performance measures managers need to be aware of the complexity in the variety of measures. Performance measures can be broadly classified cross three dimensions **(Figure 6)**. The first dimension is 'measure type', which includes both financial and non-financial measures. Johnson and Kaplan (1987) underscored the need for inclusion of non-financial measures because traditional accounting/financial measures ignore clients and internal operational needs. Based on similar logic, McNair and Mosconi (1987) called for the alignment of financial and non-financial measures to be in accordance with business strategy. Santori and Anderson, (1987) stressed the importance of non-financial measures in monitoring and motivating the progress of the human factor of the organization. Maskell (1991) suggests that in a world-class manufacturing environment performance is primarily measured using non-financial measures. Financial measures define pertinent elements in terms of a monetary resource equivalent, whereas non-financial measure tend to define operational as well as qualitative measures, such as employee moral, customer relationships, etc.

The second dimension is 'tense', that is, a leading versus lagging indicator, which depends on how a measurement is intended to be used (Higgins and Hack, 2004). Measures can be used both to judge outcomes as well as predict the future. Lagging indicators are important to show actual outcomes, while leading indicators are vital because they can be used to glean information, guide decision making and assess likelihood for success (Ittner and Larcker, 1997). Leading indicators serve as timely reference points that influence short- and long-term strategy. They allow the organization to take pre-emptive action to resolve issues that may be hindering progress towards a goal (Kaplan and Norton, 2000b). For example, revenue and net earnings is a lagging indicator, yet customer satisfaction is a leading indicator of revenue.

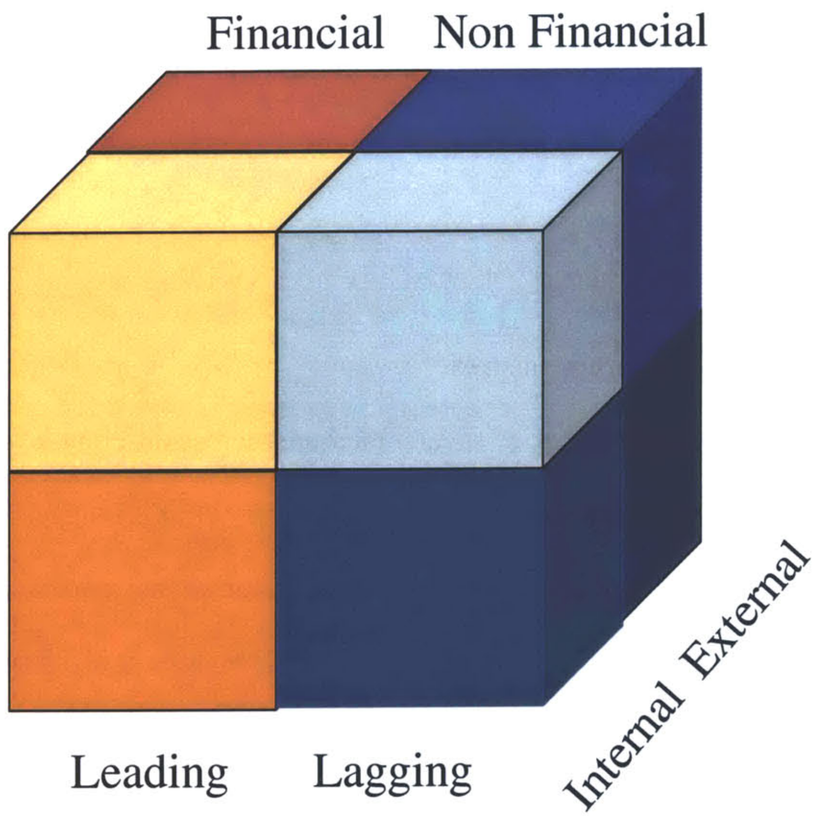


Figure 3.6: Dimensions of performance measurement

The third dimension is 'focus', that is, internal versus external. It is critical to measure a firm's internal performance against targets set, based on stakeholder expectations (Crowther, 1996). It is also equally important to measure external performance to set benchmarks and satisfy some of the external stakeholders and maintain competitive positions (Basu and Wright, 1996). Dumond (1994) explains two contextual measures, an internal one –organizational performance and health - andan external one –the market within which the organization competes and events that impact performance. Bullinger et al. (2002) take a supply chain perspective and explain that large-scale networks are characterized by a high internal and external dynamic. The (internal) structure of the network changes rapidly, new partners have to be integrated, others have to be excluded, depending on customer orders, productivity, etc. In addition, the network is permanently subject to (external) changes of business environment (e.g. market demand, competitors,).

3.3.3 Levels of performance measures

Good measures are indices made up of several measures across different levels in an organization (Higgins and Hack, 2004). Neely and Gregory (1995b) suggest two levels of measures: individual measures and a performance measurement system that aggregates all of them. Other researchers (e.g., Johnston et al., 2002; Melnyk et al., 2004; and Lohman et al., 2004) suggest performance measures can be categorized in hierarchical fashion across three levels of aggregation to achieve overall optimal performance. These three levels of measures are linked with each other **(Figure 7).** At the base is the 'individual metric', the building block. Individual metrics are aggregated to form various 'metrics sets'. Each set directs, guides, and regulates an individual's activities in support of strategic objectives. And the top level is the 'metric cluster', which aggregates the individual metric and metric set in a fashion to link with strategy and stakeholder values (Brignall 2003; C Lohman, 2004).

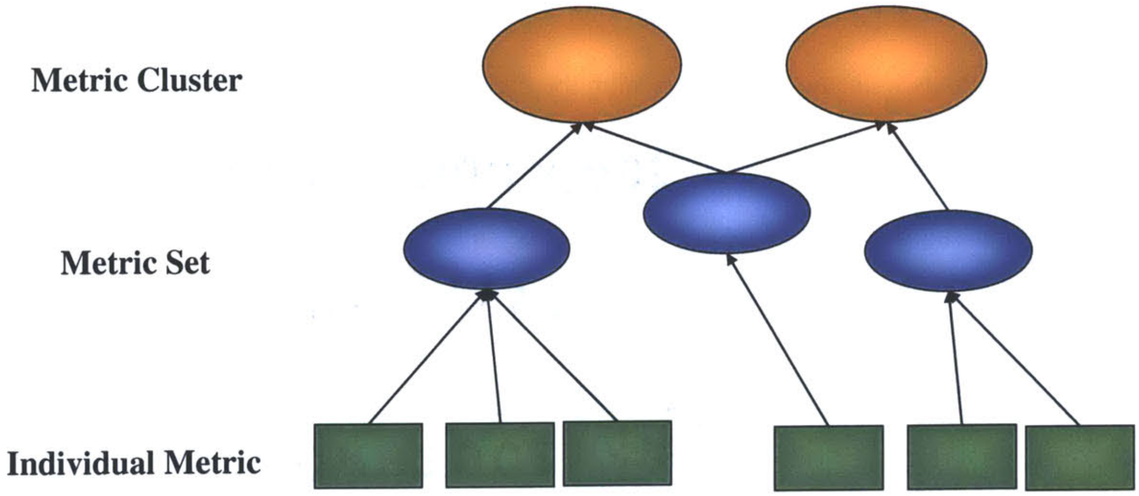


Figure 3.7: Levels of performance measures

Metric clusters are derived from stakeholder values and prioritized strategic choices. The metrics set consists of measures assigned by a strategic level to direct, motivate and evaluate performance of a specific activity, process, area, or function. The metrics set is critical because it is often a leading indicator, and because the scope and complexity of an individual's set can be viewed as a load imposed on a manager's finite mental capacity. Coordinating and managing the development of the various individual metrics, metrics sets and metric cluster is the performance measurement system.

The performance measurement system is ultimately responsible for maintaining alignment and coordination. Alignment deals with the maintenance of consistency between the strategic goals and measures as plans are implemented and restated as they move from the strategic through tactical and operational stages of the planning process. Alignment attempts to ensure that at every stage objectives set at higher levels are consistent with and supported by measures and activities at lower levels. In contrast, coordination recognizes the presence of interdependency between processes, activities or functions. It deals with the degree to which the measures in various related areas are consistent with and supportive of each other. Coordination strives to reduce potential conflicts that can occur when one area focuses on maximizing uptime (for example, by avoiding setup and running large batches) and another focuses on quality and flexibility. Coordination tries to maintain an equivalence of activities, goals, and purpose across departments, groups, activities and processes.

Measures need to be part of an integrated system that integrates the goals of everyone in the organization, such that they all work together for the benefit of the organization as a whole (Sinclair et al. 2000). Architecting a performance measurement system considering roles, elements, dimensions, and levels require a systematic structure and a process.

3.4 Performance measurement frameworks

Performance measurement frameworks have arguably made the largest impact upon the performance measurement literature, with a plethora of ever more complex ones having been developed since the late 1980s, addressing one or more dimensions, levels and/or roles of performance measurement (Ghalayini et al., 1997). Most performance measurement systems developed in organizations are a collection of best practices that have been grafted onto various performance measurement frameworks, and have been found to work anywhere between very well and very badly (Johnston et al., 2002). Eccles (1991) postulated that a performance measurement framework provides the structure and procedure to execute performance measures in a consistent and complete way.

The basic requirements for a successful performance measurement system are frameworks with two aspects: structure and procedure. Generally, they also have a number of other tools and techniques, such as statistical process control, etc. (Bititci et al., 1997; Kennerley and Neely, 2003a; Folan and Browne, 2005). Performance measurement frameworks assists in the process of performance measurement system building by clarifying performance measurement boundaries, specifying performance measurement dimensions or focus, and may also provide initial intuitions into relationships among performance measurement dimensions. Performance measurement frameworks can be classified based on two aspects Folan and Browne, 2005):

- The structural framework - A framework specifying a typology for performance measure management
- The procedural framework - A step-by-step process for developing performance measures from strategy and a systematic process to manage the evolution of a performance measurement system.

Several authors have researched and presented different aspects of, as well as the entire performance measurement framework (Ghaylani 1997, Johnston, 2003). Performance measurement framework design based on structural framework development has considerably outstripped the pace of procedural performance measurement framework development. Structures presented by researchers and practitioners have evolved to address drawbacks from previous frameworks and to better serve the organization to deploy novel operational strategies.

This section presents a review of selected eminent performance measurement frameworks, some of which have been widely adapted by the industry. The frameworks are reviewed and presented roughly in the sequence of their evolution, which includes: 1) Strategic Measurement and Reporting Technique; 2) Balanced Scorecard and Strategy Maps; 3) Performance Prism; and 4) the European Quality Foundation Model. These four frameworks capture primarily structural elements. Dixon (1990) identified that performance measures should change with the change in the business environment. Very few procedural frameworks have been proposed that describe systematic procedure to develop and maintain the performance measurement system. In addition to these four frameworks with structural emphasis, two procedural frameworks are reviewed: 5) a framework for designing and auditing a performance measurement system, and 6) a framework of factors affecting the evolution of performance measurement system. These are procedural aspects of developing, auditing and maintaining a performance measurement system.

3.4.1 Strategic measurement and reporting technique (SMART)

In response to the dissatisfaction with traditional performance measures and management accounting systems, Wang Laboratories, Inc. developed a new approach to measurement -- the Strategic Measurement And Reporting Technique (SMART) (Cross and Lynch, 1988). SMART aims to integrate financial and non-financial reporting, link operational performance measures to strategic goals, focus the measurement system on satisfying customer needs and ultimately on achieving corporate goals. The SMART hierarchy (or 'performance pyramid') is shown in **Figure 8**. At the top of the pyramid is the corporate vision, which defines the markets the company competes in, product scope and services provided. The vision leads to strategic goals for the marketplace (market share, etc.) and detailed financial goals. These goals are called strategic business objectives, and lead to business operating system objectives of customer satisfaction, flexibility and productivity. To meet these objectives, people must work across functional boundaries and business units. The last level in the hierarchy is departmental and work centre criteria, including quality, delivery, process time, and waste. Waste is the only category that includes cost. For each goal, objective, and criterion, SMART needs at least one measure. It also recognizes that measures are imperfect, and will be improved over time to serve future requirements of customers better.

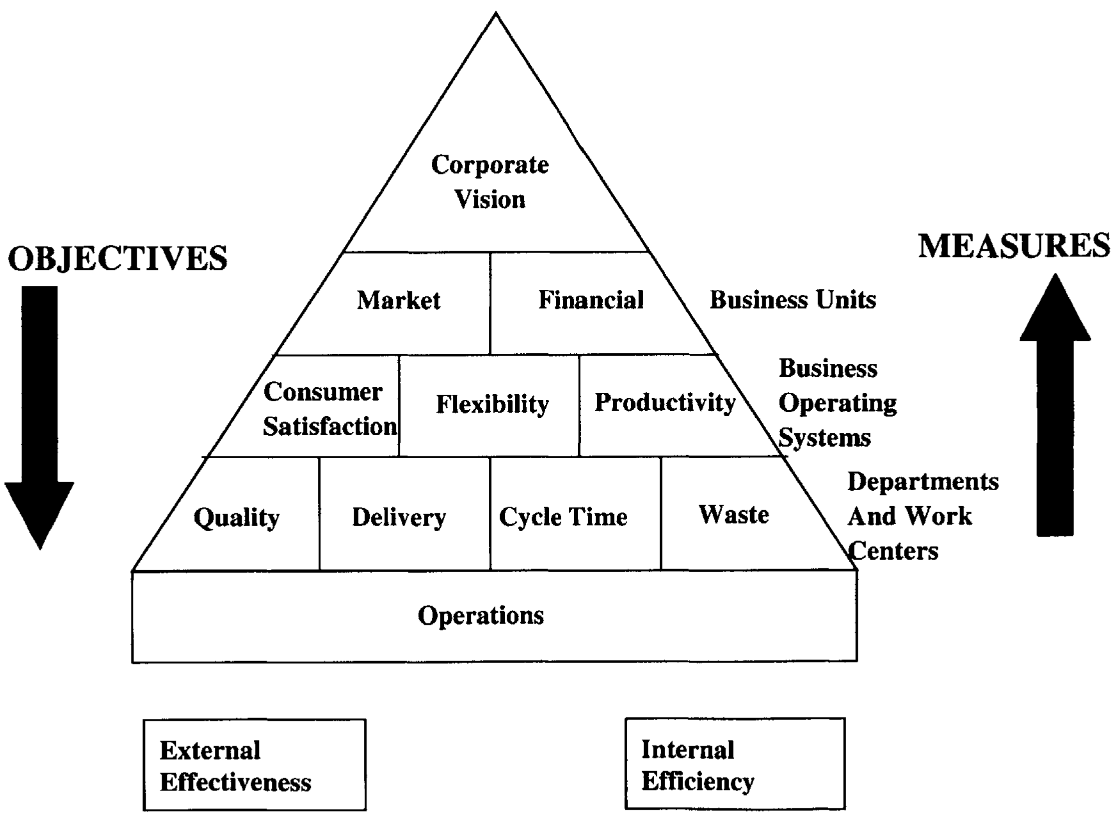


Figure 3.8: The Performance Pyramid (Cross and Lynch, 1988)

3.4.2 The Balanced Scorecard and Strategy Maps

Schineiderman (1988) invented the Balanced Scorecard at Analog Devices. It was further refined and publicized by Kaplan and Norton (1992). The Balanced Scorecard provides a high-level structure to integrate strategic goals with financial and non-financial measures. Goals are set by managers with regard to four perspectives:

- **Financial perspective:** How do we look to our shareholders?
- **Internal business perspective**: What must we excel at?
- **Customer perspective:** How do our customers see us?
- **Innovation and learning perspective**: How can we continue to improve and create value?

In 1996 Kaplan and Norton provided an additional procedural framework through which the scorecard can be applied as a system—thus managing the firm's strategy. The framework is in four stages:

- ''Translating the vision'' is concerned with clarifying and gaining consensus over a version of the firm's strategic vision that is operational upon all levels of the organization (i.e., from the top level down to the local level).
- ''Communicating and linking'' is the process by which managers communicate their strategy up and down the organization and link it to departmental and individual objectives.
- ''Business planning'' is the process by which companies integrate their business and financial plans.
- ''Feedback and learning'' gives companies the capacity for strategic learning; existing processes review whether individual and departmental financial goals

have been achieved, while the Balanced Scorecard enables a company to monitor short-term results for its three additional perspectives.

Strategy maps (Kaplan and Norton, 2000a) are a natural extension to balanced scorecards. Although the strategy map follows the logic of the scorecard, it offers a different visualization of the four scorecard perspectives. In this way it reflects the assumed causal relationships between the goals and measures on the scorecard **(Figure 9)**. Although strategy maps are relatively easy to produce, they can be constraining if they are bound too closely to the four balanced scorecard perspectives. Most organizations today are more complex than the four perspectives included in the scorecard and executives are required to address the needs of stakeholders other than just customers and shareholders.

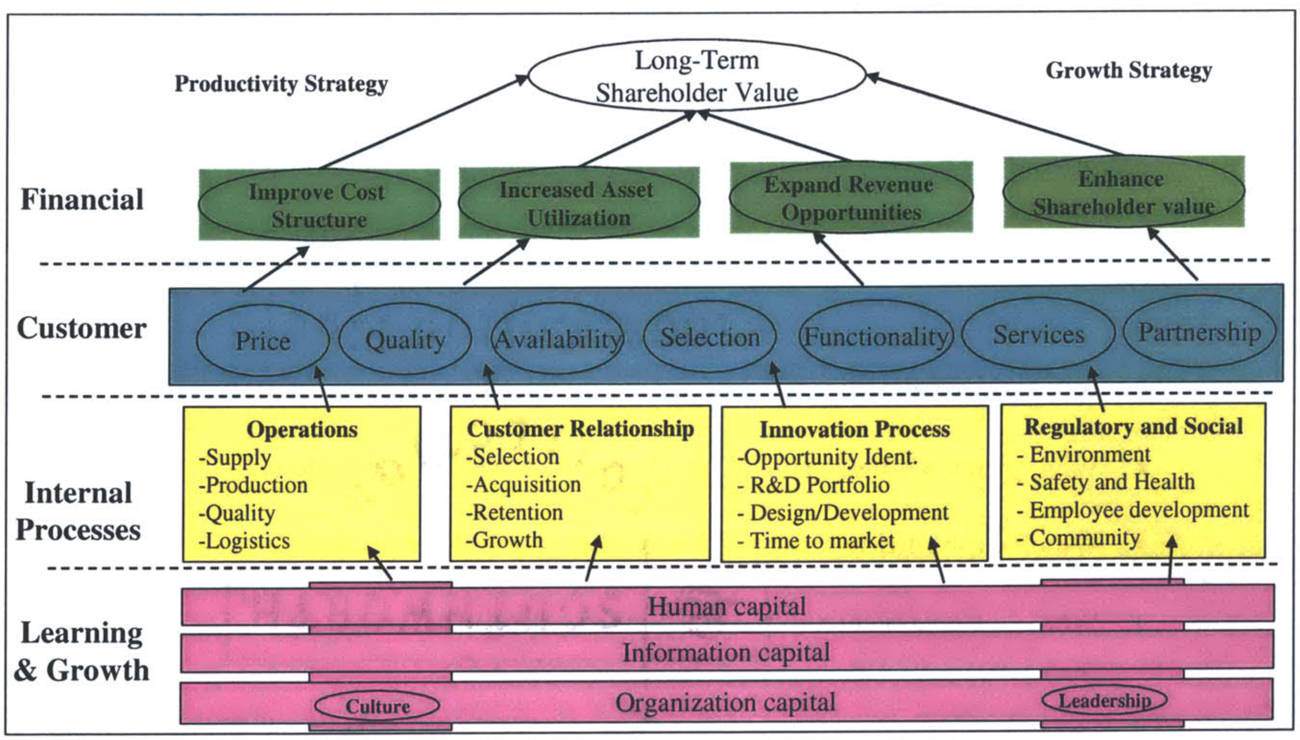


Figure 3.9: Balanced Scorecard and Strategy Map adapted from Kaplan and Norton, (2000)

3.4.3 The Performance Prism

To overcome the shortcomings in the Balanced Scorecard approach, the Performance Prism was developed **(Figure 10)** (Neely and Adams, 2001). The Performance Prism is based on the belief that organizations aspiring to be successful in the long term in today's business environment have an exceptionally clear picture of who their key stakeholders are and what they want. They have defined what strategies they will pursue to ensure that value is delivered to these stakeholders. They understand what processes the enterprise requires if these strategies are to be delivered and they have defined what capabilities they need to execute these processes. The most sophisticated of them have also thought carefully about what it is that the organization wants from its stakeholders – employee loyalty, customer profitability, long-term investments, etc. In essence, they have a clear business model and an explicit understanding of what constitutes and drives good performance. The Performance Prism takes a broader view of stakeholders and encourages organizations to address the following questions:

- Who are our key **stakeholders** and what do they want and need?
- What **strategies** do we have to put in place to satisfy these needs?
- What **process** do we need to have in place to execute our strategy?
- Which **capabilities** do we need to perform our processes?
- What do we expect from our stakeholders in **return**?

Addressing these five questions allows organizations to build comprehensive success maps, sometimes by each major stakeholder (see **Figure 11** for an example of a customer success map, Neely et al., 2002). A further refinement suggested by Neely et al., (2002) is the notion of failure or risk maps. These identify potentially critical failure points in an organization that if unmonitored could lead to excess exposure to risk. The broader stance adopted by the Performance Prism and its reliance on success and failure maps provides a flexible structure that enables organizations to map everything that is important to them in their success and failure maps.

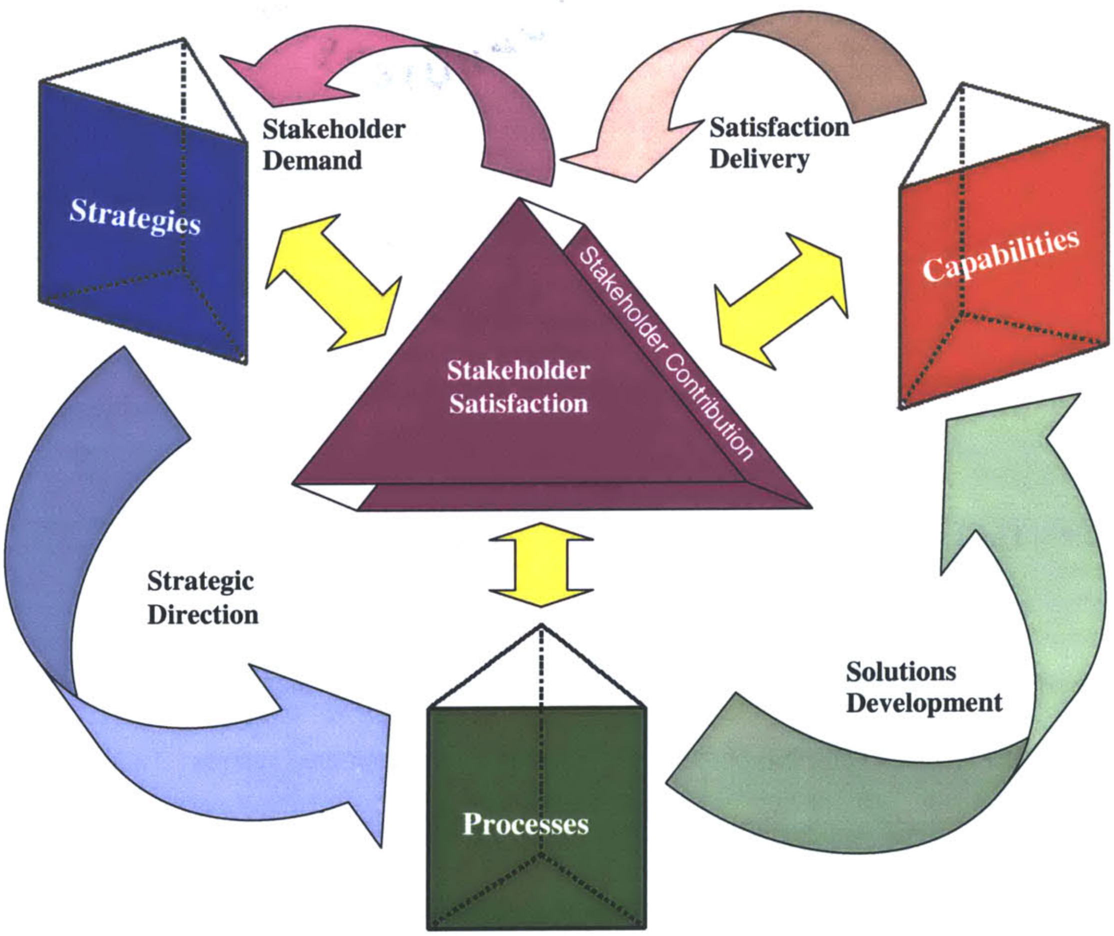


Figure 3.10: The Performance Prism

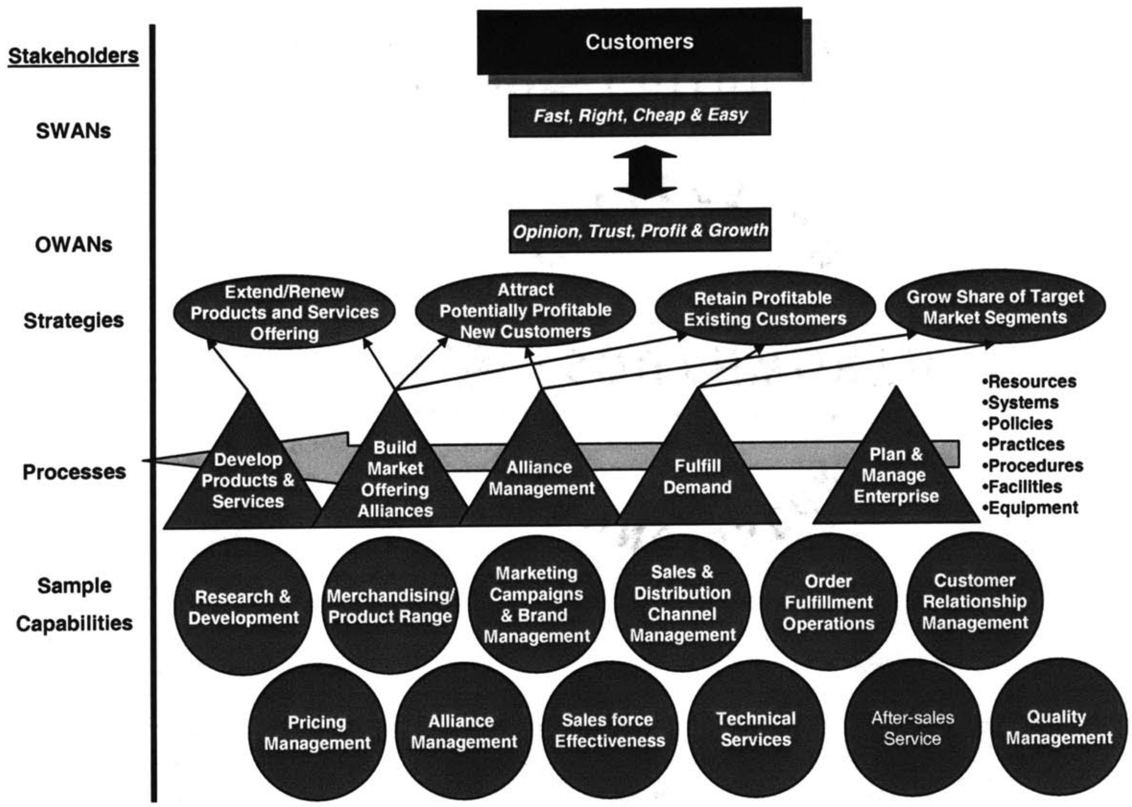


Figure 3.11: Customer success map example (Neely et al, 2002)

3.4.4 The European Foundation Quality Model (EFQM)

The EFQM is a non-prescriptive performance measurement framework based on nine criteria (EFQM, 1997). Five of these are "enablers" and four are "results". Enabler criteria cover what an organization does **(Figure 12)**. Results' criteria cover what an organization achieves. Results are caused by enablers and feedback from results help to improve enablers. The EFQMmodel, which recognizes there are many approaches to achieving sustainable excellence in all aspects of performance, is based on the premise that excellent results with respect to performance, customers, people, and society are achieved through leadership driving policy and strategy that are delivered through people, partnerships, resources, and processes. Within this approach there are some fundamental concepts which underpin the EFQM model:

- Results Orientation: achieving results that delight all the organization's stakeholders.
- Customer Focus: creating sustainable customer value.
- Leadership and Constancy of Purpose: visionary and inspirational leadership, coupled with constancy of purpose.
- Management by Processes and Facts: managing the organization through a set of interdependent and interrelated systems, processes and facts.
- People Development and Involvement: maximizing the contribution of employees through their development and involvement.
- Continuous Learning, Innovation and Improvement: challenging the status quo and effecting change by using learning to create innovation and improvement opportunities.
- Partnership Development: developing and maintaining value-adding partnerships.
- Corporate Social Responsibility: exceeding the minimum regulatory framework in which the organization operates and to strive to understand and respond to the expectations of their stakeholders in society.

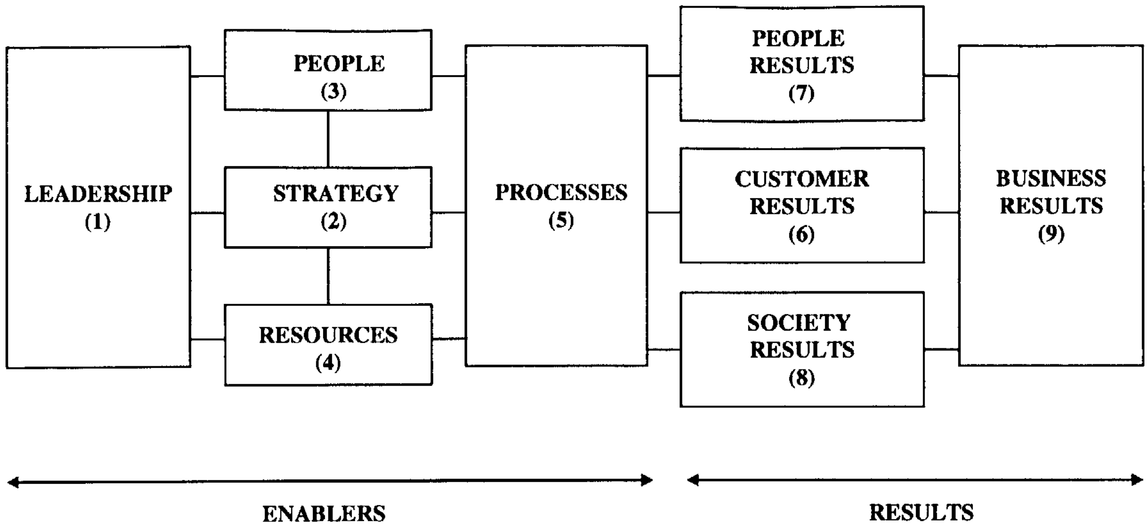


Figure 3.12: European Foundation for Quality Management model (1998)

3.4.5 A framework for designing and auditing performance measurement system

Medori and Steeple (2000) have proposed a framework that embraces both the design and auditing of performance measurement systems. Their framework offers a comprehensive iterative process which replaces the requirement for a structural performance measurement framework with the stipulation that they are measuring in areas related to six competitive priorities (quality, cost, flexibility, time, delivery, and future growth). In introducing a procedural framework for performance measurement system design, they are effectively detailing the components of a system **(Figure 13)**. The procedural performance measurement framework follows six stages:

Stage 1: A company's manufacturing strategy is defined, and the strategic requirements (including customer requirements) are identified.

Stage 2: Strategic requirements are matched against competitive priorities by listing them in a performance measurement grid. The performance measurement grid captures the six measurement categories (i.e. quality, cost, flexibility, time, delivery, and future growth).

Stage 3: Measures for the company priorities from stage 2 are then selected from a separate predefined list of performance measures (mainly from non-financial measures, with full descriptions and methods of calculation). Next is stage 4, which is omitted if the company has no existing performance measurement system.

Stage 4: Audit—the existing set of measures is listed and compared with the new measures that were identified in the previous stage. Three rules are applied:

- Existing measures that are congruent with new measures are kept and continually used; existing measures that are divergent with the new selected measures are deemed no longer relevant or useful to a company are scrapped.
- New measures are selected that do not tie into previous measures that diverge from goals.
- Existing measures are implemented. They represent ''gaps'' in the performance measurement system;
- If no ''gaps'' are identified then stage 5 (next) is omitted.

Stage 5: Implementation of measures - an eight-step plan is provided for implementing the new set of measures selected from the previous stage. These eight steps include development of each element of the metric record sheet described in the beginning of this chapter.

Stage 6: Periodic maintenance - the last stage of the system includes periodically reviewing a company's performance measurement system.

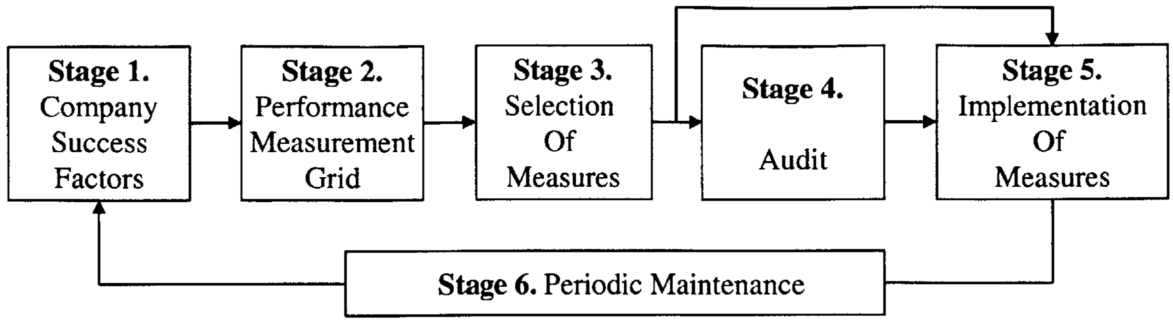


Figure 3.13: Basic framework presented by Medori and Steeple (2000)

3.4.6 A framework of factors affecting the evolution of a performance measurement system

Kennerley and Neely (2003b) provide an understanding of how measurement systems can be managed so that a dynamic and relevant set of performance measures can be maintained, reflecting an organization's changing requirements. They answer two key research questions:

(1) What factors affect (facilitate and inhibit) the way in which measurement systems change over time **(Figure 14)**?

(2) How can organizations manage their measurement systems so that they continually remain relevant?

Their work demonstrates that a complex range of factors can facilitate or inhibit this evolution and presents a framework that provides an understanding of how evolution can be managed. The research demonstrates that the existence of capabilities broadly grouped under the categories of process, people, systems and culture enables organizations to cope with a changing environment and modify their performance measurement system accordingly. For achieving the effective use of a performance measurement system, they explain three subsequent phases of evolution:

- Reflect on the existing performance measurement system to identify where it is no longer appropriate and where enhancement needs to be made.
- Modify the performance measurement system to ensure alignment to the organizations new circumstances.
- Deploy the modified performance measurement system so that it can be used to manage the performance of the organization.

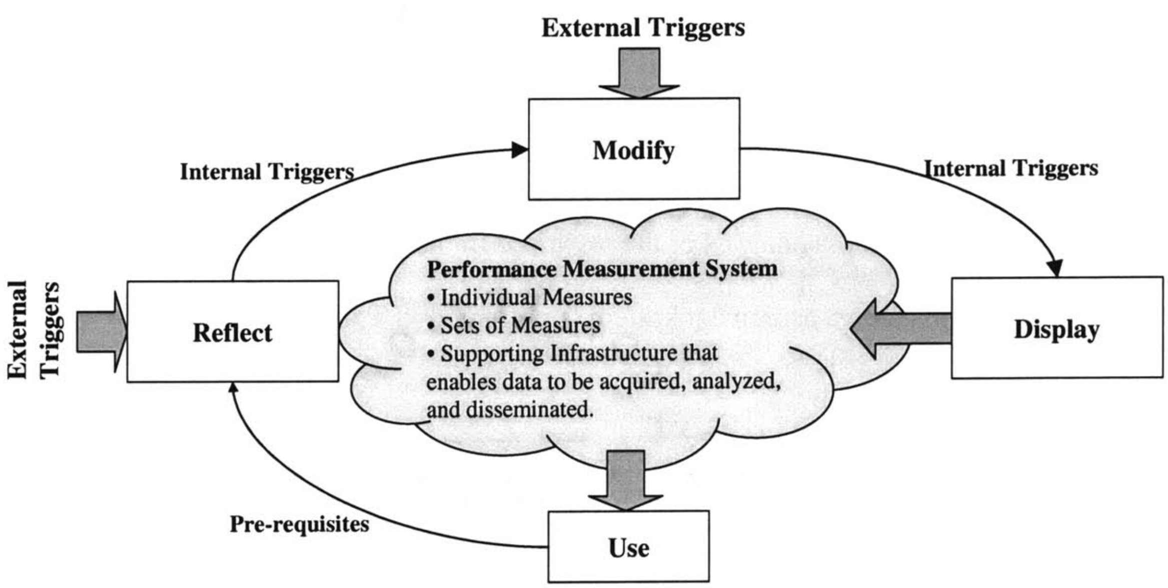


Figure 3.14: Factors affecting the evolution of a performance measurement system (adapted from Kennerly, 2003)

3.5 Evaluating performance measurement frameworks from a lean enterprise perspective

As identified in the previous chapter, the lean enterprise performance system should have the following attributes:

- Stakeholder value measures at the strategic level
- Established causal relationships among measures at all levels
- A method to ensure the use of uniform set of metrics

Along with these attributes, it should also comprise of the other attributes that have been identified for the performance measurement system for the system change initiatives, such as:

- Incorporating financial and non-financial measures at all levels
- Communication of strategy top down and bottom up feedback
- External vs internal focus
- Process management and measures

The strength and weakness analysis of the reviewed framework from the lens of lean enterprise performance measurement system is presented in **Table 1**.

None of the performance measurement frameworks, except the Performance Prism, include all stakeholders. The Performance Pyramid looks at only customers. The Balanced Scorecard, the most widely used performance measurement framework, restricts performance measurement to four predefined buckets. Yet some of the excluded ones are suppliers and employees, who are critical for deploying lean philosophy

(Norreklit, 2000). These four categories restrict the design of performance measurement and managerial attempt to retrofit all the measure into these categories. The conceptual framework of the Performance Prism includes all stakeholders, and before designing the measures first determines what is a stakeholder's value. However, the Performance Prism does not describe how to capture stakeholder values. Each stakeholder may put a different value to the same measure depending on context; thus, it becomes difficult to identify the value (Brignall, 2003). In the EFQM framework results are primarily driven by the customer and financials (i.e., business results), and other stakeholders, such as leadership, is folded into enablers. This model does not support stakeholder involvement in identifying and enabling value delivery. The design and audit model is restricted to six measurement buckets (quality, time, cost, flexibility, delivery, and future growth), which is again short of linking these measures to stakeholder values.

Defining and establishing the causal effect relationship is imperative for designing synchronized dynamic systems (Sterman, 2001). Performance measurement frameworks do not explicitly explain the definition and validation of the cause-effect relationship. This allows users to freely modify the structure while deploying the framework. Also, a lack of understanding of causality limits the use of this performance measurement system to monitoring and control (Ittner and Larcker, 2003). This is because if the causality is not understood, it is hard to make sense from feedback and communication to coordinate, improve or motivate. The Performance Pyramid connects strategic measures to operational measures, but does not describe explicit relationships. The Balanced Scorecard presumes relationships and interdependence across four perspectives. Also the relationship is assumed to be unidirectional, such as learning and growth driving internal processes, which in turn drives customer satisfaction, which ultimately drives financial results. These relationships may not hold true in the lean environment. For example, learning and growth constantly need feedback from customers as well as internal processes (Norreklit, 2000). Also it is primarily designed to provide senior managers with an overall view of performance. Thus it is not intended for (nor is it applicable to) factory operations-level employees (Ghalayini et al., 1997). The Performance Prism and Success Map includes creating a causal map for each stakeholder. However, it does not address methods to define or establish causal relationships. Also use of separate maps of the individual stakeholders may lead to siloed optimization to achieve one particular stakeholder's value.

The design of causal relationship is more robust if the time lags between the cause and effect is understood and captured in the design (Sterman, 2001). None of the frameworks include any estimation or heuristics on time lag. Schneiderman (1999) and Norreklit (2000) point out weakness of the Balanced Scorecard model for not considering time lag in its design, but at the same time they acknowledge that it is one of the most difficult elements to estimate between actions and measures.

Using a unified set of measures across systems will avoid local optimization of decisions. Same measures or sets of measures are used by different managers for decision making on different issues. For instance, a financial manager uses inventory turns to make a decision on operational cash flow, where as an operations manager follows it to manage the delivery time. If the formulae used by the two managers are different, it may lead to a non-lean behavior. None of the frameworks describe a procedure to manage a uniform set of measures in a dynamic environment.

Table 3.1: Analysis of strengths and weaknesses of Performance Measurement Frameworks

Performance Measurement Framework	Strengths	Weaknesses
Strategic measurement and reporting technique (SMART)	• Integrates strategic objectives with operational performance measures. • Aggregates financial and non-financial measures across various functions and business units.	• Does not capture measures with respect to all stakeholder values • Does not provide any mechanism to identify causal relationships between measures across functions or levels. • Does not explicitly integrate the concept of continuous improvement. • May promote local optimization due to functional approach
The Balanced Score card	• Scorecard approach to integrate strategic, operational, and financial measures. • Focus on linkages and strategy maps • Most widely accepted	• The linkages between the measures are presumed and unidirectional. • Explicitly focuses on customers but leaves other stakeholders implicit. • No deployment system that breaks high-level goals down to the sub-process level .
European Foundation for Quality Management	• Contains self assessment tests • Focuses not only on the results, like the balanced scorecard, but also on the drivers of success	• Enterprise performance management is broader than quality management. • Loosely defined framework with no supporting process of implementation.
The Performance prism	• Has a much more comprehensive view of different stakeholders (e.g. investors, customers, employees, regulators and suppliers) than other frameworks. • Provides visual map causal relationship map of measures for individual stakeholders.	• It offers little about how the causal relationships between the performance measures are going to be realized. • There is little or no consideration is given to the existing systems that companies may have in place.
A Framework for design and audit	• Provides detailed implementation guidelines. It can be used both to design a new performance measurement system and to enhance an existing performance measurement system . • It also contains a unique description of how performance measures should be realized.	• The performance measurement grid provides basic design for the performance measurement system, and the grid is only constructed from six categories. • The causal relationships among the measures is not explained.
A Framework of factors affecting evolution	• Provides a systematic process of assessing the existing performance measurement system and adapting to the changing internal and external environment. • Design against people, process, system , technology	• Does not consider stakeholders as one of the factors affecting the measurement system.

Conclusion

Performance measures and measurement system design should be comprehensive enough to address roles of performance measurement. The body of literature in the area of performance measurement is very extensive. However, there is very little or no work that has been done to design the performance measurement system for the lean enterprise. The design of performance measures should involve multiple attributes such as elements, dimensions and levels of measurement. And the design of performance measures should involve both structural and procedural frameworks. None of the eminent performance measurement frameworks include the attributes required for the design of performance measurement system for the lean enterprise. Use of the suggested performance measurement, such as balanced scorecard, may result in an impediment to adopting lean philosophy across the enterprise. Also, the evolution of a performance measurement framework with the internal and external environment is very critical for the successful outcomes.

The next chapter presents a case study of a major aerospace and defense sector company to explore:

- To identify the efficacy of existing performance measures and measurement frame work in the lean adoption
- To understand the barriers for adoption of the lean practices from the performance measurement perspective

Chapter 4

Performance measurement perspective on enterprise transformation: A case study

Introduction

Transformation to a networked enterprise through embracing lean principles and practices poses many challenges in achieving and sustaining desired levels of enterprise performance. One of these challenges is to build a performance measurement system across all levels of an enterprise that will support strategic goals and their subsequent actions. In 1998, Alpha Corporation embarked on an enterprise-wide transformation journey to create operational excellence. The case study on Gamma Tech, an aerospace and defense subsidiary of Alpha Corp., focuses on understanding the role of performance measurement and its supporting systems in enabling and driving the enterprise-wide transformation.

The case study highlights two aspects described earlier in Chapters 2 and 3. First, evolution of strategies and corresponding actions also demand transformation of a performance measurement system for successful execution. Second, enterprise transformation by embracing lean philosophy requires a single unified performance measurement system. Current frameworks such as the Balanced Scorecard are not comprehensive enough to design such systems. We interviewed ten senior executives at Gamma Tech to gain insights into current and historical transformation efforts and a corresponding performance measurement system.

The first section describes the interplay between the corporation's transformation over the last few decades and corresponding changes at Gamma Tech. The historical evolution of Alpha Corporation's strategic objectives, corresponding enterprise-wide actions and supporting measures used to achieve the objectives are documented. In parallel to this, Gamma Tech's evolution along the same dimensions is explored.

The second section captures the current state of Alpha Corporation's transformation journey undertaken to achieve the strategic objective of delivering both breakthrough and sustainable return on invested capital (ROIC) by improving the portfolio of businesses and creating operational excellence. Alpha Corporation's objective is to create operational excellence via best in class processes, talented people and successful customers by implementing improvement strategies such as Six Sigma, Integrated Supply Chains and Performance Management Process. It created a balanced scorecard to measure its achievement against these objectives. The implementation of these strategies in the context of Gamma Tech's current management process is discussed. A systematic process, the Goal Deployment Process, is used at Gamma Tech to deploy these strategies and track transformation efforts.

The third section discusses the lessons learned and challenges in transformation journey from a performance measurement perspective.

4.1 Alpha Corporation: History

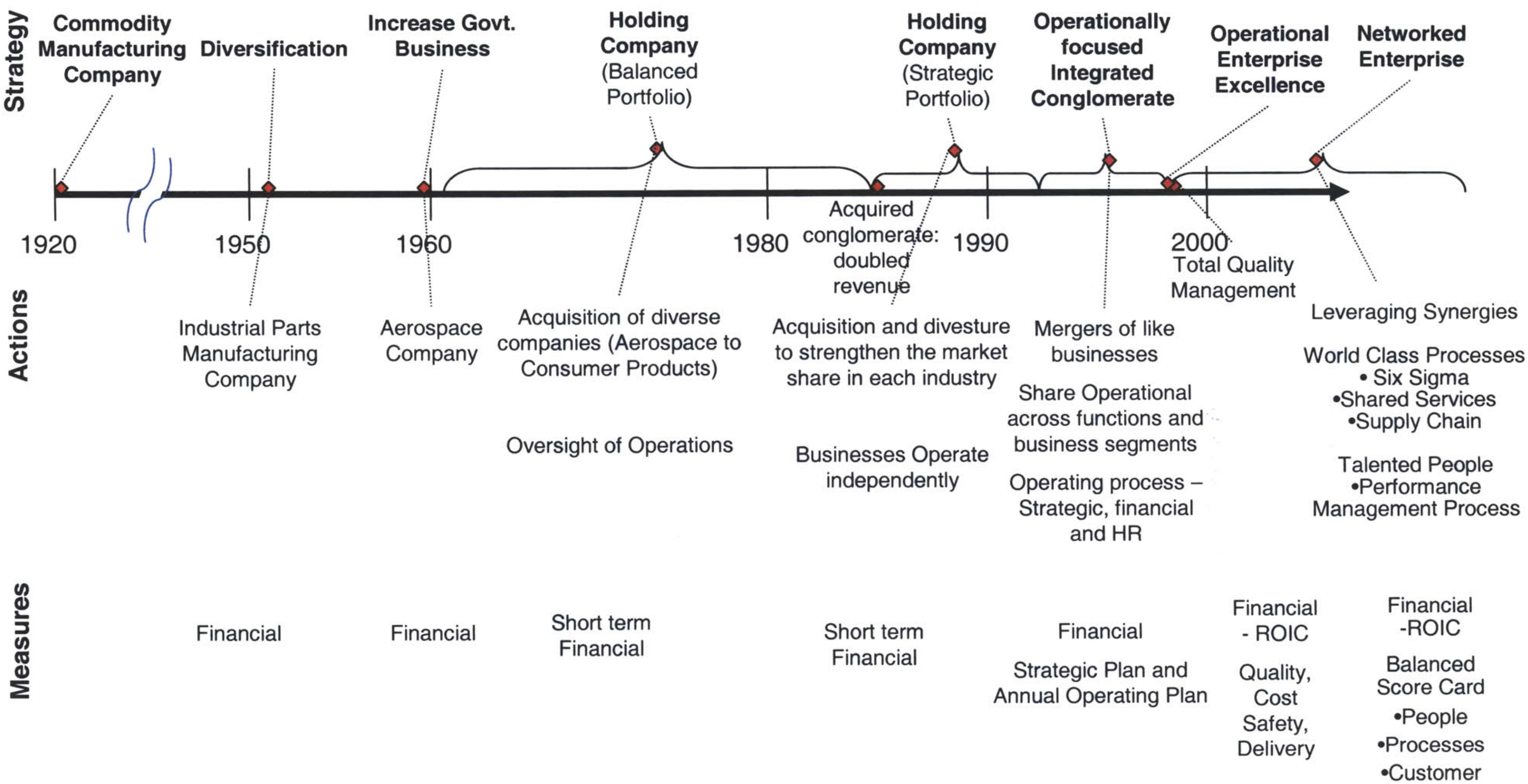
Alpha Corporation is a conglomerate that operates in multiple countries and has a very large employee base. Established in 1920 as a commodity manufacturing company, it currently operates in five business segments across four different industries. Its evolution over the last few decades provides a fascinating look at changes in strategy, and corresponding changes within the corporation.

In the early 1950s, the commodity manufacturing company started diversifying into other businesses, first by acquiring an industrial parts manufacturing company **(Figure 1)**. The strategic move to diversify into a non-commodity industry paid off during the recession of the late 1950s. In 1958, Alpha acquired Omega Air to increase revenue from government business. For the following two decades, Alpha continued to invest in diverse groups of industries, from aerospace to consumer products. During this period, the corporation operated as a conglomerate with the strategic objective of delivering increasing financial returns to its shareholders by managing a balanced portfolio of companies. Management maintained oversight of operational issues across the group of companies, with little interference into operations.

Starting in the mid-1980s, Alpha changed its strategic direction by acquiring companies that would create dominant positions for their existing businesses in the marketplace. For example, in 1984, with the acquisition of a diversified corporation, Alpha nearly doubled its revenue from its existing businesses, including aerospace. Until the early 1990s Alpha's strategic directions were primarily focused on improving short-term financial returns. Its business model was to buy and grow strong companies, providing the necessary financial resources for each to operate independently. In essence, Alpha Corporation was a holding company that managed a portfolio of successful organizations independent of each other. The objective of each organization was to satisfy the financial goals of the holding company.

In the early 1990s, responding to global competition and increasing customer expectations, Alpha's new CEO steered the company towards creating an operationally focused, integrated conglomerate. Its strategic goal was to leverage and share operational expertise and core competence across all business segments. Enterprise-wide initiatives included mergers of like businesses and acquisitions to improve existing products, markets or manufacturing processes and capabilities. In 1997, it started a corporate-wide quality management initiative to improve product quality and process efficiency. Organizations were not only expected to manage their businesses towards achieving financial measures, but they were also expected to deliver on non-financial measures, such as quality, delivery and customer satisfaction.

Figure 4.1: History – Strategic changes and performance measurement at Alpha Corporation



4.2.1 Towards creating a networked enterprise

Since 1997, under the leadership of the present CEO, Alpha's strategic objective has been to deliver sustainable stakeholder value by developing and leveraging synergies across businesses and brands. The company's transformation path towards actualizing this vision is twofold: creating a portfolio of profitable and growing businesses, and leveraging and improving enterprise-wide management practices to optimize the operational performance across the network of Alpha businesses.

Enterprise transformation efforts at Alpha incorporate improving and standardizing processes, enhancing talent and leveraging it across the corporation, and strengthening customer relationships **(Figure 2)**. Since 1999, management has deployed more than 20 cross-functional initiative teams to develop common processes and share best practices across the businesses. An illustrative example is the creation of a cross-functional team focusing on optimizing global supply chain efficiency while improving customer satisfaction. In 2000-1, the integrated supply chain initiative produced savings worth more than $50 million by improving internal processes. At the end of the first year of its transformation efforts, the company began implementing 'lean' practices across the enterprise under the program called Six Sigma. This customized program for process improvement has three key objectives:

- eliminate waste
- reduce variability and
- accelerate growth and innovation

In addition, enterprise-wide shared service organizations are created across non-core business processes, human resources, information technology, and finance, to improve efficiency and drive down operational cost. To develop talent in line with the strategic objectives and leverage it across the enterprise, a standardized talent assessment process, known as performance management process, is being implemented across the enterprise. The performance management process is also designed to guide employees with their career development objectives.

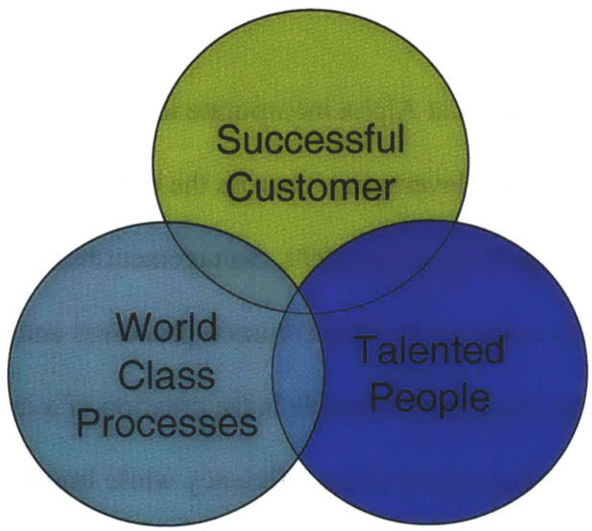


Figure 4.2: Alpha Corporation's transformation objectives

The dramatic change in Alpha's strategic approach, from managing for pure financial performance to managing operational performance across businesses to achieve financial performance, led it to broaden enterprise level measures. To control all of its diverse businesses, the corporation has deployed a Balanced Scorecard model, which provides a standardized measurement and reporting structure for operational as well as financial performance across all businesses **(Figure 3)**. The Balanced Scorecard consists of metrics under four categories, namely, world class processes, talented people, successful customers, and financial performance. All business segments are required to manage their business around these measures and report them to corporate management on a regular basis. Thus, the challenge for all segment managers is to manage their businesses using new sets of measures and deliver the desired strategic objective.

To study the challenges of enterprise transformation from the performance measurement perspective, we examined the aerospace and defense business segment, Gamma Tech.

Successful Customers
Customer Loyalty Index (CLi)
Organic Revenue Growth
Talented People
Education & Development
Inclusive Workforce
Time to Hire (days)
World Class Enterprise Processes
Price-Cost Ratio
Recordable Injury Rate
Lost Time Injury Rate
Cost of Quality
On Time Delivery (OTD)
Orders
Revenue
Cash Flow from Operations
Financial Inventory Turns
Value Pricing Benefit
Industry Leading Performance
Return on Invested Capital
Net Operating Profit
Economic Value Added

Figure 4.3: Alpha Corporation Balanced Scorecard

4.2 Gamma Tech: History

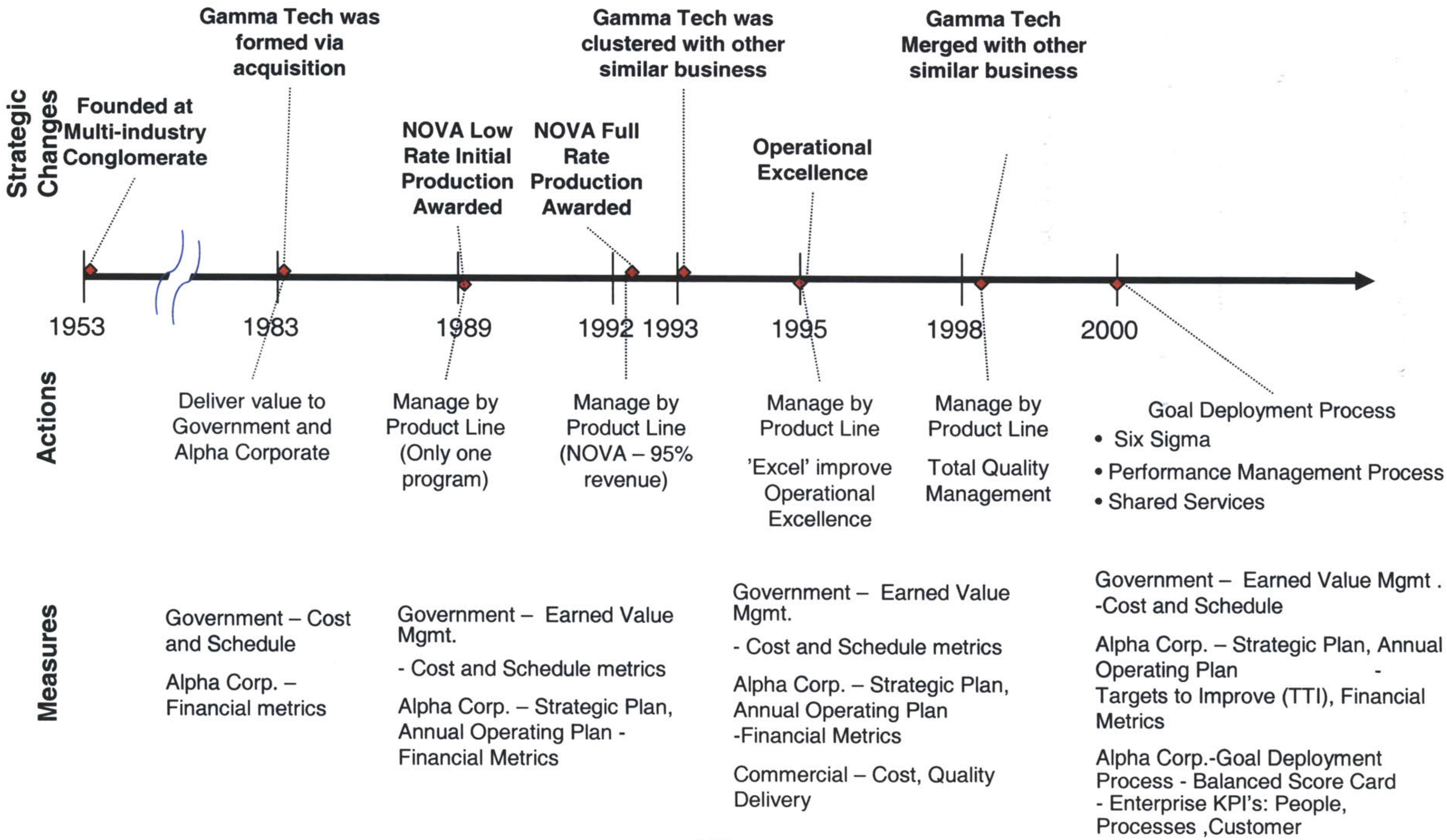
Gamma Tech is part of the defense and aerospace business segment of Alpha Corporation. Historically, the strategic objective of Gamma Tech has been to deliver value to both the Alpha Corporation and its primary customer: the U.S. Department of Defense. Alpha Corporation's strategic goals in the past and the nature of defense business in general have steered Gamma Tech's management practices and corresponding performance measurement systems to focus primarily on achieving financial goals.

Gamma Tech grew out of the defense sector of a conglomerate that was acquired by Alpha in 1983 **(Figure 4)**. Until 1988, Gamma Tech operated as an autonomous business that provided returns to the conglomerate in return for its financial support. The source of revenue was contingent on government spending, and the associated returns were generated by managing the business to deliver goods and services within contract-mandated cost and time parameters.

As noted above, in the 1990s, Alpha Corporation changed its strategy from being a holding company to an operating conglomerate. In addition to reporting on and delivering financial performance, corporate management required each business segment to report on and manage by both a strategic and operating plan, which were standardized across all business segments to incorporate respective strategic, financial, and human resource plans. Following this corporate mandate, Gamma Tech started managing its business around a five-year strategic and an annual operating plan. However, management practices at Gamma Tech continued to focus on achieving financial performance, as corporate management reviewed each business's Strategic Plan and Annual Operating Plan primarily around margins, growth and profitability. The performance measurement system at Gamma Tech continued to monitor financial measures and contract requirements.

In the early 1990s, Gamma Tech started manufacturing highly specialized defense products. Its primary customer was the NOVA acquisition program. In a short period of time, this program proved to be a success, accounting for seventy-five percent of Gamma Tech's revenue. Since then, NOVA has been under a full-rate production contract. The business at Gamma Tech was managed for individual product lines, dominated by NOVA. Due to fixed price annual contracts, revenue was fairly stable. The corporation's financial performance was dependent on adherence to cost and schedule as per the program requirement. The NOVA program is managed based on the government accounting standards. This standard allows contactors to receive almost eighty-five percent of contract revenue based on milestones of work performed before the product passes performance tests. The objective of the program manager was to achieve planned financial goals in the Annual Operating Plan while delivering the program requirements as per negotiated contracts.

Figure 4.4: History – Strategic changes and performance measurement at Gamma Tech



At the beginning of the annual contract, expected financial returns are set aside from contract revenue before budgeting for individual functions. To ensure meeting the plan, the program manager keeps a certain percent of the contract revenue as a management reserve for unforeseen events. The performance of each function is monitored and controlled against the budget and program requirements. Hence, the functions focus on operational performance and meeting budget and contract requirements. The financial performance measurement is disconnected from the operational performance. As one retired senior executive from Gamma Tech noted, "The inventory turns based on the financial numbers were fifteen turns per year, but in reality it was four or five".

4.2.1 Operational improvement efforts at Gamma Tech

As various business consolidations and mergers expanded, Gamma Tech's customer base expanded to include government and commercial customers. Performance expectations for commercial customers went beyond tracking cost and schedule metrics.

In 1993, due to a lack of commercial design and operational expertise, Gamma Tech lost a large government program bid to its competitors. This loss of a large contract and an expanding commercial customer base highlighted the need to build operational expertise within Gamma Tech. In 1994, a company-wide process improvement initiative called 'Excel' was initiated to address value delivery to the commercial customers, as well as to build needed future operational capability.

The objective of the Excel initiative was to create a tenfold improvement in operational performance. In pursuit of this, Alpha fostered teamwork and cooperation across all businesses and functions. Gamma Tech also created cross-functional teams across production and engineering operations. Under the Excel initiative, teams were urged to identify operational improvement opportunities and transform their operations to make a tenfold improvement over the next two years. These improvements were desired in addition to meeting existing performance requirements. The teams were provided with capital resources and the training required to execute the proposed transformation. The objective of the Excel program was to reduce the product cycle time, improve product quality, lower product cost and minimize waste across all business units. Hence, the activity and individual level performance was measured around a new set of operational metrics such as throughput time and inventory turns.

The Excel initiative dramatically improved business performance at one of Gamma Tech's subsidiaries in Arlington, leading to its profitable divesture in the late 1990s. However, Excel did not create significant impact on overall business performance at Gamma Tech's core business facility. One reason for its failure was the disconnected performance measurement systems at Gamma Tech's core business. The Strategic Plan and Annual Operating Plan did not emphasize operational measures. Gamma Tech's management process was designed primarily around the product line NOVA, which delivered value to government customers. Business decisions were made on the basis of financial measures and program requirements. Program and functional managers directed product line operations based on cost and schedule measures. Additionally, program managers budgeted for and managed headcount and salary. The associated incentives to individuals were designed around program performance.

This disconnect is highlighted in the following anecdote: "Consider two engineers with similar qualifications and experience, one who is a direct cost item on the program, and the other who is an indirect cost item on the program. During the annual review, an engineer who was direct on the program got a seven percent raise as opposed to the two percent raise for the engineer who was considered overhead. This discrepancy in raises resulted from the fact that there were limited indirect funds available that had to be partitioned across all personnel who were billed as overhead." This approach created incongruity and insecurity for personnel who were not directly billing a program, and Gamma Tech lost some extremely talented people along the way.

To drive the operational excellence across the integrated conglomerate, in 1997 Alpha created a new initiative called Total Quality Management (TQM). Under the TQM program, each business was asked to manage its operations around a standard set of measures, quality, safety, cost and delivery. Each business was expected to perform against non-negotiable benchmarks that were developed for industry sectors by Alpha corporate management. The TQM initiative improved the overall business performance of some of Alpha's businesses but for Gamma Tech it was merely another set of measurement reporting. A retired senior executive at Gamma Tech said, "We would come up with numbers of some sort and try to stay out of trouble".

4.2.2 Towards operational excellence: Transformation at Gamma Tech

As part of the Alpha Corporation's enterprise transformation efforts towards achieving operational excellence, in 1999 executives at Gamma Tech restructured the organization to cluster similar businesses. Gamma Tech divided its products into six business lines operated from four geographic locations. Each business unit manufactures one or more product lines. Seventy-six percent of Gamma Tech's revenue comes from defense, and rest from commercial businesses. Gamma Tech is the prime contractor for the NOVA program, which comes under one of these six business lines and generates thirty-seven percent of its revenue. For other business lines, it is a contractor or first tier supplier to other defense programs. Two of its six business lines are focused on the commercial business.

In 2000, Gamma Tech began deploying strategic initiatives that were mandated by corporate headquarters. Again, Alpha Corporation's strategic objective is to create and sustain breakthrough improvements in Return on Invested Capital (ROIC) over a 3 to 5 year period by improving processes, people and customer satisfaction. To create breakthrough process improvements, Gamma Tech started implementing lean practices under the name of a strategic initiative called Six Sigma (SS). In addition, Gamma Tech also started deploying integrated supply chain efforts initiated by Alpha Corporation. Similarly, to enhance talent development and align individual goals with its strategic goals, in 2001 Gamma Tech started deploying a standardized talent assessment process called performance measurement process (PMP). These strategic initiatives were being deployed in addition to existing enterprise management processes. To measure the performance improvements achieved through these initiatives, Gamma Tech started monitoring and reporting the measures developed under the balanced scorecard by corporate mandate.

Until 2002, strategic initiatives were implemented on an *ad hoc* basis and improvements realized through this deployment were counted towards the strategic objective. Starting in 2002, however, Gamma Tech adopted a systematic process, called Goal Deployment Process, to prioritize and deploy improvement initiatives in line with strategic objectives. In other words, the Goal Deployment Process is now used to execute the Gamma Tech strategic plan to achieve long-term breakthrough objectives. The Goal Deployment Process enables prioritization of improvement strategies, aligning actions across three different levels at Gamma Tech and ultimately with the overall strategic objective itself. It also enables planning and monitoring of actions, improvement targets for corresponding measures and responsibilities for individual actions.

4.3 Gamma Tech current management process, transformation efforts and performance measurement

There are two phases to the management process at Gamma Tech: the planning phase and the execution phase. In the planning phase the annual operating plan is created for the upcoming year and the strategic plan is created and revised for the next three- to five-year time horizon. The Annual Operating Plan includes action plans and performance goals for the upcoming year and subsequent ROIC projections. ROIC is projected by aggregating expected revenues and corresponding cost structures for the upcoming year provided by the business line strategic plans. Each business line creates an individual strategic plan that captures the projected revenues from the respective product lines based on existing contracts and expected new business. The Strategic Plan at Gamma Tech is created and revised on an annual basis to enable the long-term growth of Gamma Tech in alignment with Alpha Corporation's long-term objectives, with ROIC being the key driver. The Strategic Plan includes identified growth opportunities, corresponding improvement strategies, and subsequent ROIC projections. Growth opportunities are identified based on external sense-making of both customers and competitors, and based on the internal assessment of the functional performance and business line strategic plans. Both the Annual Operating Plan and Strategic Plan are shared with Alpha. After aggregating the ROIC projections for all of Alpha Corporation's businesses the management committee determines, for upcoming years and longer term, the expected ROIC for each of the businesses, including Gamma Tech. Followed by a series of negotiations between Alpha Corporation and Gamma Tech, the Annual Operating Plan and Strategic Plan are approved with the new expected ROIC. The approved Annual Operating Plan and Strategic Plan then are put to action in the execution phase.

The approved Annual Operating Plan is executed and managed by the business lines and functions to achieve two objectives **(Figure 5)**. The first objective is to fulfill contract requirements within the allocated budget and deliver the projected ROIC. Each business line negotiates its contracts with customers (defense programs, prime contracts and internal Alpha customers) on the basis of cost, schedule, quantity and quality requirements. Contracts are typically fixed-price annual contracts. The contract price is negotiated from the cost structure analyzed by each function against the contract requirement. Once the contract is awarded, budgets are allocated to each function accordingly. To achieve the projected ROIC, functions are monitored for adherence to budget and contract requirements. The second objective is to achieve the new expected ROIC, which is usually higher than the ROIC projected from the business line strategic plan. To close the gap between business line ROIC and corporate ROIC, each business line and function is expected to deliver agreed upon increased revenue or reduced costs. The emphasis for these efforts is on the operational improvements to reduce costs (the revenue is set by government spending plans for the year). Functions drive the improvement efforts with minimal or no excess budget for those efforts.

Figure 4.5: Gamma Tech Annual Operating Plan execution process

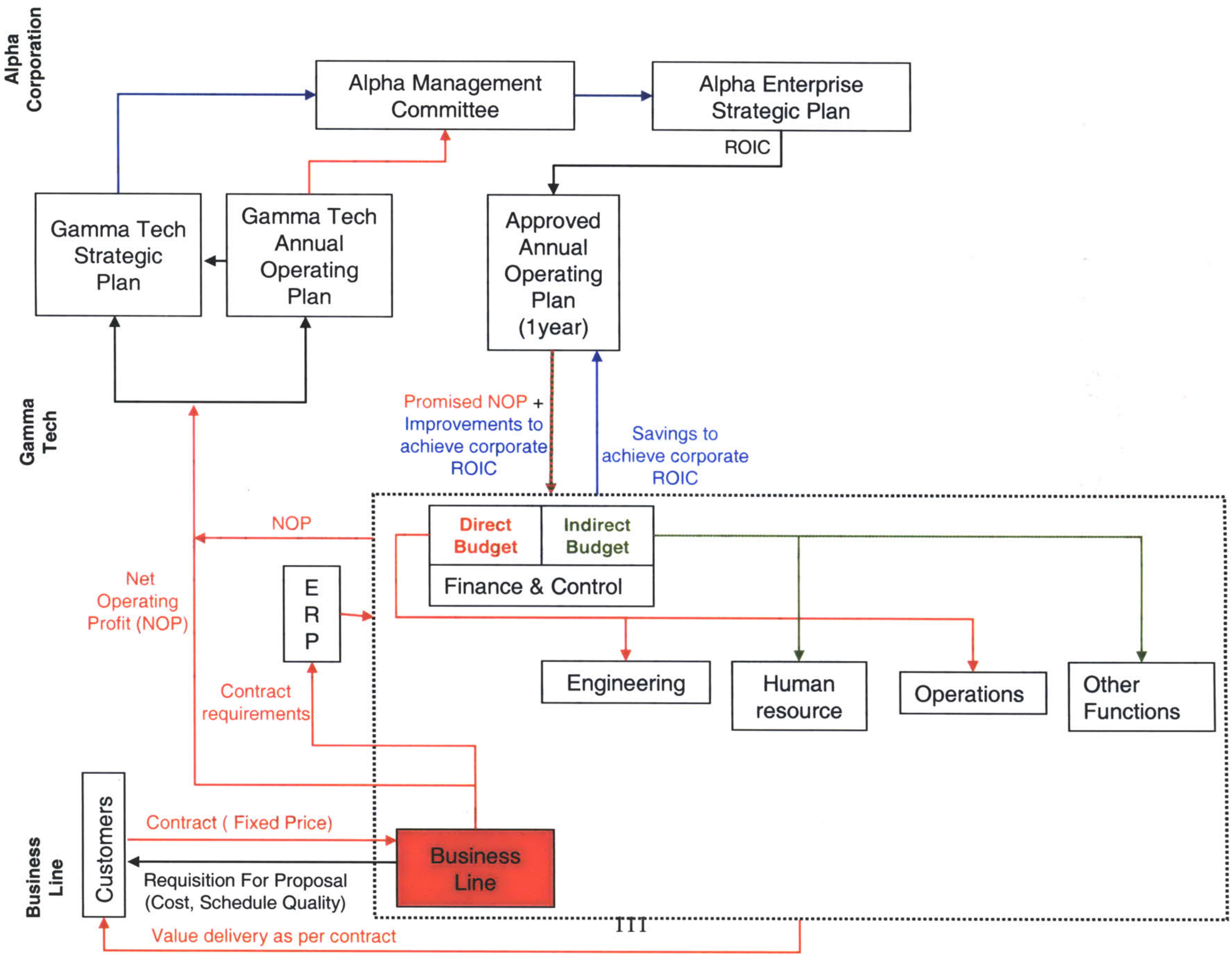
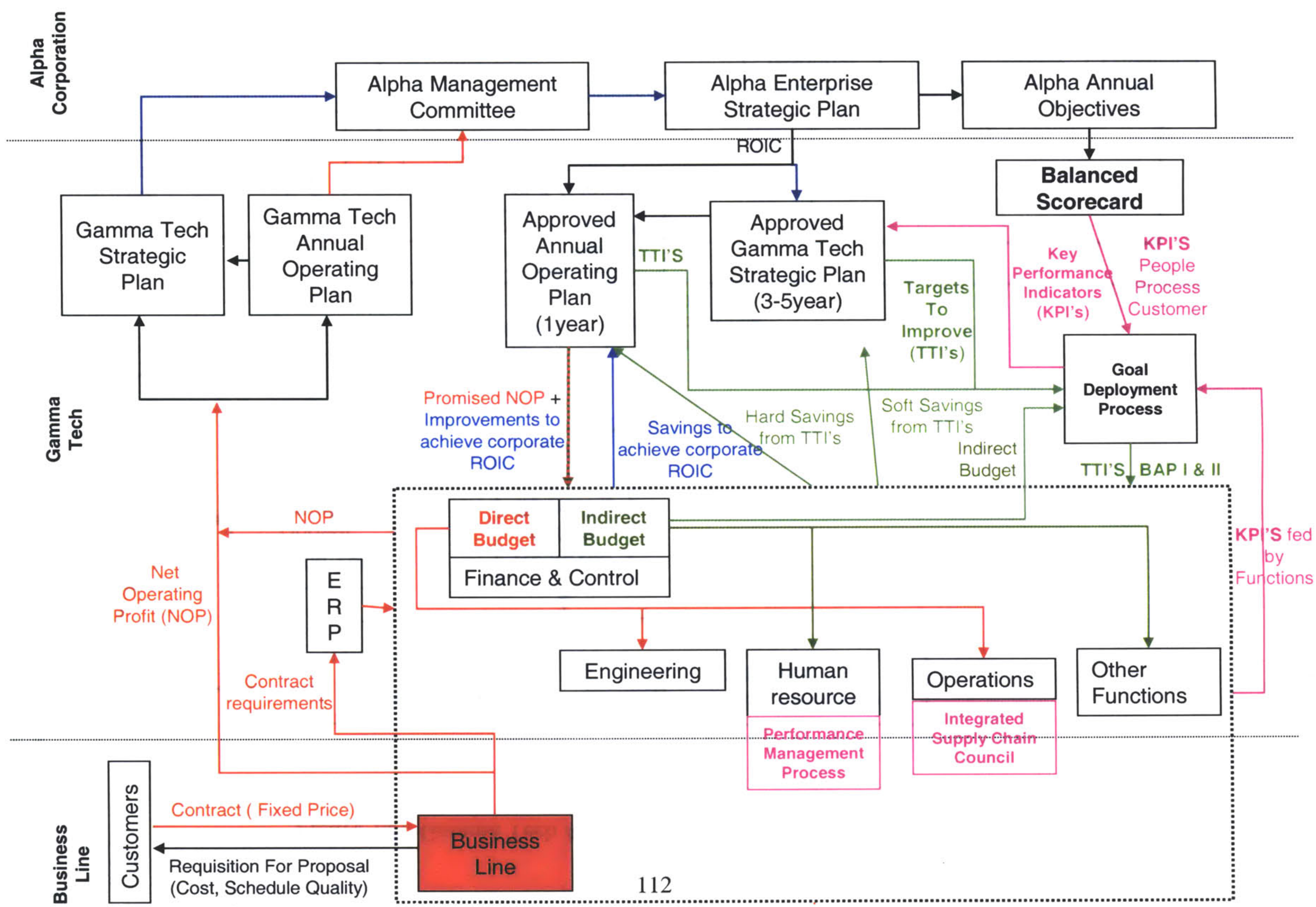


Figure 4.6: Gamma Tech Strategic Plan execution process via Goal Deployment Process



The actions and behaviors at the activity and individual level are primarily oriented towards fulfilling functional responsibilities. Functional responsibilities are part of the contract requirement. The budget allocated to each function to perform these activities is divided into two elements: direct budget and indirect budget. The activities that contribute directly towards fulfilling contract requirements are funded through the direct budget, such as engineering, and the performance of those activities are measured against contract requirements. The indirect budget is used to perform activities that will support direct activities, such as human resources. Ninety-five percent of the engineering and operations budget is direct budget and the performance for those activities is measured primarily against cost, schedule and quality.

As described earlier, the strategic plan is executed through the Goal Deployment Process **(Figure 6)**. The Goal Deployment Process involves deploying and aligning the improvement strategies and subsequent actions across the three levels of management to achieve breakthrough strategic objectives. At each level of management a matrix format **(Figure 7)** is used to align the improvement strategies/actions and corresponding improvement targets (TTIs) with objectives.

At the top (first) level matrix, as a part of the Goal Deployment Process, the strategic breakthrough objectives are refined into the annual breakthrough objectives. These objectives are mandated by Alpha. The current strategic objective for Alpha Corporation is to double the ROIC growth within the next four years. To achieve this breakthrough growth, it has established corporation-wide initiatives, which include Six Sigma, Integrated Supply Chain, and Performance Management Process. Alpha Corporation expects all its businesses, including Gamma Tech, to embrace these improvement strategies towards achieving the strategic objectives. At Gamma Tech, these improvement strategies are refined and prioritized specific to its current performance and external environment with the goal of achieving annual and strategic objectives. At the beginning of the year, annual improvement targets (TTI) are decided for the performance measures relevant to each improvement strategy. Measures include level of implementation, cost savings in terms of dollars, revenue in terms of dollars and some high-level operational measures such as inventory turns. The TTI are decided by the Gamma Tech's executive team such that they will enable them to achieve the annual and strategic objectives. The initiative managers hold the primary responsibility of implementing and monitoring the performance against the TTIs and the budget. However, since the improvement strategies and initiatives cut across business lines and functions, business line and functional managers are also responsible to achieve their respective targets. In some instances the initiative mangers are also business line or functional managers. The Goal Deployment Process is funded by the indirect element of budget.

At the second level matrix, as a part of the Goal Deployment Process, the top level improvement strategies are further broken down into detailed action plans by the initiative managers. The action plans involve designing and implementing processes to execute strategies and initiatives at the business line and functional level, identifying

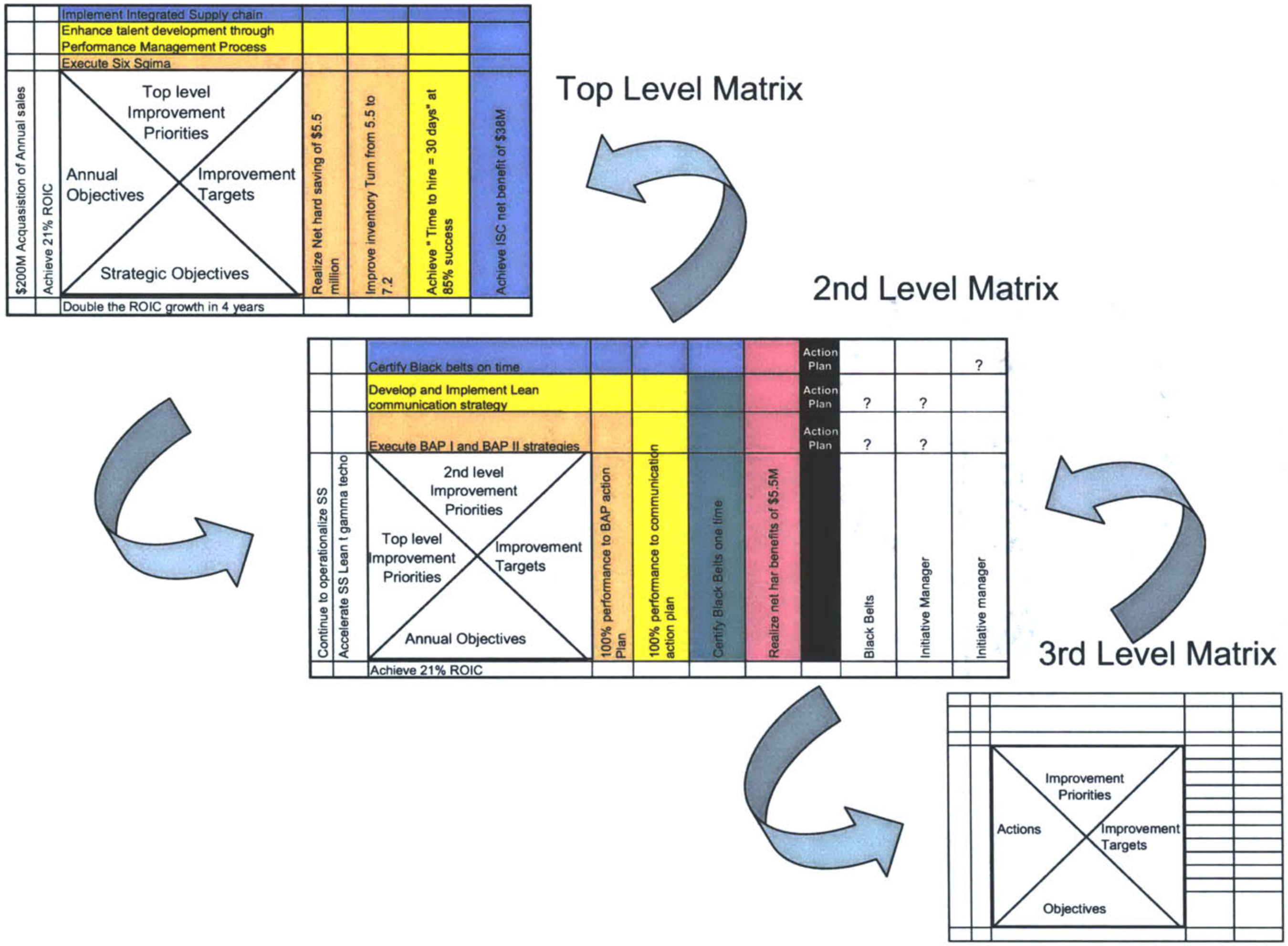


Figure 4.7: The Three Level - Goal Deployment Process

improvement opportunities at the activity and task level, empowering people, providing resources and the like. For example, one of the top level improvement strategies or initiatives is to increase the adoption of Six Sigma. It is implemented across the value streams encompassing multiple functions and business lines. To execute Six Sigma, detailed action plans are created, which include processes to identify both value streams called Business Assessment Process – I (BAP-I) and improvement opportunities across value streams called Business Assessment Process – II (BAP-II). The action plans also include recruiting and training Six Sigma champions called master black belts, communicating the Six Sigma strategy across all levels, and improving and managing the execution processes. The improvement targets are set primarily around the completion rates for each of the action plans, and the overall target is set around achieving the benefits measured in terms of dollars saved. The BAP-I and BAP-II are executed by the master black belts to identify the improvement opportunities at the activity level which are further implemented by functions and/or business lines.

At the third level matrix, as a part of the Goal Deployment Process, improvement opportunities identified under BAP-I and BAP-II are prioritized and projects are established at the activity level to implement the selected improvement opportunities. Successful implementation of the projects requires buy-in of the employees and their managers at the activity level. Since the actions and behavior at the activity level are primarily driven by the measures in the contract requirement and the direct budget, the improvement projects are sometimes not given enough importance. In 2004, the targets were set around dollars saved in the current fiscal year and projected savings in the future.

4.4 Lessons learned and challenges

The Goal Deployment Process adapted at Gamma Tech to deploy improvement initiatives such as Six Sigma provides a structured approach to a transformation of processes towards achieving desired strategic objectives. However, to align the outcomes of actions and behavior across the functions and processes with the strategic objectives and to enable managers to make effective decisions to drive the actions towards strategic objectives, it is critical to choose appropriate performance measures at each level and create a supporting performance measurement system. The existing performance measures and performance measurement system do not support the transformation in the following ways:

- The performance measurement system does not capture the causal relationships among the operational and financial outcomes. Also, the causal relationship between the outcomes due to improvement initiatives and the business unit/product line performance is not understood.
- Use of non-uniform measures by different departments to assess the performance of same process along the same dimension leads to conflicting actions and suboptimal outcomes.
- The performance measures that capture a stakeholder's perspective, such as customer satisfaction, collected at the top level, are not used effectively in the decision making.

4.4.1 Goal Deployment Process provides visibility into the transformation process

The Goal Deployment Process used to deploy the strategic objectives and corresponding improvement strategies across three different levels in the organization provides visibility into the transformation process. It facilitates the alignment among objectives, actions and corresponding measures at each level. Also, it connects the objectives and actions across different levels so that the transformation at the lowest level is aligned with the top level strategic objective. The Goal Deployment Process provides a standard process for all improvement strategies and initiatives to roll down to the root-cause level and drive the transformation. At each level of the Goal Deployment Process, individuals are assigned responsibilities and are held accountable to drive the sustainable improvements. The current limitation of the Goal Deployment Process lies in the lack of backwards traceability from the lower-level goal assignments and actual outcomes to the top-level strategic goals. Also, the Goal Deployment Process is not completely integrated with the business practices used by business units and products lines. As one senior executivenoted "We are trying to figure out how to connect the business process with the Goal Deployment Process and close the otherwise feed forward loop. This will enable Goal Deployment Process improvements in the strategy. In addition, at each level targets are set around selected measures to provide clarity around goals and objectives for the levels below. The Goal Deployment Process also involves value stream mapping which provides an understanding into interconnections among processes and tasks."

4.4.2 Disconnected performance measurement system

Disconnects between the performance measurement for the lean improvement initiatives and the regular business practices hinder the adoption of lean practices. The Goal Deployment Process uses different performance measurements than that of AOP. The legacy and emphasis on the AOP performance measures drives the actions and behaviors affecting the adoption of lean practices and improvement initiatives.

4.4.3 Causal relationships are not captured

To meet the corporation's new strategic objectives of creating operational excellence to achieve the desired ROIC, Alpha Corporation and Gamma Tech have started measuring top-level performance using the most espoused performance measurement framework, the Balanced Scorecard. It includes financial as well as non-financial measures around employees, customers and processes performance. Managers driving the transformation efforts make decisions to achieve outcomes aligned with top level goals. But as pointed out earlier, the corporation's historic focus on financial goals and government accounting standards have driven the current business unit/product line performance measures and the supporting system to monitor and control actions against short-term financial goals. Hence the actions and behaviors driven by the existing performance measures do not always support the actions required to implement and sustain the improvement projects. As one o program managers mentioned, "I hate these improvement activities; it increases my cost of disruption". Very few improvement projects are implemented and sustained at the activity level. This is primarily because existing performance measures are driven by contract requirements and direct budget. And the improvement project may or may not contribute to fulfill the contract requirement in the short term. Moreover, individual performance is measured against the contract requirement and adherence to budget and not the improvement targets. "We don't hold our managers accountable to implement and sustain the improvements", a senior executive said. Thus, to transform the actions and behavior at each level, the performance measurement system should capture the causal relationship between the outcomes due to transformation and improvement and the business unit/product line performance.

In addition, due to the legacy of achieving financial goals, overall business unit/product line decisions are driven primarily in terms of financial performance. To drive improvements in operational performance and steer the decision making to involve operational goals it is critical to capture the causal relationship between operational performance and financial performance at each level.

4.4.4 Uniform set of measures

Currently, all current-year measurement data is accessible through an Enterprise Resource Planning system (ERP), and all requisite reports are generated based on that data. Different functional units manipulate the data differently to generate the same measure. A case in point is the use of inventory turns by finance and operations. Finance measures inventory turns by looking back at the previous fiscal year on the basis of total average sales/average inventory over the twelve-month period. Operations, on the other hand, use a forward-looking formula to measure inventory turns (e.g., average orders to be fulfilled in the next twelve months/ average inventory). This results in conflicting actions by the functions, as illustrated by the following comment.

"Finance ordered the operations team to get rid of existing parts in order to improve the inventory turns. The inventory was required by operations in order to meet their schedule looking forward to the upcoming year. The inventory was reduced, and the operations team ended up spending an additional $60,000 to procure the same components again."

A uniform set of metrics would address this problem and ensure that the activities by different functions within the enterprise were aligned.

4.4.5 Unused measures

There is a large amount of measurement data gathered across all levels to fulfill the balanced scorecard reporting requirement. However, most of the performance measures aggregated in the balanced scorecard are not utilized to make decisions towards operational improvement or transformation. One example is the regular gathering of customer satisfaction data. There is little sense making that happens on the basis of that data; i.e. the data gathered for customer satisfaction is not used to preempt a possible loss of customers.

4.5 Conclusion

The evolution of strategic approaches at Alpha Corporation and at Gamma Tech led to the adoption of system change initiatives at the enterprise level as well as across business lines. However, the performance measurement system was not transformed to support these initiatives, and actually impeded the desired transformation. The legacy performance measurement and its supporting systems create barriers for transforming to the new actions and performance measures. Changing the performance measures at the enterprise level, that is, the balanced scorecard measures, is necessary but not sufficient for improvement initiatives. It is critical to change the performance measures at each level and integrate them into regular business practices. This integration requires an understanding of the causal relationships between the performance measures. Also, to avoid non-lean behavior, design performance measures need to uniform across the enterprise. Thus a formal design of the performance measurement system and its evolution is critical for the successful adoption of the improvement initiatives and enterprise transformation. The next chapter presents a conceptual design for a performance measurement system that supporting the enterprise-wide transformation by adopting lean practices.

Chapter 5

Conceptual framework for designing the lean enterprise performance measurement system

This chapter presents a conceptual framework for the design of lean enterprise performance measurement system. The objective of this chapter is not to claim that the proposed framework is a panacea for all ills befalling performance measurement. Its objective instead is to propose a conceptual framework and some methods to develop a performance measurement system involving key attributes identified for the transformation and management of the lean enterprise

5.1 The conceptual framework

The conceptual design of the performance measurement system for the lean enterprise is based on a simple structure that consists of three levels of performance measures as shown in **Figure 1**. As identified in Chapter 3, these three levels of measures are individual metric, metric sets and metric clusters. The interconnections between individual metric, metric sets and metric clusters represent causal links. The development of the structure involves a selection of stakeholder value measures, establishment and validation of causal relationships between measures, and managing a consistent set of measures to avoid local optimization. The procedural aspect of this design involves the use of various tools and methods to develop, use, and evolve the structure and ultimately the performance measurement system itself. The stakeholder value analysis is proposed for the selection of performance measures at the top level. Causal relationships between measures are established, validated and evolved using the system dynamics and structural equation model. To manage for consistent measures across the enterprise, a performance measure dictionary is used.

5.2 The structure

Individual metric: Individual metrics are measures that capture task-, activity-, or employee-level performance contributing to the overall performance of a process or processes. They are designed based on the objective of one or multiple processes.

Metric set: Metric set are measures that capture performance across a group of activities or for the overall process, evaluated by measuring end-to-end performance or by aggregation of individual metrics. Each set directs, guides, and regulates an individual's activities in support of strategic objectives.

Metric cluster: Metric clusters aggregate the individual metric and metric set in a fashion to link with strategic objectives and stakeholder values. This captures overall performance across one or more value streams.

This structure can be represented across the value stream as shown in **Figure 2.** The metric clusters are value stream or enterprise-level measures, depending upon the boundaries of the enterprise. The metric set measures performance at processes or sub-processes that constitute the value stream. Metric sets play a major role in synchronizing activities and strategic objectives, as well as co-coordinating processes across the value stream. And individual metrics are measures at the building blocks for the process and value stream level measures. For example, as seen in **Figure 2,** the individual metrics - that is, employee training hours and numbers of parts per minute produced - affect the process cost or process yield. Metric Sets - process yield and process cost - contribute to the metric cluster - overall cost.

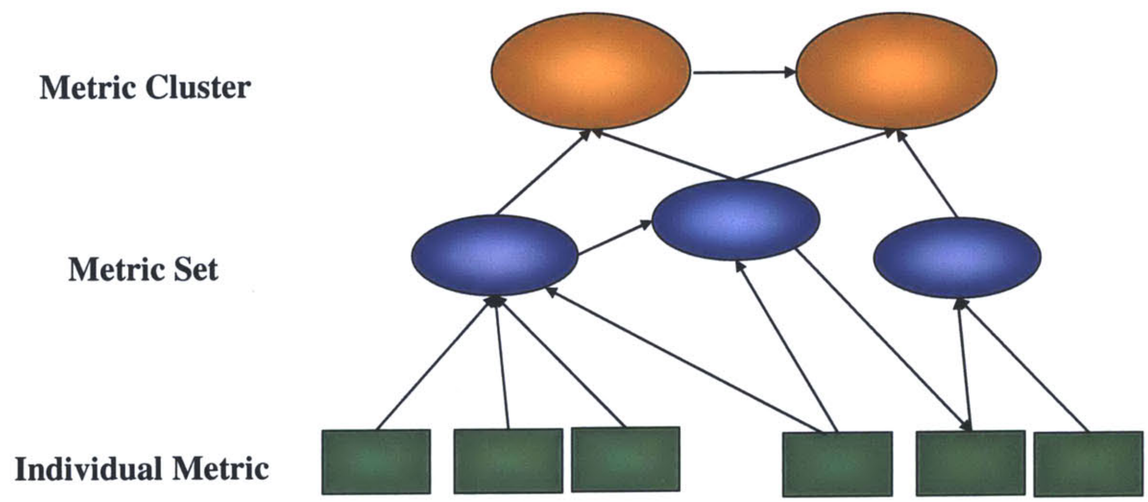


Figure 5.1: The conceptual design of performance measurement system for the lean enterprise

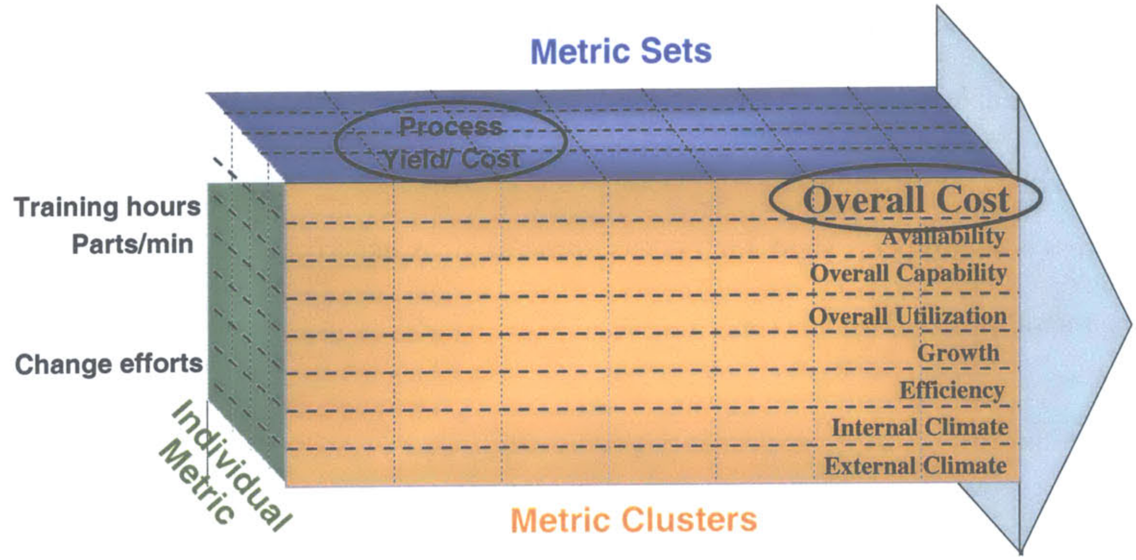


Figure 5.2: Value stream representation of the performance measurement system

5.3 Identifying stakeholder values and creating and weighting metric clusters

The objective of a lean enterprise is to deliver value to all stakeholders. The strategies to deliver value, as well as the process to execute strategies and actions and behavior at each level of the enterprise should be aligned with delivering stakeholder value. Thus, top level measures and metric clusters of the lean enterprise should be derived from stakeholder value and aligned with actions across the enterprise.

Stakeholder theory describes stakeholders as persons or groups with a legitimate interest in procedural and/or substantive aspects of the enterprise activity (Freeman, 1984). Stakeholders are identified by their interest in the enterprise, such as suppliers, shareholders, etc. (Freeman, 1984; Earl and Clift, 1999). In other words, stakeholders are groups that drive or contribute value to the enterprise in accomplishing its vision, can be affected by implications of any decisions and can directly or indirectly influence decisions and their consequences (Earl and Clift, 1999). Stakeholder theory holds that managers should pay attention to all stakeholders. Freeman and McVea (2001) emphasize that stakeholder management is a never-ending task of balancing and integrating multiple relationships and multiple objectives. However, many researchers and critiques (e.g., Smith, 2003; Sundaram and Inkpen, 2004) have argued that stakeholder theory provides no formula for adjudicating among stakeholders' disparate interests. Jensen (2002) further argues that any theory of enterprise decision making must tell decision makers how to choose among multiple stakeholders with competing and, in some cases, conflicting interests. Customers want low prices, high quality, and full service. Employees want high wages, high-quality working conditions, and specific benefits, including vacations, medical care, and pensions. Suppliers of capital want low risk and high returns. Communities want high charitable contributions, social expenditures by companies that benefit the community at large, increased local investment, and stable employment. And so it goes with every conceivable stakeholder. Thus, top level measures derived from stakeholder values may result in a long list of measures. Managers at the enterprise level would want to make trade-offs to maximize value delivery with given resources and capabilities.

In this framework, the stakeholder value analysis method is adapted from Earl and Clift's (1999) work, to derive metric clusters and to put weights on each of them to facilitate trade-offs. The stakeholder value analysis method is divided into three steps.

The first step involves identifying the stakeholder. The definition of stakeholders not only includes external stakeholders, but also internal ones such as employees, management, etc. The list of stakeholders may include 15-20 entities, depending on the scope and boundary of the enterprise. Stakeholder selection should be done very carefully as the stakeholder value analysis is completely dependent on it.

The second step is to identify the values or performance attributes that are of importance to each stakeholder. The methodology includes using a generic questionnaire with questions such as “What do ouy value? What do you expect to get from your involvement in the enterprise? What are the things that would make the enterprise highly thought of by you? ”What measures would you use to identify that value?” The questionnaire can be populated by conducting interviews of one or more representatives from each stakeholder group.

In the third step, the list of values provided by each stakeholder can be further clustered into metric clusters, as shown in sample analysis carried out by an auto parts manufacturer **(Figure 3)**. Multiple values can fall into one cluster since each of these values can be complementary or similar to each other. For example, “customers value better price” can be complemented by “compensation of the employee”, and hence both are clustered in an overall cluster, namely, system cost.

Stakeholder Values

Metric Clusters

	Customer	Leadership	Employees/Union	Shareholders	Suppliers
System Cost	•Price • Proactively Minimize System Cost	• Innovation Process • Productivity	•Compensation	•EBITDA •Future Business	•Competitive Pricing •Early Definition of Requirements
System Capability	•Variability Improvement -Manufacturing Process -Design -Supply -Supplier's Supplier	•Quality •Better Workforce			•Early Definition of Requirements
Business Growth	•Synergies •Bond Supplier-Customer • Logistics •3D- Design Management	•Goal Alignment		•Future Business	
Human Resource Development		•Goal Alignment	•Work Environment •Compensation		
Cash Flow				Cash Flow	Prompt Payment
Employee Satisfaction			•Career Development •Better Safety •Work Environment		

Figure 5.3: Stakeholder value clustering (example)

The fourth step involves value trade-offs. This involves assigning appropriate weights to each values so that important values receive higher weights while unimportant value receive lower ones. Different stakeholders may put different weight on each of the values. Assigning specific weights to each of the values can be a cumbersome and difficult task for stakeholders. Moreover, averaging those weights can skew the analysis significantly. For example, one stakeholder may assign a 90% weight to one value, while another assigns 10% to the same value. Averaging these two weights may result in fifty percent, which does not accurately reflect the weight's true importance to both stakeholders.

Hence, Earl and Clift (1999) recommend the use of the Pairwise Comparison technique (or Eigen vector approach) developed by Saaty (1980). The key advantage of the Pairwise Comparison is that it allows managers to systematically determine the weights for each of the values. In this method, each stakeholder is asked to compare pairs of values one at a time. The method can be described as follows:

There are five stakeholder values: A, B, C, D, and E. Each stakeholder is asked to compare these value based on the preference scale described in Table 1. Thus, the stakeholder is asked how important is:

A versus B, A versus C, A versus D, A versus E,

B versus C, B versus D, B versus E,

C versus D, C versus E,

D versus E

Hence, assuming that there are n stakeholder values, each stakeholder is asked to make $n((n-1)/2$ pairwise decisions (a_{ij}). These decisions can be used to construct an n by n matrix, when $i = j$. The Eigen vector of this matrix approximates the stakeholder's overall weight for each value and ultimately the metric cluster itself. Earl and Clift (1999) further explain that the best way to understand Eigen vector is to imagine it as an "*averaging of all possible ways of thinking*" where "ways of thinking" is the pairwise comparisons provided by the stakeholders.

Table 5.1: Preference Scale (adapted from Earl and Clift, 1999)

Values for comparison	Definition
1	Equally important or preferred
3	Slightly more important or preferred
5	Strongly more important or preferred
7	Very strongly more important or preferred
9	Extremely more important or preferred
2, 4, 6, 8	Intermediate values to reflect compromise

5.4 Establishing and validating causal relationships

Eccles and Pyburn (1992) noted that for successful deployment of a total quality management initiative, it is imperative for managers to develop a comprehensive performance measurement model that establishes and validates the causal relationship. Ittner et al. (2003) conducted a survey in the financial services industry and found that companies that manage performance using causal models, linking non-financial measures with financial ones, perform better. In the case of the lean enterprise, the transformation and its management involve deployment of a set of human- oriented and process-oriented practices. Adoptions of these practices across processes leads to better integrated and maturer processes required to manage the lean enterprise (Hallam, 2003). To deliver value to stakeholders in optimal fashion it is not only necessary to understand interdependencies across the processes and their maturity level, but also the causal effect relationships among the performance of practices across processes **(Figure 2)**. For example, imparting training to employees will strengthen the enabling process, which in turn improves the execution of the life cycle process. In addition, to ensure efficient and effective value delivery to the customer it is critical to understand how and to what extent training efforts affect the overall process cost which contributes to customer value. Hence, to ensure the specific stakeholder value delivery (customer value in this case), in an efficient and effective manner, it is critical to establish and validate causal relationships between performance measures.

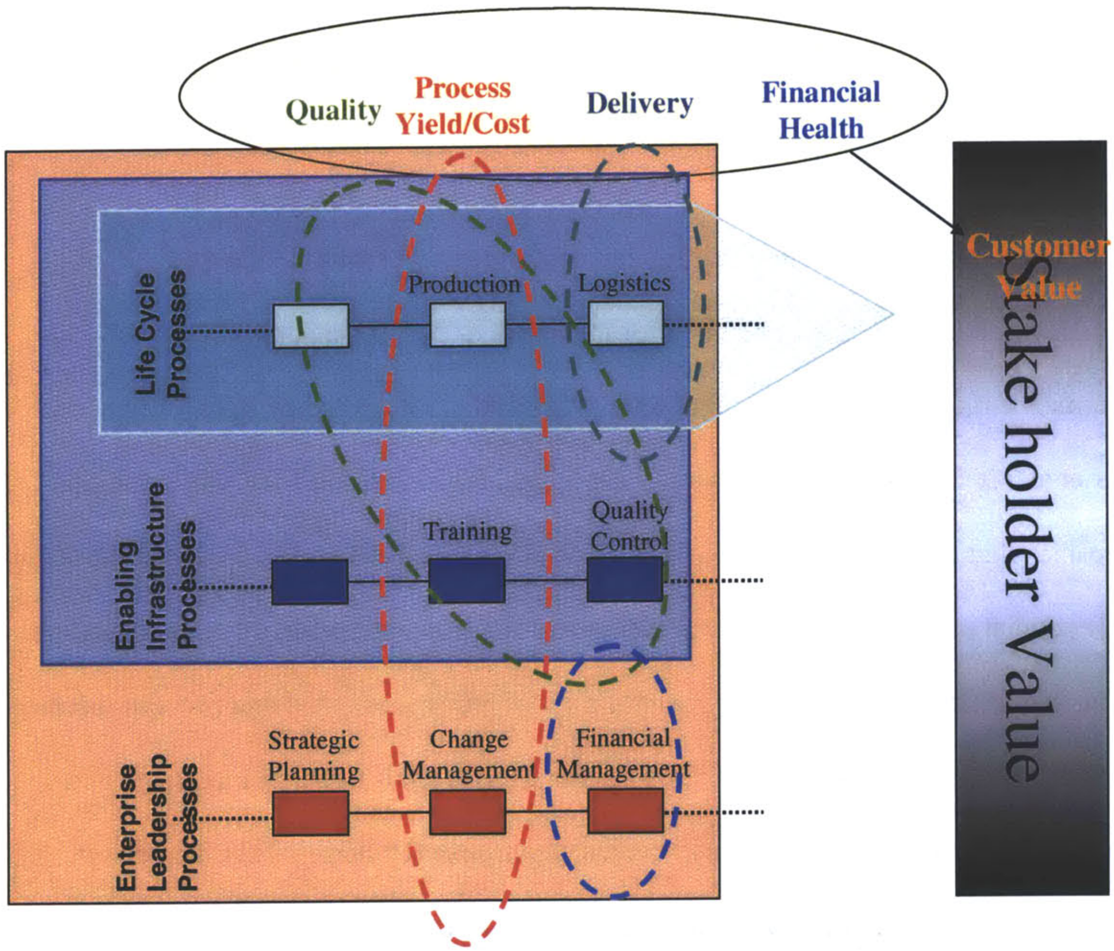


Figure 5.4: Interdependencies across measures

In this conceptual performance measurement system design, we propose to use two techniques to establish and validate relationships between measures: system dynamics and the structural equation model (SEM). Design of the lean enterprise performance system can quickly become overwhelmingly complex due to large numbers of performance measures at each level. Since the lean practices rely heavily on scientific methods (Spear and Bowen, 1999), system dynamics and structural equation modeling provide scientific rigor to the performance measurement and management process.

System dynamic models are frequently developed and used to represent, analyze, and explain the dynamics of a complex system. The dynamics or behavior of a system is defined by the structure and interactions of its components. Through the use of qualitative and quantitative attributes, a system dynamic model helps to understand the change in behavior of the components of a system due to change in policies or reconfiguration of other parts of the system. The system dynamic model provides understanding of the change in behavior of the various system components due to the explicitly defined interactions. However, it does not provide explicit evaluation of these interactions and alternate path of actions to the decision makers (Santos et al., 2002). To overcome this drawback, the proposed conceptual design incorporates the SEM technique along with the system dynamics.

The structural equation model as defined by Schumacker and Lomax (1996) "allows examination of a set of relationships between one or more independent variables, either continuous or discrete, and one or more dependent variables, either continuous or discrete". The structural equation model is a combination of multiple regression and factorial analyses. SEM is a model testing procedure and not a model developing technique. In other words, SEM can be used to test validate the hypothetical cause and effect relationship but these relationships need to developed based on theory, knowledge or even hunches. Before testing the relationship itself, the directionality of the relationship needs to be understood. Hence the combination of a system dynamic model and SEM can provide a comprehensive tool set to design the structure of a performance measurement system.

The first step towards establishing the causal relationship is development of a system dynamic model that captures the hypothesized causal relationships. Consider the simplified causal loop diagram **(Figure 5)** that explains the attributes affecting the system capability of the enterprise. It captures interactions and directionality between various attributes that affect the system capability. Also it captures the dynamic between various activities and outcomes. For example, loop 3 captures the reinforcing dynamic between system capability and employee capability. That is, an increase in employee capability is achieved via imparting the black belt training to the employees and reducing employee turnover. An increase in employee capability, in turn, improves system capability, which positively impacts the order to delivery time, improving customer satisfaction. Improved customer satisfaction leads to better net operating profit, increasing investment capability and leading to more budgetary allowance for black belt training. Similarly, loop 1 and loop 2 represent the impact of supplier relationships and process capability on the system level capability. Thus the system dynamic model enables the understanding of hypothetical indirect and direct measures affecting the system level capability. In addition, the system dynamic model allows capturing of time delay between the impact of one performance outcome on another, such as the impact of employee capability on process improvement. It is vital to understand the time delays; however, it very difficult to understand them in the context of a performance measurement system (Santos et al., 2002).

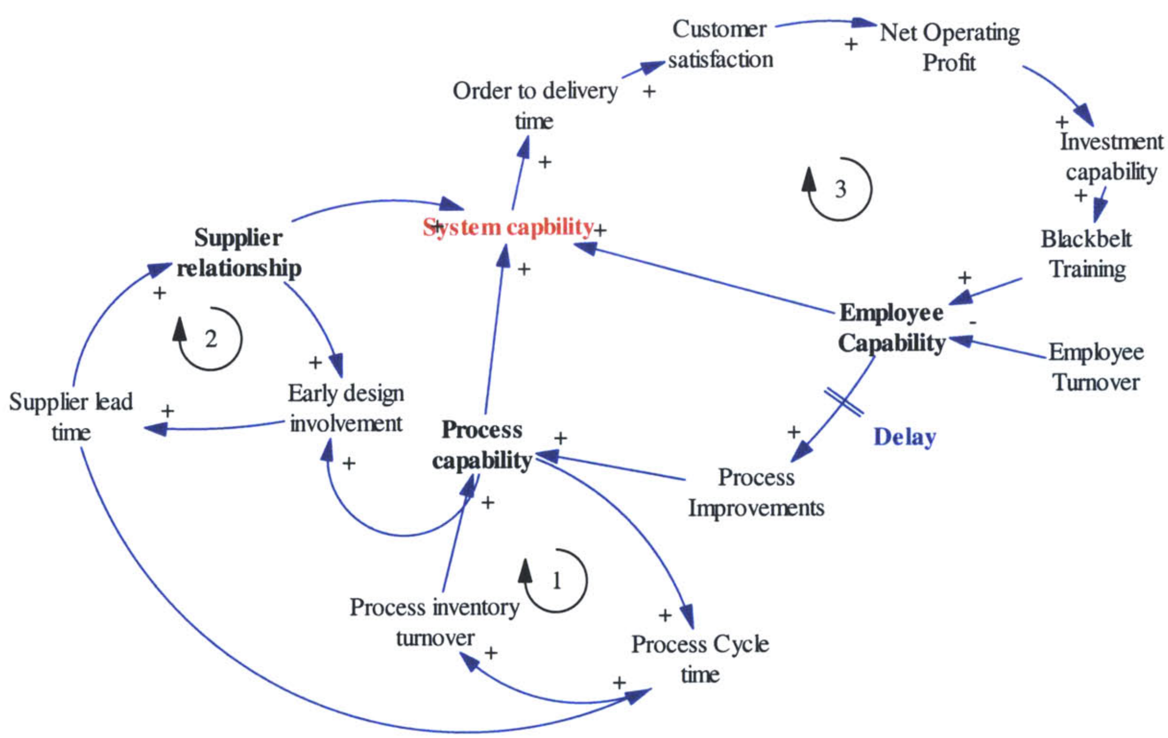


Figure 5.5: Example of a causal loop diagram for the performance measurement of system capability

Developing the cause and effect relationship between performance measures and understanding their behavior based on these interactions is necessary but not sufficient for decision makers. It is imperative for them to validate these relationships and better understand the precise impact of each performance outcome one interdependent performances. To better explain the relationships and variance in performances due to interactions, a structural equation model (SEM) is used.

The SEM deals with measured and latent variables. A measured variable is one that can be observed directly and is measurable. For example, in the example above, process cycle time is a measured variable. Measured variables are also known as observed variables, indicators or manifest variables. A latent variable is a variable that cannot be observed directly and must be inferred from measured variables. For example, in the example above process capability is the latent variable. Latent variables are implied by the covariance among two or more measured variables. They are also known as factors (i.e., factor analysis), constructs or unobserved variables. The SEM is a combination of multiple regression and factor analysis.

Structural Equation Models are divided into two parts: a measurement model and a structural model. The measurement model deals with the relationships between measured variables and latent variables. The structural model deals with the relationships between latent variables only. One of the advantages to the SEM is that latent variables are free of random error. This is because error has been estimated and removed, leaving only a common variance.

Figure 6 shows the SEM for the example above. In an SEM, measured variables are indicated by rectangles or squares and latent variables are indicated by ellipses or circles. Error terms ("disturbances" for latent variables) are included in the structural equation model diagram, represented by "e" for a measured variable and "d" for a latent variable. Error terms represent residual variances within variables not accounted for by pathways hypothesized in the model.

The parameters of an SEM are the variances, regression coefficients and covariance among variables. A variance can be indicated by a two-headed arrow, both ends of which point at the same variable, or, more simply by a number within the variable's drawn box or circle. Regression coefficients are represented along single-headed arrows that indicate a hypothesized pathway between two variables. (These are the weights applied to variables in linear regression equations). Covariances are associated with double-headed, curved arrows between two variables or error terms and indicate no directionality.

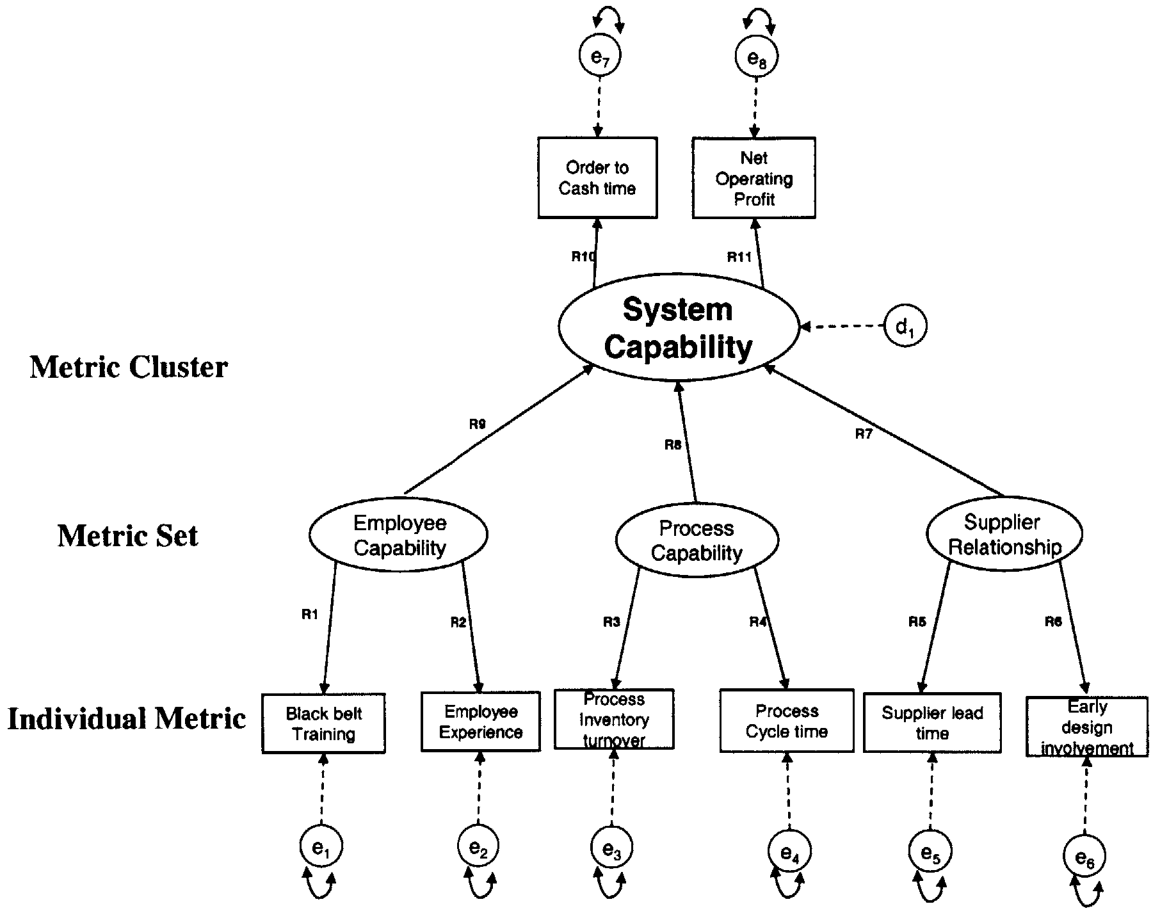


Figure 5.6: Structural equation model for the performance measurement of system capability

We can interpret the results of an SEM from two perspectives: the measurement model and the model as a whole. The measurement model part pertains to each latent variable and its associated measured variables, and there are three questions that can be asked: (1) How well do the measured variables reflect the latent one? (2) Are some observed variables better than others? And (3) How reliable is each measured variable? Each latent variable is a mini-factor analysis, so we can go back and remove variables that do not seem to do much except add error variance. Once we have derived a set of measured variables that work well, we can turn our attention to the model as a whole to see how well it fits the data. Are there some latent variables that don't have significant paths to others or (even worse) have significant paths but with the wrong sign?

5.5 Developing a uniform and consistent set of measures

The objective of understanding stakeholder values and developing the causal relationships across measures is to avoid a decision that will lead to local optimizations and non-lean behavior. As noticed above, various decision makers at different levels of the enterprise or across different processes may use the same measures to achieve different performance objectives. For example, the measure inventory turns is used by the operations decision maker to ensure on-time delivery and order fulfillment to the customer while managing the pull production process, while a financial decision maker uses the same measure to maximize cash to cash cycle time. If these two managers use tdifferent formulae for the same measure, it may lead to suboptimal decisions and non-lean behaviors. Given the complexity of the enterprise, it easily possible that various interdependent functions or processes may use the same measure with different design elements, as described in Chapter 3. To avoid non-optimal behavior, this conceptual design proposes to create a performance measure dictionary (C. Lohman, 2004). The dictionary will consist of the detail design of all the elements of measures, for each individual measure across the enterprise. Only owners of the measure and a few other executives will have permission to alter the elements of measures. All the decision makers will have to use the standard design established in the performance measure dictionary. This will ensure the uniformity and consistency of measures across the enterprise.

Chapter 6

Conclusion and future research

6.1 Conclusion

This research emphasizes that designing the performance measurement system is imperative to support lean enterprise transformation and its management. The evolution of lean practices across three stages and attributes, and corresponding performance measurement systems are presented. This research identified three key attributes for the design of lean enterprise performance measurement systems. They are:

- Enterprise-level stakeholder value measures
- Causal relationships between measures across different levels of the enterprise
- A uniform and consistent set of measures across the enterprise

The case study of an aerospace and defense business emphasizes that a disconnect between the performance measurement of lean practices and regular business practices creates a barrier to the adoption of lean practices. Further, the literature review of the performance measurement theory and widely accepted performance measurement frameworks revealed that none of the existing performance measurement frameworks address the attributes of a lean enterprise performance measurement system. A conceptual model for the design of performance measurement explained tools and techniques to be used to design the attributes. The following conclusions can be drawn from this research work:

1. For the successful transformation to the lean enterprise and subsequent management it is imperative to design a supporting performance measurement system

A successful transformation to a lean enterprise while delivering value to all stakeholders in an efficient and effective manner via systematic enterprise-wide adoption of the lean practices entails the synchronization of various subsystems across the enterprise. The scientific rigor required to deploy lean practices, such as continuous improvement, is enabled by using appropriate performance measurement techniques. In addition, the synchronization across enterprise subsystems is achieved through a performance measurement system. It enables alignment of subsystem-level performance with enterprise-level performance goals, and coordination and communication of performance across the subsystems.

2. The design of a lean enterprise performance measurement system should address the increase in scope and complexity of lean practices

At the lean production process level, synchronization across various tasks, activities and employee behavior to support lean practices is achieved through a visual management system. This visual management enables the performance measurement system by providing visibility across the production process, an understanding of causal relationships across performance measures, and a single source of information. At the next level, the adoption of system change initiatives such as TQM and JIT encompasses functions, suppliers and customers, all of which increase the complexity of deploying lean practices. The adoption of system change initiatives not only demands synchronization across tasks and employee behaviors, but also coordination and communication vertically and horizontally across select subsystems of the enterprise. It is achieved through overcoming the limitations of a traditional financial performance measurement system by incorporating the following attributes: use of non-financial measures along with financial ones at the enterprise level; including external as well as internal performance measures; and communicating strategic goals vertically and horizontally across the enterprise.

At the lean enterprise level, the broad scope of deploying of lean principles across the enterprise further increases complexity. Consequently, the supporting performance measurement system should not only incorporate the previously identified attributes, but also should include:

- Stakeholder value measures
- Causal relationships across enterprise-wide measures
- A uniform and consistent set of performance measures

3. The role of performance measurement in the lean enterprise is not limited to monitoring and controlling performance, but also includes communication and coordination of performance across subsystems, identifying improvement opportunities and motivating appropriate behavior

Traditional performance measurement systems are primarily focused on monitoring and controlling resource and outcomes. However, to achieve synchronization across the enterprise, subsystems communication and coordination of the performance is critical. Moreover, to institutionalize lean philosophy among employees, the measurement system should support identification of improvement opportunity and motivate them to achieve that improvement.

4. The performance measurement efforts supporting the lean initiatives should be integral part of the enterprise performance measurement system

The case study of Alpha Corporation and its aerospace and defense business Gamma Tech highlight the challenges of adopting enterprise-wide lean practices and principles due to a disconnected and less formal performance measurement system. At Alpha Corporation the disconnected performance measurement system leads to non-lean actions and behaviors.

5. The widely accepted performance measurement frameworks proposed in the literature to design enterprise performance measurement systems do not address key attributes critical to the lean enterprise.

The review and analysis of the six widely accepted performance measurement frameworks, including the Balanced Scorecard, reveals that the none of the frameworks address the establishment and validation of causal relationships between measures. No framework except the Performance Prism includes design of stakeholder value measures. Also, creating a uniform set of measures has not been considered in any of these frameworks.

6. Stakeholder value measures are included as top-level enterprise measures, and their corresponding weights can be derived using Eigen vector analysis.

7. The causal relationship between the measures should be established, validated and evolved on an ongoing basis. The directionality of the causal relationship can be established and validated using system dynamic modeling techniques. In addition, the significance of the causal relationship and the variance in performance due to other interdependent measures can be established and validated using a structural equation model.

8. Creating a uniform set of measures across the enterprise is critical to avoid local optimization and non-lean behavior. It can be achieved by creating a measurement dictionary which includes a complete description of all the elements of measure. A deliberately limited number of people should have access to alter these definitions. These people may include measurement owners and a few top-level executives.

6.2 Future work

As is often the case, this research has raised additional questions and opened new avenues of study. The main focus of future research should be in the area of empirical testing.

1. Empirical testing of the proposed conceptual design

The methods proposed in this research make a logical argument for an effective design of the performance measurement system. However, it is very important to validate the use of these methods in the context of the proposed design for the lean enterprise performance measurement system. Empirical testing of these modeling techniques demand collection of a large data set, and in some cases, introduction of new measures and subsequent data collection. During this research attempts were made to collect performance measurement data of Alpha Corporation, but significant challenges were encountered along the way.

The foremost challenge is identifying a limited set of measures that can provide a reasonable view of the enterprise, with minimum complexity in creating the model. We realized that the number of measures can quickly run into hundreds, which make it very difficult for modeling part of the design. The second challenge is availability of the data. In many cases data on human processes are not collected. Since human-oriented process comprises a significant part of the lean enterprise, it is difficult to explain the variance without understanding human-oriented processes as well. The third challenge is unifying the measures. In several cases there is repetitive collection of same measure at different sources. For example, customer satisfaction was measured by the marketing team as well as the delivery side of the manufacturing team. The fourth challenge is normalization of the time series data. In many cases measurement definitions change frequently - almost every year - which makes it difficult to normalize the same measure over the period of time.

2. Identify the key performance measures at the each level of the enterprise that can explain the impact of lean.

It would be ideal to develop some hypothesis around relationships between measures and test them to establish some generalized co-relations in the lean enterprise approach. This is a very difficult task and it may need an introduction of new measures at the site of data collection.

It may prove feasible to carry out the data collection and empirical testing in two ways. the sites that are deploying the lean practice towards transformation to the lean enterprise should be identified. Then one must collect the existing performance measures data and understand the underlying system. There must be some intelligent hypothesizing regarding the relationships among performance measures based on the management's decision and lean enterprise theory. Further, testing these relationships using the proposed design must be undertaken.

The second approach could be to design and introduce selected critical performance measures, based on theory and best practices, across the enterprise that has embarked on the transition-to-lean journey. Hypothesizing the relationships among these measures and validating the relationships using the methods explained in the conceptual design should then follow.

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